"COMPOSITION, STRUCTURE AND DISTRIBUTION OF PLANT COMMUNITIES IN LAKE NAKURU NATIONAL PARK."

BY

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D E C L A R A T I O N

This thesis is my original work and has not been presented for a degree in any other University.

JOSEPH GOKO MUTANGAH DATE 25 Jan. 1989

This thesis has been submitted for examination with my approval as University Supervisor.

PROFESSOR JOHN O. KOKWARO DATE 25 Jan. 1989

To my mother (Monica Wambui Mutang'a) who has sacrificed so much of her life for my education both locally and in India.

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The apparent lack of quantitative information on the vegetation status of Lake Nakuru National Park, where there are alarming reports of high mortality rates among the browsing and grazing mammals such as waterbuck, warthogs, impalas and buffalos, prompted this study. It's main purpose was, therefore, to provide baseline data on the composition, structure and distribution of vegetation in the park.

The vegetation analysis involved the use of Releve Method to obtain data for classification and mapping. Quantitative analysis of woody species was carried out by P.C.Q. Method (Point-Centred Quarter Method) using line transects, in order to determine the distribution patterns of species and consequently that of plant communities. Soil analysis was also done using standard methods.

From the results obtained by Releve Method, 19 plant communities were distinguished and with reference to land scape features, a vegetation map of the Park was drawn up. Results from quantitative analysis interpreted statistically using reciprocal averaging ordination have indicated floristic overlap between plant communities.

The ecological importance, abundance and distribution of these species has been discussed. The pattern of variation in vegetation has been shown to coincide with the pattern of variation in soil properties, with an altitudinal range simulating vegetation zonation from the Lake to the escarpments.

A number of suggestions and recommendations have been put forward and it is hoped that the scientific findings of this study will provide baseline data upon which future ecological monitoring will depend. They will also be used in the planning and management of the Park.

CHAPTER ONE

I N T R O D U C T I O N

1. 1. THE COMMUNITY CONCEPT:

A plant community is defined as a group of stands that are similar in species composition and structure, and occupy similar habitats. A vegetation stand is a particular aggregation of plants having a higher degree of uniformity in composition and structure and occupying an area of essentially uniform environment (Hansen and Churchill, 1961). The study of community structure and composition is the effort to understand how a community, as a living system of interplaying species populations is organized. Plant communities are identified through variations that occur in the homogeneity or uniformity of the vegetation cover in an area where these variations are easily visible and distinquishable to the eye. These variations are caused by a number of vegetational attributes or environmental factors (or both) and must be studied for adequecy of description and understanding of a plant community (Whittaker, 1975 and Daubenmire, 1968).

The vegetational attributes that influence the nature of a plant community include among others, physiognomy, floristic composition and spatial distribution patterns (Barbour, Burk and Pitts, 1980). Physiognomy is a combination of the external appearance of the vegetation, its vertical structure and the

life forms of its dominant taxa. Floristic composition is the species component of the community that consists of a complete list of plant species, species abundance, importance or dominance. The relative spatial distribution pattern is the horizontal arrangement of species within a community showing whether the species are randomly distributed, clumped or overspread.

Kershaw & Looney (1985) state that it has become increasingly evident that extremely small variation of an environmental factor (factors) operating over quite large areas will produce corresponding variations in the vegetation structure. Environmental factors reported to cause variations in vegetation cover are altitude, climate, topography and soils (physical environment) and others such as fire, cultivation and grazing (Pratt and Gwynne, 1977). Soils form one of the most important environmental factor that control the distribution pattern of plant species (Kershaw & Looney, 1985, Bailey and Poulton, 1968). Texture, moisture content, salinity and pH are the major soil factors found to influence the distribution of plant communities (Anderson and Herlocker, 1973; Meiri and Levy, 1973; Loveday, 1974 and Goldberg, 1982).

Classification and description of plant communities depend entirely upon the records of environmental factors and vegetational attributes. These records are obtained from the field

through various analytical methods and thus the need for quantitative techniques for expressing different attributes of communities have long been recognized (Daubenmire, 1968).

I. 2 GENERAL LITERATURE REVIEW

Studies on composition, structure and distribution of plant communities have been carried out in many parts of the world. The purpose and importance of these studies is to monitor the present and future ecological trends of the communities concerned (Asby, 1961; Hansen and Churchill, 1961), and in most cases they are linked with the problems of land utilization and long-term conservation strategies of the world's natural resources. In Europe, Asia and America, extensive studies on community structure and floristics have been conducted (Grubb, Lloyd and Pennington, 1963; Paijmans, 1970; Proctor, Anderson, Chai and Vallack, 1983). Information derived from these studies has been used to map, classify and describe vegetation in various countries. The same information has been extended into the environmental protection and management programmes world-wide. In addition, studies on environmental factors, particularly soil properties have been carried out and their findings are used to interpret the distribution patterns of plant species in a community (Goldberg, 1982; Jayasuriya and Pemadasa, 1983).

Similar studies have been conducted in Africa where a conspicuous ecological diversity contributes greatly to the wide

variety of habitats that are characterized by various vegetation types. White (1983) produces an account on the vegetation of African continent whereby he classifies the vegetation into sixteen major plant communities (formations) on the basis of their physiognomic structural characteristics and he points out that these divisions are not designed arbitrarily but in such a way that they can accommodate the great regional formations of Africa. Detailed vegetation studies have however, been carried out in many countries of Africa including Nigeria (Hopkins and Jenkin, 1962; Ramsay and De Leeuw, 1964; Hall and Okali, 1979), Ghana (Lawson, Armstrong-Mensah and Hall, 1970), Cameroon (Stark and Hudson, 1985) and Botswana (Tinley, 1966).

In East Africa, vegetation covers a full range of eco-climatic zones, ranging from montane forests to semi-desert scrubland (Platt and Gwynne, 1977). The distribution of vegetation types in this region follows water availability gradient which is controlled by topographic and physical properties of the soil. Classification and description of East African vegetation started four decades ago (Greenway, 1943) but with some difficulties caused by high diversity of eco-climatic characteristics. However, with increased research on the plant communities, these difficulties have been overcomed and the vegetation types are now well defined and described (Pratt, Greenway and Gwynne, 1966; Trapnell and Langdale-Brown, 1972; Lind and Morrison, 1974 and Pratt and Gwynne, 1977).

On a regional basis, several authors have recently reviewed the vegetation of East Africa, laying emphasis on the physiognomy, floristic composition and taxonomic features. In Tanzania such contributions come from Boaler (1966), Wolfgang, Schmidt, Gottingen, (1975), Kahurananga (1979), Beck, Scheibe and Sensor (1983), Beck, Scheibe and Schulze (1986) and Loth and Irins (1986). In Uganda vegetation work of Langdale-Brown, Osmaston and Wilson (1964) is very important. In Kenya contributions from Rehder, Beck, Kokwaro and Scheibe (1981), Lamprey (1981), Kokwaro (1985 and 1988), Kabuye, Mungai and Mutangah (1983), form the baseline information to the study of plant communities in this country.

There has been, however, a relative lack of adequate quantitative information in most of the vegetational studies in East Africa, making these studies far from complete. Quantitative estimates and precision aid in the interpretation on the distribution patterns of plant communities or even aid in the recognition of the changing balance between species (Sykes, Horrill and Mountford, 1983). In Kenya among the few authors that have applied quantitative techniques intensively in their work on vegetation analyses include Taiti (1975) who, using Point-centred Quarter Method (P.C.Q.) analysed and described fourteen plant communities in Maasai Mara National Reserve and related their distribution to the soil properties. Lamprey (1984), using Leithead (1979) Method analysed and described woodland

communities in Marsabit. In Kora National Reserve similar quantitative vegetation analyses were conducted where vegetation was analysed and described along a caternary sequence from ridges to the riverine flood plains (Agnew, Payne and Waterman, 1983).

I. 3. PREVIOUS RESEARCH WORK IN THE PARK

Lake Nakuru National Park, first established in 1961, has been a bird sanctuary of international reputation. The birdlife forms a unique spectacular display that attracts thousands of both local and foreign tourists into the park. This phenomenon, however, makes the biology of the lake to become the most important component of the ecosystem to receive priority in the research activities of the Park. Thus, most of the research work in this Park has been concentrated on the limnology of the lake where factors controlling the balance between biological and physical environments form the centre of many research interests in the study area. Mavuti (1975) investigated the biology of aquatic invertebrates of the genera Sigara and Micronecta. Estimates on evaporation rates of the Lake have been carried out using the aerodynamic, energy budget, penman and water budget methods (Mimira, 1976). Schwan and Lamberti (1986) investigated the influence of oxygen concentration on the respiratory behaviour of tilapia (Sarotherodon alcalicus grahami) in Lake Nakuru. Other important investigations

on Lake Nakuru include abundance and feeding of the Lesser flamingo, biomass and distribution of fish, algal standing crop and photosynthetic production (Vareschi 1978, 1979 and 1982).

In 1974, the Park was expanded from its former boundaries that included the Lake itself and its immediate shoreline to include the surrounding farms that formed a belt round the park purposed to act as a buffer zone between the lake environment and the neighbouring Urban Settlement of Nakuru Municipality, agricultural farms and Industries (Vaucher, 1973). The present landscape of the park is characterized by hills, ridges, cliffs, rocky outcrops, troughs, plains and lake basin. This variation in landform structure is due to geological complexity associated with the Rift Valley system and has resulted in a high degree of ecological diversity that produces a wide range of terrestrial habitats occupied by different vegetation types and vertebrate animals. Research on large and small mammals in these terrestrial habitats has been going on particularly in the fields of ecological assessments of their densities, biomass and distribution. Results from these studies have shown a high mortality rate of most of the animal species studied (Kutilek, 1974, Wirtz, 1982 and Schwan, 1986). Other studies on large mammals include the translocation and settlement of endangered and threatened animal species into the Park such as Rothschild's giraffes (Kakuyo, 1980) and Rhinoceros (on-going project).

Prior to this study, no botanical studies had been carried out in the Park. However, there had been a few records of plant

collecting in the Park by visiting taxonomists and workers such as Kutilek (1974) but generally, their botanical work had been casual and scanty. In addition, the only available information on the general vegetation of the Park was in most cases related to the distribution of animals in the Park. This information, however, was based on broad aspects of dominant plant species and general physiognomy and was used by earlier workers to classify the vegetation into four major plant communities, namely, Woodlands/Forests, Bushlands, Grasslands and Shoreline vegetation (Vaucher, 1973, Kutilek, 1974 and Kakuyo, 1980).

I. 4. SCOPE OF STUDY

There were three major problems that called for an urgent Vegetation Survey in Lake Nakuru National Park prior to this study. These are: 1. the high degree of ecological diversity within a relatively small area (188 km^2) that comprises the park, creating a wide variety of habitats characterized by plant communities that needed to be defined, classified and mapped. 2. high mortality rates and further additions of browsing and grazing game animals in the Park created threats to the planning and management programmes in the Park. 3. Lack of quantitative information in the early descriptions of vegetation types in the study area made them inadequate and unreliable.

The landscape of the Park, as indicated elsewhere, comprised of hills, escarpments, rocky outcrops, cliffs, plains and lake basin. Each of these landforms possesses its own environmental characteristics responsible for its unique vegetation cover, composition and structure. It becomes, therefore, quite difficult to classify or describe such widespread small, dissimilar vegetation units (mosaics) without application of advanced vegetational analytical techniques which were not available to the early observers. They used aspects of dominant plant species and general physiognomy to demarcate arbitrarily the conspicuous vegetation types.

High mortality rates in animals such as Impalas, waterbuck warthogs and Buffaloes have been noted with a great concern (Kutilek, 1974 and Wirtz, 1982). In addition, more herbivores from vulnerable areas of uncertain protection are being translocated into the study area that has been fenced with an electrified fence and declared as an animal sanctuary for the endangered and threatened animal species (Jenkins, 1983). This high increase in animal populations without a correspondingly increase in land surface and food supplies, creates a big problem to the conservation and management strategies of the Park as this could cause complete failure of vegetation regeneration leading to extinction of certain plant species, which as a result could upset the ecological balance of the Park and hence a total failure to the whole rationale of conservation and management programmes of the Park.

Vegetation observations in the Park prior to this study were based on visual judgement by different people mainly naturalists, taxonomists and zoologists. Information from such sources is always subject to personal errors, bias or both. In addition, lack of quantitative information on the species abundance, relative importance of each species, relationships among species and the environmental influence on the distribution of plant communities made earlier classification and descriptions of the vegetation types in the Park not only inadequate but also unreliable.

I. 5. OBJECTIVES

The main purpose of this study was to analyse and describe the overall vegetation types within the entire Park. This was to be achieved by way of answering the following questions:

(a) What major plant communities occur in the Park ?
(b) What are their botanical and physiognomic characteristics ?
(c) What are their distribution patterns and
(d) What are their relationships with the environmental parameters ?

This can be further broken down into minor objectives as follows:-

(i) To investigate the floristic composition of all the plant communities in the Park.

(ii) To map all distinctive communities on the basis of their physiognomic structural characteristics.

(iii) To determine the relative importance of the woody species.

(iv) To investigate the spatial distribution patterns of woody species.

(v) To investigate the soil properties and their influence on the distribution of plant communities in the study.

CHAPTER TWO

THE STUDY AREA

2. 1. LOCATION AND SIZE OF THE STUDY AREA

Lake Nakuru National Park is one of the main National Parks in Kenya with an international reputation as "the Lake of a million flamingos" where up to 1·4 million flamingos have been recorded at one time (Wirtz, 1982). It is located in the eastern Rift Valley, about 150 km. north west of Nairobi, within latitudes $0^{\circ}18'$ S to $0^{\circ}30'$ S and longitudes 36° 03' E to 36° 07' E. The Park is surrounded by agricultural farms and ranches on the East, South and West. In the North-West lies Nakuru Municipality (fig. 1 a).

The Park was first established as a bird sanctuary in 1961, covering two-thirds of the southern part of the Lake. In 1968, the remaining one third of the northern part of the Lake was included in the Park boundaries to form a complete Park consisting of the Lake and its immediate foreshore covering an approximate area of 42 km^2. Later the agricultural and industrial activities as well as direct influence of Nakuru town posed a major threat to the fragile lake environment and as a result the Government, with financial assistance from World Wildlife Fund, bought the surrounding farms and ranches and included them in the Park to form the present Lake Nakuru National Park, covering an area of about 188 km^2 including 40 km^2 occupied by the lake itself (Vaucher, 1973).

Fig. 1 a. Satellite imagery of Lake Nakuru National Park and its immediate environs. To the north - west lies Nakuru Municipality and to the east and south the Park is surrounded by cattle Ranches. On the west are agricultural farms (Landsat print 1986, obtained from Regional Centre for Mapping, Surveying and Remote Sensing).

The delineated vegetation divisions have been described in Section 4:1 on Floristic Composition.

Fig. 1a. Satellite Imagery (Scale 1:200,000) of Lake Nakuru National Park.

The Park is well serviced with motorable roads that run round the area making most parts of the Park accessible, particularly the Picnic and Camping Sites, Lodges and View Points (Fig. 1 b). Besides wildlife rehabilitation tourism is the major occupation in the Park. Large numbers of both local and foreign tourists visit the Park annually where they deposit large sums of money in form of entrance fees and accommodation expenses (Table 1). The main centre of attraction is the spectacular birdlife formations displayed by water birds such as Flamingos (Phoenicopterus ruber and Phoeniconaias minor) Pelicans (Pelecanus onocrotalus and P. rufescens) and Cormorants (Phalacrocorax africanus). Accommodation services are provided by the two reputable lodges: Lion Hill Lodge and Lake Nakuru Lodge, supplemented by numerous picnic and camping sites where tourists provide their own services.

The Park has been surrounded with a Solar-powered electric fence that has been put up as a protective mechanism from poaching activities as Rhinoceros (Diceros bicornis) are being translocated into this park to live and breed in safety. After successful breeding it is hoped to transfer Rhinos back to areas where they have become extinct.

Fig. 1 b. Road network within the Park portraying a high degree of accessibility to almost every part of the Park. In addition to this expedient transport system, occurrence of numerous well maintained picnic and camping sites as well as the presence of two reputable lodges: Lion Hill Lodge and Lake Nakuru Lodge plays an important role in the promotion of tourist industry in the Park.

LAKE NAKURU NATIONAL PARK

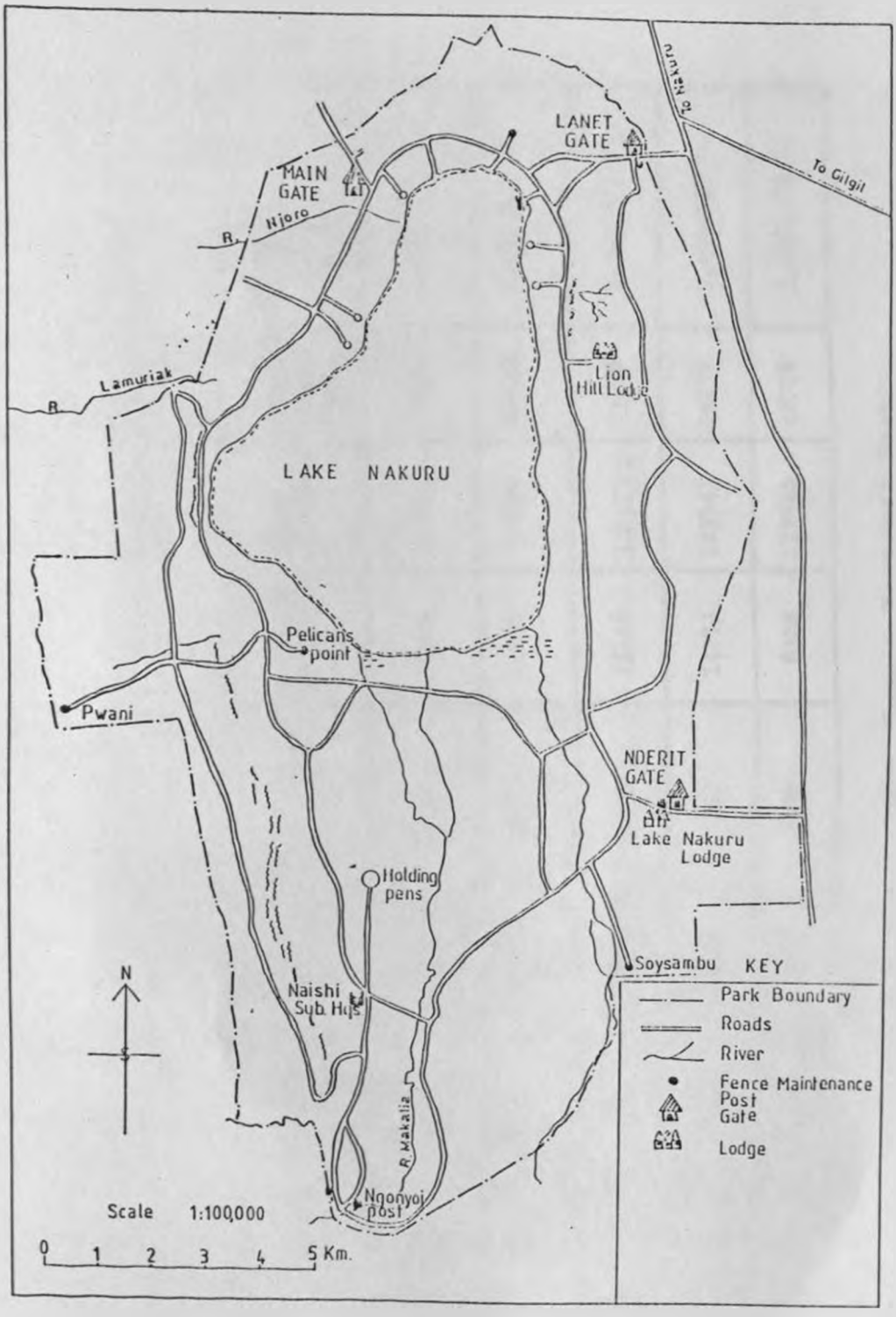


Fig. 1b Road Network

Table 1 L A K E .N A K U R U N A T I O N A L P A R K : V I S I T O R S T A T I S T I C S

1 9 8 2 - 1 9 8 6:

YEAR	CITIZEN	NON-CITIZEN	CHILDREN	SCHOOL CHILDREN	FREE ENTR-ANTS & VIP'S	SEASONAL T/HOLDERS	TOTAL VISITORS	TOTAL VEHI-CLES	REVENUE COLLECTED KSHS.
1982	17552	3504	5825	7861	8488	12549	55779	15529	1,878,523.65
1983	24606	37957	3152	14498	5154	12688	98055	16412	2,467,694.50
1984	28781	53045	2658	18524	5616	15146	123770	23296	3,160,659.65
1985	24461	63535	6524	12533	4217	14273	125543	24137	3,459,927.00
1986	29668	67905	8400	9305	4182	8388	127848	22778	3,822,379.40

(Source of information: Finance Section, Lake Nakuru National Park).

A pollution hazard is mounting in this Park caused by sewage discharge from Nakuru Town (Plate 1). There are several industries in this town manufacturing or dealing in a variety of chemical compounds ranging from agricultural fertilizers to highly toxic pesticides, detergents, oils and heavy metals. The danger is that the end products of these chemicals are finally drained into Lake Nakuru that has no outlet. The presence and accumulation of the pollutants of heavy metals (arsenic, tin, copper, zinc, mercury and cadnuum) have already been detected and reported in different tissues of birds and fish living in Lake Nakuru (Dejoux, C., Deelstra, H. and Wilkinson, R.C., 1981).

Plate 1. The sewage discharge from Nakuru Town on its way to Lake Nakuru where it causes pollution hazards.

2. 2. GEOLOGY:

The Park falls within the Rift Valley, a zone of complex geology having been under the influence of tectonic and volcanic forces for many years. These forces have altered the landscape of this area from a peneplain to a landform of ridges and troughs that run almost in a North-South direction (McCall, 1967). According to this author, the general landscape of Lake Nakuru National Park is best described under five broad topographic features. These are: the Sirrkon hill (Lion Hill), the Western Escarpment, the Central plains, the Tuff cones and the Lake with its littoral zone (fig. 2).

The Lion Hill is situated on the eastern side of the lake and runs from north to south direction. It consists of pliocene volcanic rocks. Faulting and displacement on top of the hill forms troughs that are filled with laval depositions of phonolytic trachytes.

The Western Escarpment arises from the west shore of the lake and forms part of the Mau Escarpment system. This area is characterized by faults that produce scarps, cliffs and rocky outcrops which are composed of phonolytic lavas that grade into porphyritic trachyte commonly known as Mbaruk Basalt.

Fig. 2a. Topographic Features. The Park is bordered to the east by Sirrkon (Lion) Hill and to the west by Western Escarpment. Between these two walls lies the central plains upon which the lake is situated. To the north-west of the plains lie the residuals of once existed craters and these are commonly known as Tuffs or Elementeita tuffs, comprising of the Honey Moon hill and Crescent hill (Adopted and Modified after McCall, 1967).

LAKE NAKURU NATIONAL PARK

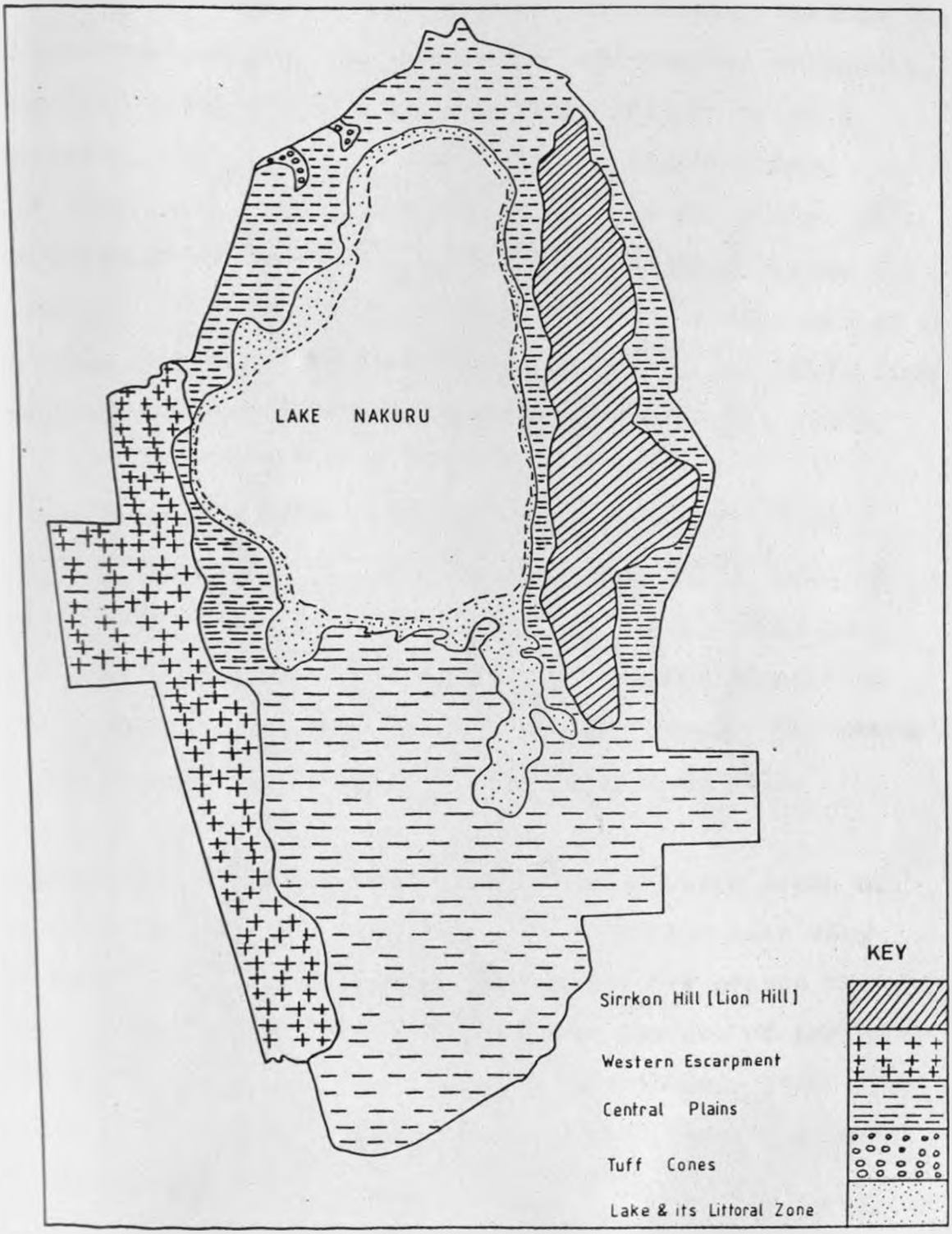


Fig. 2a. Topographic Features

The central plains occupy the northern and southern parts of the lake between the Lion Hill and the Western Escarpment. They are characterized by lacustrine and riverine sediments. Geological evidence indicates that there used to exist a large lake (130 - 200 m. deep) formed approximately 10,000 years ago. This lake stretched from the slopes of Mount Longonot in the south to those of Menengai Crater to the north. The lake disappeared as climatic conditions of this region became adverse leaving behind residue lakes such as Lake Naivasha, Elmenteita and Nakuru (Vareschi, 1982).

The tuff cones commonly known as Elmenteita tuff cones consist of the Honey Moon Hill and Crescent Hill, both of them located in the northern side of the Park. They are steep-sided and composed of light and coloured stratified tuffs containing boulders of lava of both porphyritic trachyte and basalt type particularly in the Honey Moon Hill.

The lake is a shallow saline pan with an average depth of 1 m. and a maximum depth of 4 m. It is filled with very fine clay, silts or gravels. During the dry season thin crusts of white trona are formed on the surface of the sediments in shallow pools and along the shoreline. These are dissolved when the lake fills again during the wet season (Curry - Lindahl, 1971).

2. 3. SOILS:

The soils found on the floor of the Rift Valley are derived from the sediments of lacustrine and volcanic origin (Maskall,1987). In Lake Nakuru National Park, soils are of four main types: Type 'A' include those soils on the Lion Hill, Type 'B' those on the Western Escarpment, Type 'C' those on volcanic plains and Type 'D' those soils on the lacustrine plains (fig. 3).

Soils on the Lion Hill are developed on olivine basalts and ashes of major older volcanoes. They are well drained, very friable, deep, dark reddish brown to dark brown and smeary, clay loam to clay, with a thick acid humic topsoil, in places shallow to moderately deep and rocky.

Soils on the Western Escarpment are developed on undifferentiated Tertiary volcanic rocks (basalts, rhyolites and Andesites). They are a complex of well drained, shallow to moderately deep dark brown, firm stony clay loam to loam, in places with humic top soil.

The soils on the volcanic plains are developed from ashes and pumice beds from recent volcanoes. They are well drained moderately deep brown to dark brown, very friable loam to sandy clay loam.

Fig. 2b Main soil types of Lake Nakuru National Park. Type 'A' are soils on Lion Hill, 'B' those on western escarpment 'C' those that occur on volcanic plains and 'D' those found on lacustrine plains. Type 'D' is further divided into two subtypes: 'D1' are soils developed on sediments from volcanic ashes and other sources; 'D2' those soils developed on sediments mainly from volcanic ashes. (Adopted from the Exploratory Soil Map of Kenya 1980).

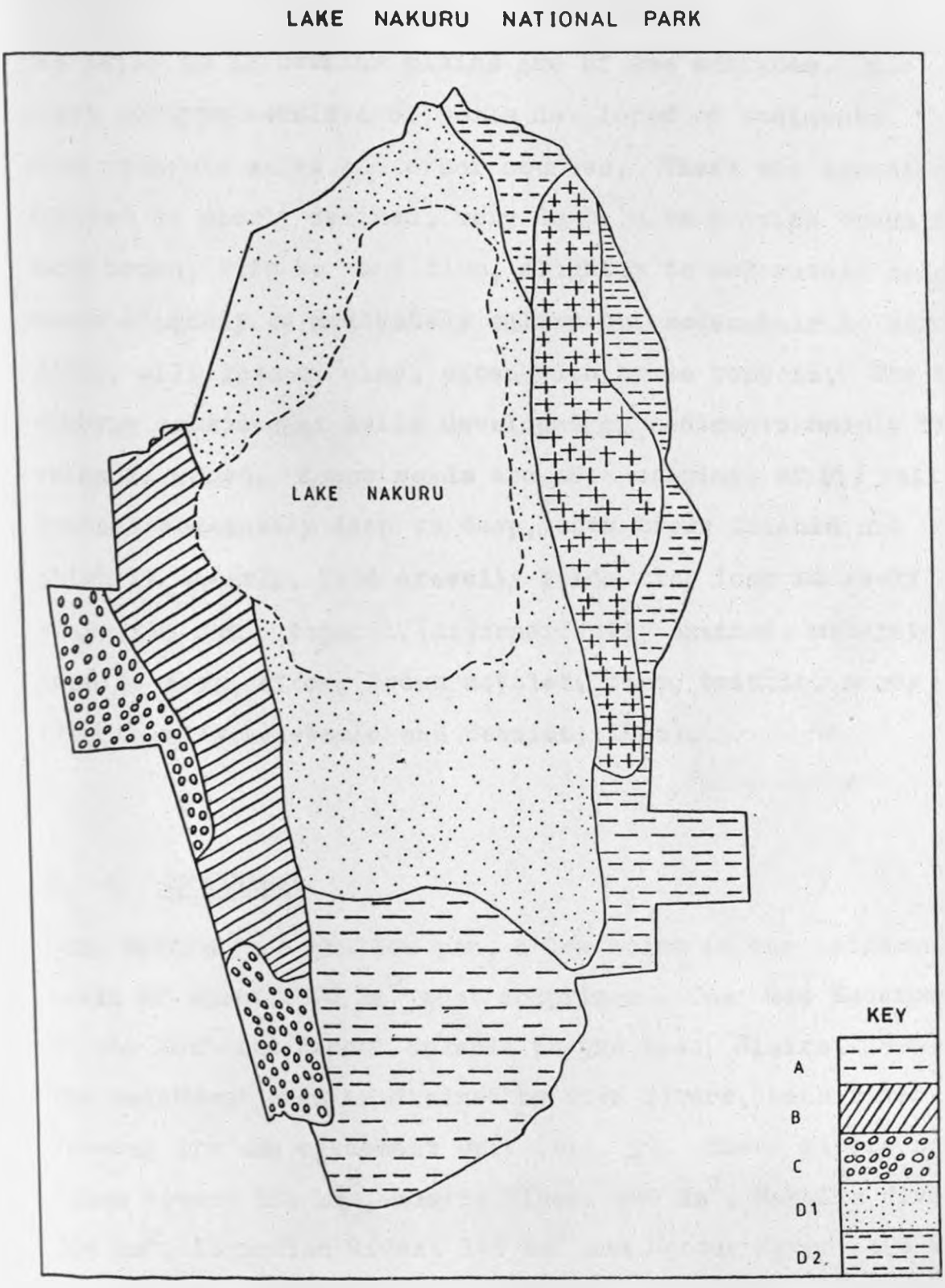


Fig. 2b. The main soil types of Lake Nakuru National Park.

The soils on lacustrine plains are of two subtypes. The first subtype consists of soils developed on sediments from volcanic ashes and other sources. These are imperfectly drained to poorly drained, very deep, dark greyish brown to dark brown, firm to very firm, slightly to moderately calcareous slightly to moderately saline but moderately to strongly sodic, silt loam to clay, often with humic topsoil. The second subtype consists of soils developed on sediments mainly from volcanic ashes. These soils are of a complex- of (i) well drained moderately deep to deep, dark brown friable and slightly smearly, fine gravelly sands clay loam to sandy clay with humic topsoil.(ii)imperfectly drained, moderately deep to deep, strong brown mottled, firm, brittle, sandy clay to clay (Jaetzold and Schmidt, 1983).

2. 4. DRAINAGE:

Lake Nakuru is a shallow pan, a low point in the catchment basin of about 1800 km^2 that comprises The Mau Escarpment on the West and Bahati Uplands in the East (Nimira, 1976). The catchment area is drained by five rivers, each river forming its own catchment unit (fig. 3). These rivers are: Njoro River: 681 km^2, Nderit River: 480 km^2, Makalia River: 335 km^2, Larmudiac River: 143 km^2 and Ngosur River: 196 km^2.

Fig. 3. Drainage system showing the river systems and catchment areas. Rivers Njoro and Larmudiac enter the Park from the west, whereas Makalia and Nderit enter from the south. River Ngosur from the north disappears just before it enters the Park but believed to reappear in the northern lakeshore in form of fresh-water streams. (Modified after Nimira, 1976).

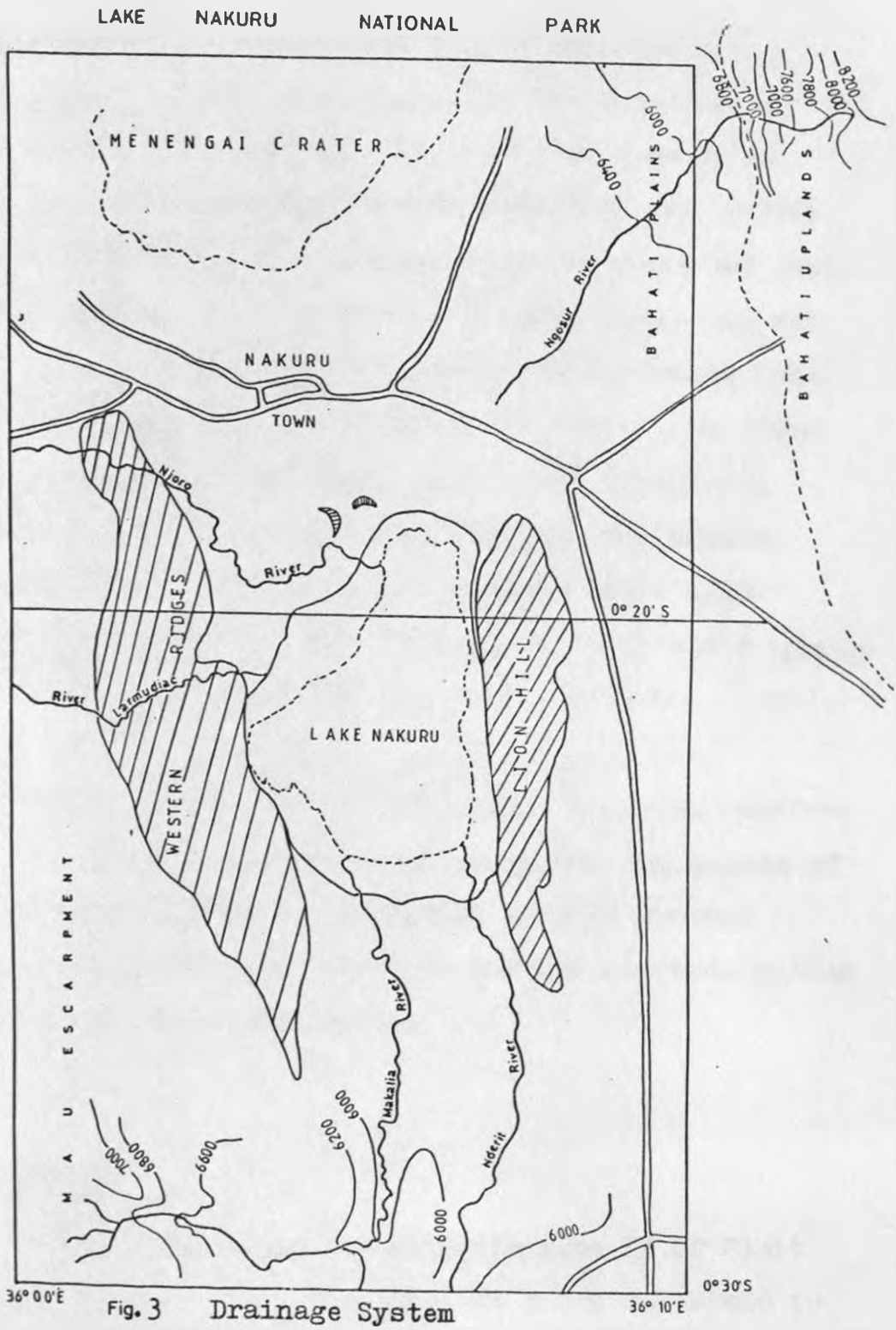


Fig. 3 Drainage System

Scale 1:250000

The Njoro, Larmudiac, Makalia and Nderit are seasonal rivers and their systems drain down the Mau Escarpment into Lake Nakuru. The surface flow of these rivers is greatly reduced as they pass through pumiceous and porous soils where they lose much of their water underground just along their courses. This underground water finds its way into the lake as it accrues to the water table below Lake Nakuru. The Ngosur River is a permanent stream and flows off Bahati Uplands to the Bahati plains but disappears underground before it reaches Lake Nakuru. The Ngosur water passes underground to feed the water table under Lake Nakuru where it reappears in form of fresh water springs on the north-eastern shore of Lake Nakuru (Vaucher, 1973).

The water input of Lake Nakuru is through rainfall, surface drainage and underground water accrueing from the losses of the surface stream flows. The output is only through evaporation, a factor that accounts for the constant rising and falling of Lake water levels.

2. 5. CLIMATE:

The study area falls under eco-climatic zone IV of Platt and Gwynne, 1977 which is described as a dry sub-humid to semi-arid. Rainfall records from meteorological station 9036261 in Nakuru has been represented in form of histograms

Fig. 4 Rainfall distribution in the Park. Two seasons are notable, wet season between April and August and a dry season from December to February (fig. 4 a) over a period of 18 years the annual average rainfall has been maintained as 800 mm. (an indication of a reliable rainfall) with an exception of one year (1984) with a minimum rainfall as 560 mm. due to a severe drought experienced throughout the country (Fig. 4 b). Source of data - Nakuru Meteorological Station Regn. No. 9036261.

LAKE NAKURU NATIONAL PARK

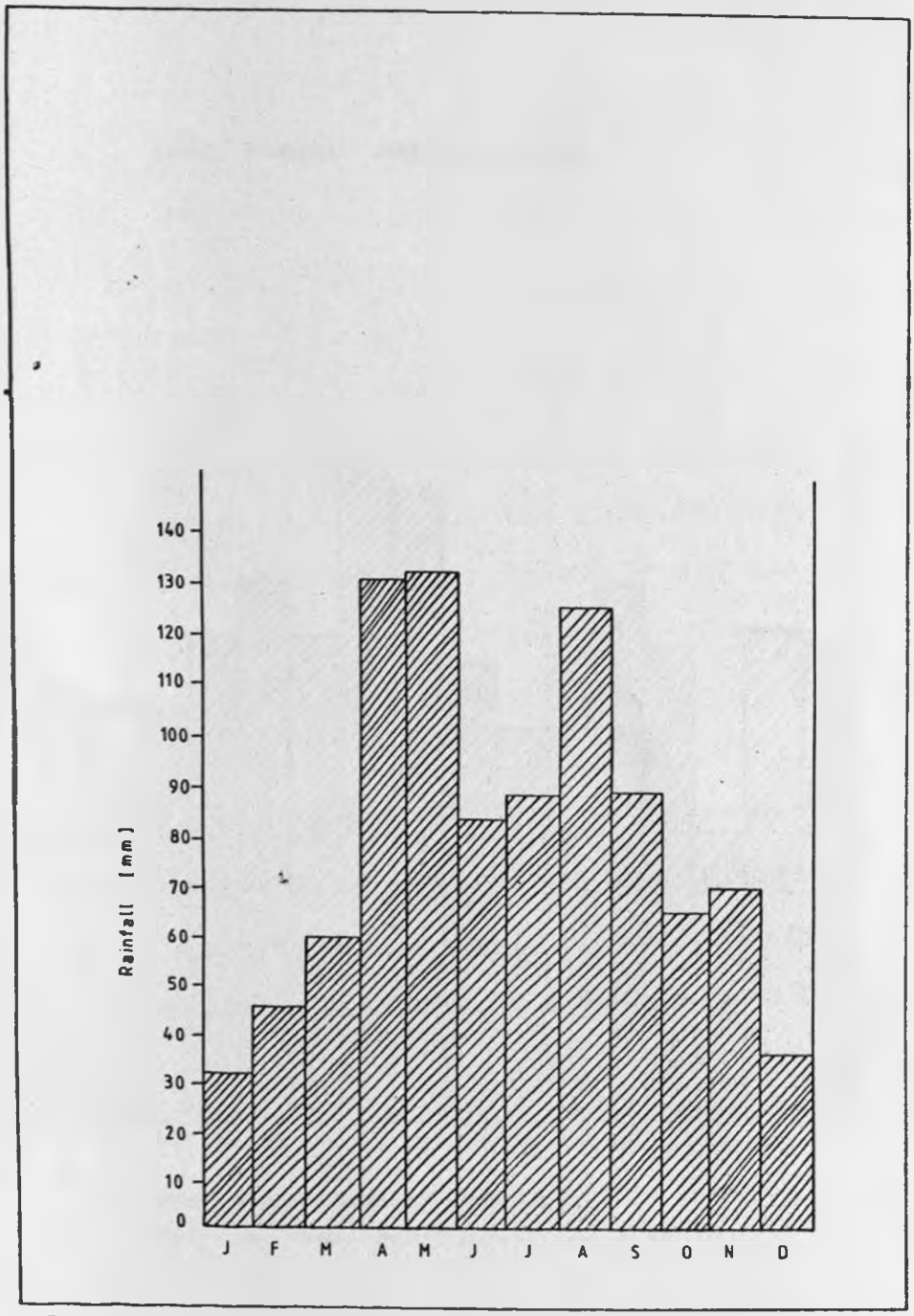


Fig. 4a. Monthly Rainfall Distribution (1969-1986)

[Data from Nakuru Meteor Station Reg No. 9036261]

LAKE NAKURU NATIONAL PARK

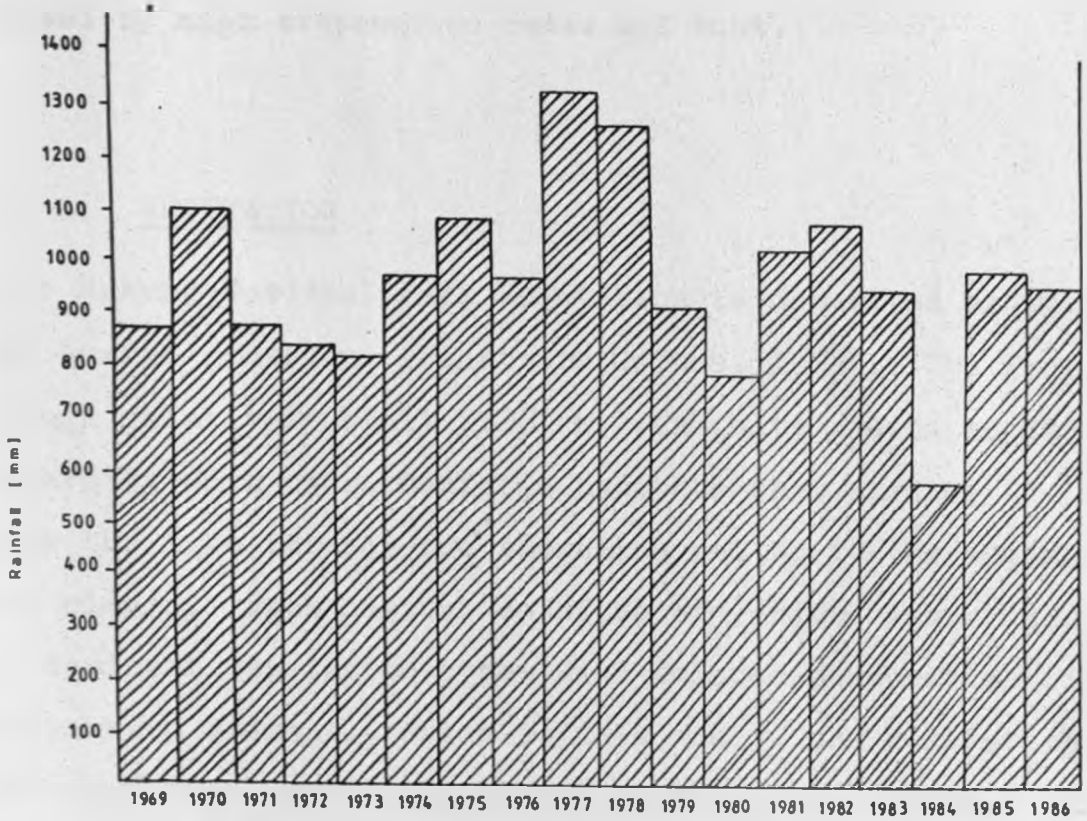


Fig 4 b.

Annual Rainfall Distribution [1969 - 1986]

[Data from Nakuru Meteor Station - Regn No 9036261]

they are reported to cause air pollution. The area experiences high evaporation rates between 1800 - 1900 mm. per year (Nimira, 1976). Vareschi (1982) measured the solar radiation in Lake Nakuru and found that midday peaks of global radiation were lower in dry season than in wet season, a phenomenon he suggested might be due to mist caused by high evaporation rates and dust.

2. 6. VEGETATION

Lake Nakuru National Park Vegetation is described as wooded and bushed grassland (Pratt and Gwynne, 1977). The Park, though relatively small (188 km^2) exhibits a wide ecological diversity with characteristic habitats that stretch from the lake through the shoreline and up to the escarpments and ridges. Each habitat consists of various associations of dominant vegetation types with related communities of vertebrate animals. Prior to this study, the vegetation of this Park was scantily described in relation to animal distribution. The only available information on the vegetation has been based on general physiognomy of dominant taxa.

By use of visual observations and personal judgement, the early workers, particularly those involved in the study of animal demography, behaviour and distribution patterns in the study

area made an attempt to classify the vegetation of Lake Nakuru National Park according to habitat types. They recognized six main habitat types, namely the lake and its littoral zone, the foreshore, the escarpment, the open grasslands, the bushes and the woodlands (Kutilek, 1974 and Kakuyo, 1980).

2. 7. FAUNA:

The animal distribution is closely related to distribution patterns of vegetation types in this Park. Large aquatic animals include the Hippopotamus (Hippopotamus amphibus) and the clawless otters (Aonyx capensis). In the lake is also found a single species of fish (Tilapia grahami) introduced into the lake from Lake Magadi in 1961 (Curry - Lindahl, 1971).

The shoreline (marshes, swamps and alkaline mud flats) vegetation and grasslands offer optimal habitats for herds of waterbuck (Kobus deffasa), Thompson's Gazelle (Gazella thompsoni), Bohor Reedbuck (Redunca redunca), Impala (Aepyceros melampus), Burchells zebras (Equus burchelli) and Warthogs (Phacocoerus aethiopicus).

In the woodlands and forests are found Black Rhinoceros (Diceros bicornis) herds of Buffalos (Syncerus caffer) that occasionally come out into the grasslands,

Leopards (Panthera pardus), Lions (Panthera leo), Baboons (Papio anubis), Bushbucks (Tragelaphus scriptus), Giraffes (Giraffa camelopardus rothschildii) and Black and White Colobus Monkey (Colobus polykomos).

The bushlands harbour a few herds of Elands (Taurotragus orynx), Bushbucks (Tragelaphus scriptus), Steinboks (Raphicerus campestris), Impala (Aepyceros melampus) Chandler's Reedbuck (Redunca fulvorufula chandleri and Dikdik (Rhynchotragus kirki).

The cliffs and escarpments provide a habitat for Rock Hyrax (Heterohyrax brucei), Klipspringer (Oreotragus oreotragus) and Chandler's Reedbuck (Redunca fulvorufula chandleri).

The greatest concentration of animals is in the grasslands and open woodland habitats as they provide favourable conditions for shade, cover and forage. The Park has been reported to have the highest concentrations of waterbuck in Kenya (Kutilek, 1974, Kakuyo, 1980).

Lake Nakuru is world famous for its spectacular birdlife that consists of both aquatic and terrestrial birds. The common Lake and Lakeshore birds include both the Greater and Lesser flamingos (Phoenicopterus ruber and Phoeniconaias minor), White and pink-backed pelicans (Pelecanus onocrotalus

and Pelecanus rufescens), Cormorants (Phalacrocorax africanus), Ducks (Oryura maccoa, Aythya erythrophthalma and Aythya fuligula), Ruffs (Philomachus pugnax), Little stints (Calidris minuta), Herons (Ardea cinerea), Egrets (Egretta gazetta), Ibis (Hagredashici hagadash) and Marabou storks (Leptoptilos crumeniferus).

The grasslands, Escarpments and Cliffs form habitats for different kinds of birds which include Secretary birds (Sagittarius serpentarius), Hornbills (Bucoruus leadbeateri), Guinea fowls (Numida mitrata), Verreaux's Eagle (Aquila verrauxi), Swifts (Apus apus, Apus affinis), Black-shouldered kites (Elanus caeruleus), African Rock Martin (Hirundo fuligula) and Cliff chat (Thamnolaea cinnamomeventris).

In the woodlands and bushlands the common birds include Augur Buzzards (Buteo augur), Hildebrandt's Francolin (Francolinus hildebrandti), Red-eyed doves (Streptopelia semitorquata), Laughing doves (Streptopelia senegalensis), Lilac-breasted Roller (Coracias caudata), Chestnut-bellied kingfisher (Haloyon leucocephala), Hoopoe (Upupa epops), Grey woodpecker (Mesopicos goertae), Blue-eared Glossy Starling and Ruppell's Glossy Starling (Lamprotornis chalybaeus and L. purpuropterus) Scimitar-bills (Phoeniculus cyanomelas), Larks (Mirafra africana, M. africanoides, M. and Calandrella cinerea), Pipits (Anthus similis, A. leucophrys and A. novaeseclandiae and Shrikes (Lanius minor, L. collaris, L. collurio and L. isabellinus).

CHAPTER THREE

MATERIALS & METHODS

3. 1. INTRODUCTION: A reconnaissance was carried out in October 1986 to provide baseline information on the vegetation status in the Park. During this survey, emphasis was laid on gathering information on floristic composition of various vegetation stands because very little of this knowledge was available from the previous scanty records. The method that was used to collect field data is that of Mass Plant Collection and Identification used by plant taxonomists (Curtis and McIntosh, 1951). Field identifications of all vascular plants encountered were carried out with the aid of various floral publications that included the Flora of Tropical East Africa (Clayton, 1970, 1974 and 1984), Upland Kenya Wild Flowers (Agnew, 1974) and Kenya Trees and Shrubs (Dale and Greenway, 1961). The plants that could not be identified in the field were collected, labelled and taken to the National Herbarium, Nairobi, where their scientific names were determined using herbarium specimens. In this way a preliminary plant checklist was compiled and became a necessary tool in all floristic studies that followed.

Methods of vegetation analysis are numerous and literature discussing their underlying principles, philosophies and statistical treatments has constantly been revised by several authors (Phillips, 1959, Shimwell, 1971, Mueller-Dombois and Ellenberg, 1974, Kershaw and Looney, 1985). In the present

study suitable methods were selected for collecting and processing field data particularly the methods that have been found most applicable in studies related to East African vegetation. However, some of these methods had to be tested in the field before they could be recommended for detailed analysis. This resulted to some slight modifications in some of the methods so as to fit the locality of their applications.

Three analytical approaches were adapted to cover the wide scope of the intended vegetation survey and each approach was governed by the applicability of specific methods found suitable for its operations. These approaches include:

(a). Vegetation mapping and classification.

(b). Quantitative analysis of woody species.

(c). Vegetation zonation along environmental gradient.

The first approach concerns the delineation and demarcation of vegetation boundaries and classification of various vegetation stands into distinct plant communities. The second approach deals with the determinations of species abundance, dominance and relative importance to explain the distribution patterns of various plant communities. The third approach was to evaluate the possible influence of environmental parameters on an apparent vegetation zonation around Lake Nakuru.

3. 2. VEGETATION MAPPING & CLASSIFICATION:

The purpose of vegetation mapping in this study was to determine, delineate and plot the main plant communities occurring in the study site. To accomplish this various vegetation stands had to be grouped and classified on the basis of their physiognomic structural characteristics and species composition. This operation was carried out in three ways:

1. Aerial photographic interpretations.
2. Ground floristic investigations.
3. Community sampling by Releve Method.

3. 2. 1. Aerial photographic Interpretations:

The aerial photograph presents a detailed picture in which interrelated patterns of soils and vegetation, rock types, landscapes and drainage, land-use and settlement can be noted separately or in combination (Langdale-Brown, Osmaston and Wilson, 1964). Aerial photographs and Landsat prints (.fig. 1a) and images taken from Lake Nakuru National Park were used extensively to locate vegetation boundaries and the main geographical features. Panchromatic colour as well as Black- and-white aerial photographs (Scale 1: 20,000) taken in 1979 were obtained from the Department of Wildlife Conservation and Management, Ministry of Tourism and and Wildlife. Landsat Satellite prints and images (Scale 1: 50,000) taken in 1986 were obtained from Regional Centre for

Surveying, Mapping and Remote Sensing, Nairobi. Vegetational characteristics were examined stereoscopically and apparent homogeneous vegetation units or stands were determined and delineated. Using traverse data on a transparent overlay of the same scale, details of vegetation boundaries and geographical features were transferred from a Landsat map into a baseline legend map. Final delineations on this map bounded the vegetation of the Park into the following physiognomic vegetation types: Forests, woodlands, bushlands, grasslands, Escarpment/Cliff formations and shoreline vegetation comprised of marshes, swamps, floodplains and mudflats.

3. 2. 2. Ground Floristic Investigations:

To counter-check the vegetation information derived from aerial photographic interpretations, ground floristic survey was carried out after the rainy season, between September and December, 1987, when vegetation development was optimal. This facilitated out not only identification of plant species but also produced a complete plant Check-list (Appendix I). The investigator visited each vegetational unit (already shown in the legend map) several times recording all vascular plants encountered by their botanical names and cover. This exercise was similar to that carried out during reconnaissance survey, but in this case it involved detailed collections and identifications of plant species throughout the study site in order to develop a complete and comprehensive plant list of all the plants occurring the Park as well as enumerating the dominant plant species in each vegetation unit.

3. 2. 3. Community sampling using Releve Method.

In order to group and classify the various vegetation types through mathematical treatment sampling plots (releves) were located on the legend, map and these were analysed using Releve method described by Mueller-Dombois and Ellenberg (1974). On reaching the sample point in the field, the location was briefly scanned to find a representative location for the actual releve. Releve sizes varied considerably depending on the nature of the vegetation type but usually they were 1 x 1 m. for grasses, 5 x 5 m. for herbs, 10 x 10 m. for low shrubs, 25 x 25 m. for high shrubs, 50 x 50 m. for higher shrubs and low trees and 100 x 100 m. for medium and high trees (Hall and Okali, 1979; Loth and Prins, 1986). A total of 78 releves were sampled throughout the Park between April and June 1987. In each sample plot the investigator walked through the vegetation stand as much as possible and all vascular plants encountered were recorded and vegetation cover was assessed on the basis of Braun-Blanquet scale of vegetation rating (Mueller-Dombois and Ellenberg, 1974). In addition to enumeration of species composition and cover, other features such as terrain characteristics and soil properties were also noted in each sampling plot.

3. 2. 4. Data Analysis

As mentioned earlier plants were identified as much as possible in the field with the aid of taxonomic publications. Only those plants that could not be identified in the field were taken to National Herbarium to have their botanical names determined with herbarium specimens. Field samples from Releve Method

were grouped into floristic vegetation types according to the Braun-Blanguet tabulation method in which species with similar distribution patterns are grouped into sociological species groups (Mueller-Dombois and Ellenberg, 1974; Loth and Prins, 1986). The classification of the vegetation types was partly computed using the computer ordination pattern of Twinspan Programmes (Hill, 1979).

3. 3. Quantitative Analysis of Woody species

This analysis was carried out to quantify the species abundance (density) and dominance (cover) of the woody species as the main interest was to determine floristic variations and interrelationships between plant communities in the forests, woodlands and bushlands. Point-Centred Quarter Method (P.C.Q.) described by Mueller-Dombois and Ellenberg (1974) was chosen for this analysis because it is simple to apply in the field and has been recommended by several authors for East African Vegetation (Taiti, 1973; Agnew, Payne and Waterman, 1983). Open Acacia xanthophloea woodlands were analysed using a modified P.C.Q. Method described by Leithead (1979) and recommended for East African woodlands by Lamprey (1981).

3. 3. 1. Community Sampling by Point-Centred Quarter Method

A legend map was used to locate the sampling sites. In the field, representative vegetational stands, characterized by homogeneity in species composition and physiognomic structure, were selected for stratified sampling. In each stand a line transect(s) was randomly established using a compass bearing whose orientation was determined by the nature of the

landform features. Twenty four of such transects were set up throughout the Park except on the eastern side of the Lake where vegetation cover was completely devastated by fire that broke out a few months before vegetation sampling commenced.

In each transect, sampling points were located each at an interval of 10 m. apart along the line. At each point all woody plant species nearest to it were identified and their measurements taken that included their distance from the sampling point, their girths (diameters) and heights. The distance was measured using a Tape Measure of 30 m. (100 ft.) long. The stem diameter was initially measured using a pair of Venier callipers but with field experience and practice, direct diameter measurements were taken using a Steel Tape 3 m. (10 ft.) long. Where diameter at breast height could not be measured (because the stem trunk forked below the breast height), the diameter at ground level was measured. If this was still not possible because the branching was underground (particularly for Tarchonanthus camphoratus stems), individual branches were measured separately and then measurements were summed up. The height estimates were taken using a Haga gauge.

3. 3. 2. Data Analysis

Vegetation measurements derived from P.C.Q. Method were used to calculate Relative density and dominance of woody species as follows:

$$\text{Relative density} = \frac{\text{Individuals of species A}}{\text{Individuals of all species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{total basal area of species A}}{\text{total basal area of all species}} \times 100$$

(Basal area of each species was calculated from its diameter measurements using the formula $3{\cdot}14\ r^2$)

Relative Importance Value (RIV) of each species is calculated as follows:

RIV = Relative density + Relative frequency + Relative dominance (Curtis and McIntosh, 1951)

But relative density is same as relative frequency from P.C.Q. records (Agnew, Payne and Waterman, 1983).

Therefore, RIV in this study was calculated as Relative density + Relative dominance.

Using Reciprocal Averaging Ordination Method (Hill, 1973), RIV values were computed using Twinspan Computer programme to show species spatial distribution patterns and interrelationships between plant communities.

Height measurements were used to construct profile diagrams to show both vertical and horizontal vegetation structure of every plant community sampled.

3. 4. Vegetation Analysis Along Environmental Gradient.

Investigations were made into the cause of apparent variation in vegetation cover and composition from the lake shoreline

through the cliffs into the escarpments (west) and hills (east) as well as from the Lake shoreline to the central plains (south). This could only be achieved by running profile transects from the Lake to the neighbouring terrestrial habitats, analysing both vegetational attributes and environmental factors encountered along the transects. It is because of its continuity through an area that a transect can be used to relate changes in vegetation along a line or strip with changes in the environment. Four such profile transects were established throughout the Park using a compass bearing whose orientation was subjectively chosen so as to pass through representative regions with diverse ecological characteristics.

3. 4. 1. Field sampling

Vegetation records were made along each transect. Floristically distinct plant communities were determined and mapped with the aid of aerial photographs and Landsat prints. All plant species encountered along the transect were identified and listed. Physiognomic structural features along each transect were also noted for each plant community. In addition, soil samples were collected at various points along the profile transect, in most cases at an interval distance of 100 m. apart. At each point, soil samples were taken using a Dutch Soil Auger at depths of 0-20 cm. (upper layer) and 20 - 40 cm. (lower layer) unless the underlying rock prevented further excavation. In shallow soils, particularly those at cliffs and rocky outcrop areas, only one set of samples was collected and often these

were from less than 10 cm. deep. The soil layers (lower or upper) in this case, do not necessarily refer to pedological horizons. In most of the sampling points soil samples were collected from four different positions and these subsamples were thoroughly mixed to form a single composite sample weighing about 2 kg. of fresh soil. The soil samples were taken to the laboratory for analysis at Egerton University.

3. 4. 2. Soil Analysis

Before analysis, the soil samples were air dried in the laboratory and during this process stones, debris and large roots were removed from the samples which were then grounded using a pestle and mortar and sieved through a 2 mm. mesh. The sieved samples were stored in self-sealed polythene bags that were labelled bearing the date the sample was collected and the number of the sample. The samples were later analysed for both physical and chemical soil properties. The three properties that were examined from the soil samples include (1) Texture (2) P^H and (3) Salinity.

Soil Texture: This property was determined using Buoyuocus Hydrometer Method as described by Milford (1976). This method was chosen because it is one of the simplest and most rapid methods for mechanical analysis of soil. The process involved weighing 50 g of the soil sample and placing it in a bottle which was filled up to ⅔ full of water. 5 ml. of Sodium hexametaphosphate (Calgon) solution was also added into the

bottle. Six such bottles were prepared using different soil samples. The bottles were corked and fitted into a Mechanical Shaker machine and the contents in the bottles were shaken for 12 hrs. after which they were transferred into the settling Buoyuocos Cylinders. In each cylinder distilled water was added to make one litre (1000 ml) suspension which was thoroughly stirred. After settling times the density of the suspension was measured with a calibrated Hydrometer. The first set of readings were taken after 4 min., settling time at which the buoyant force on the hydrometer is known to be due to a concentration of clay and silt in the suspension, the sand having already settled down at the bottom of the cylinder. The second set of readings was taken after 2 hrs, the settling time when the buoyancy on the hydrometer is determined by the concentration of clay particles in the suspension, silt particles having already precipitated out of the suspension. Temperature of the suspension was also taken in each set of hydrometer readings.

Soil pH and Salinity: A soil-water suspension was made of every soil sample at a ratio of 1:2.5 (Soil:water) in distilled water. pH (2.5) measurements were taken using a portable Jenway pH Meter. The suspension was further diluted to 1:5 (Soil : Water) ratio and electrical conductivity (Ec5) was measured for every sample using a portable Jenway Conductivity Meter.

3. 4. 3. Data Analysis

Hydrometer measurements were used to calculate the percentages of sand, silt and clay particles in each soil sample. Using

Textural Triangle Diagram (Fig. 5), soil textural class (soil type) of every soil sample was determined (Appendix II). The soil samples were determined for the presence or absence of salinity from electrical conductivity measurements according to the following salinity classes (ILACO, 1981):

Class	Effect	Electrical Conductivity (mm. hos. cm.)
0	Free	0 - 4
1	Slightly affected	4 - 8
2	Moderately affected	8 - 15
3	Strongly affected	> - 15

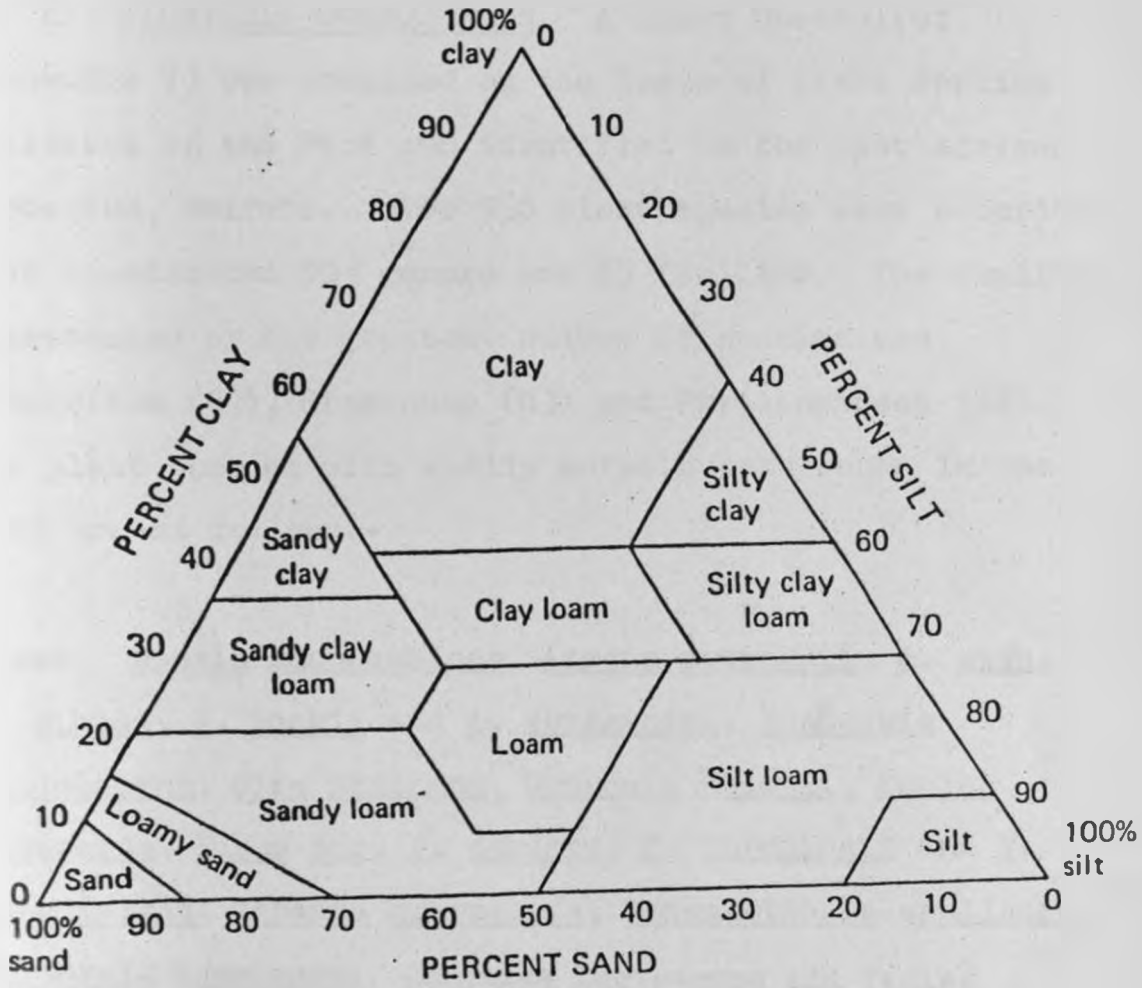


Fig. 5. Textural Triangle Diagram showing the relationship between the class name of a soil type and its particle size distribution. The diagram was used in the naming of the soils of Lake Nakuru National Park based on a mechanical analysis conducted using Hydrometer Method (see Table 12 at the appendix II).

CHAPTER FOUR

R E S U L T S

4 : 1. FLORISTIC COMPOSITION. A plant Check-list (Appendix I) was compiled on the basis of plant species collected in the Park and identified in the East African Herbarium, Nairobi. Over 550 plant species were recorded that constituted 305 genera and 85 families. The families represented by the greatest number of species are Compositae (68), Gramineae (63) and Papilionaceae (41). The plant species with easily notable occurrence in the Park are as follows:-

Trees: Acacia xanthophloea, Acacia gerrardii, A. seyal, A. albida, A. hockii and A. abyssinica; Euphorbia candelabrum, Olea africana, Cussonia holstii, Euclea divinorum, Ficus sur, F. cordata, F. thonningii and F. wakefieldii; Tarenna graveolens, Steganotaenia araliacea, Warburgia ugandensis, Canthium lactescens and Teclea simplicifolia.

High Shrubs: Tarchonanthus camphoratus, Rhus natalensis, Maerua triphylla, Cordia ovalis, Maytenus heterophylla, Grewia similis, G. bicolor, Psydrax schimperiana, Dombeya burgessiae, Heteromorpha trifoliata, Iboza multiflora, Obetia pinnatifida, Calpurnia aurea Vernonia auriculifera, Buddleja polystachya, Cassia didymobotrya and Croton dichogamus.

Low Shrubs: Pluchea bequaertii, Psiadia punctulata, Solanum incanum, Lippia ukambensis, L. javanica, Lantana trifolia, Ocimum suave, Erythrococca bongensis, Tinnea aethiopica, Aspilia mossambicensis, Hibiscus calyphyllus, H. fuscus, H. aboneurus, H. micranthus, H. flavifolius, H. vitifolius, Abutilon holstii, A. engleranum, A. longicuspe and A. rehmannii, Pavonia patens, Clerodendron myricoides, Cassia bicapsularis, Sesbania sesban, Dodonaea angustifolia, Plectranthus barbatus, Helinus integrifolia, Gnidia subcordata, Withania somnifera, Aloe graminicola, A. secundiflora and A. kedongensis.

Lianes/Twiners/Climbers: Senecio petitianus, S. lyratipartitus, Crassocephalum vitellinum, Capparis tomentosa, C. fascicularis, Cynanchum tetraptera, Periploca linearifolia, Pergularia daemia, Dregea schimperi, Commicarpus plumbagineus, Sarcostemma viminale, Ipomoea cairica, Cyphostemma nodiglandulosum, C. nierense, Toddalia asiatica, Pterolobium stellatum, Stephania abyssinica, Phytolacca dodecandra, Hypocratea africana and Peponium vogelii.

Herbs: Hypoestes verticillaris, Achyranthes aspera, Tagetes minuta, Gutenbergia cordifolia, Senecio discifolius, Kalanchoe densiflora, Aerva lanata, Melhania ovata, M. velutina, Crotalaria agatiflora, C. incana, C. desertícola, C. vallicola, Indigofera bondanii, I. brevicalyx, Tephrosia emeroides, Vigna membracea, Rhynchosia minima, R. elegans,

Urtica massaica, Pentanisia ouranogyne, Pentas zanzibarica, Oldenlandia corymbosa, O. scopulorum, Cirsium vulgare, Conyza striata, Crassocephalum **picridifolium**, Kalanchoe densiflora, Crepidiodes, Heliotropium undulatifolium, Craterostigma plantagineum, C. hirsutu , Cycnium tubulosum, Justicia flava, J. heterocarpa, J. exigua, Monechma debile, Priva curtisiae, Verbena bonariensis, Fuersetia africana, Leonotis nepetaefolia, Leucas glabrata, L. martinicensis, Ocimum basilicum, Becium obovatum, Plectranthus cylindraceus, P. assurgens, Satureja biflora, Commelina benghalensis, C. reptans, C. africana, Asparagus africanus, A. buchananii, A. aethiopicus, A. falcatus, Sansevieria parva, S. robusta and Farsetia stenoptera, Polygala sphenoptera and Felicia muricata.

Epiphytes/Parasites: Actinopteris semiflabellata **(Adiantaceae),** Polystachya striata (Orchidaceae), Viscum **tuberculatum,** Odontella fischeri and Phragmanthera rufescens (Loranthaceae - Parasites).

Sedges: Bulbostylis hoechstetteriana, Cyperus immensus, C. laevigatus, C. obtusiflorus, C. rigidifolius, C. teneriffae, C. usitatus, Fimbristylis humilis, Mariscus mauronus, M. macrorus, M. impubes, M. aristatus and M. mollipes.

Grasses: Andropogon chinensis, Aristida adoensis, A. kenyensis, Brachiaria brizantha, Cenchrus ciliaris, Chloris gayana, C. pycnothrix, Cymbopogon caesius, C. nospischilii, Cynodon dactylon, C. nlemfuensis, Digitaria abyssinica, D. velutina, Eleusine indica, Eragrostis brawnii, E. superba, E. cilianensis, E. tenuifolia, Harpachne schimperi, Hyparrhenia anamesa, H. hirta, Loudetia kagerensis, Microchloa kunthii, Panicum maximum, Pennisetum hohenackeri, P. mezianum, P. procerum, P. schacelatum, P. squamulatum, Rhynchelytrum repens, Setaria pumila, S. schacelata, S. verticillata, Sporobolus africanus, S. consimilis, S. confinis, S. fimbriatus, S. pyramidalis, S. spicatus, Themeda triandra and Trichonema teneriffae.

The most conspicuous species include Acacia xanthophloea, A. gerrardii and Cussonia holstii (Trees); Tarchonanthus camphoratus, Maytenus heterophylla, Rhus natalensis, Cordia ovalis, Grewia similis and Maerua triphylla (High shrubs); Psiadia punctulata, Ocimum suave, Solanum incanum, Erythrococca bongensis, Aspilia mossambicensis and Lippia ukambensis (Low shrubs); Senecio petitianus, Cynanchum tetraptera, Sarcostemma viminale and Capparis tomentosa (Lianes); Cyperus laevigatus, C. teneriffae, C. obtusiflorus and Mariscus impubes (Sedges); Aristida adoensis, A. kenyensis Chloris gayana, C. pycnothrix, Cymbopogon nospischilii, Cynodon nlemfluensis, C. dactylon, Digitaria abyssinica,

Harpachne schimperi, Hyparrhenia anamesa, Panicum maximum, Pennisetum mezianum, P. squamulatum, Rhynchelytrum repens, Setaria pumilla, S. verticillatum, Sporobolus spicatus, S. africanus, S. pyramidalis, S. confinis and Themeda triandra (Grasses), Hypoestes verticillaris, Tagetes minuta, Achyranthes aspera, Gutenbergia cordifolia, Commelina reptans, Crotalaria incana, Indigofera bogdanii, Pentanisia ouranogyne, Monechma debile, Justicia exigua, Aerva lanata, and Leucas martinicensis (Herbs).

Plant species with uniform composition and structure and occupying an area of essentially uniform environmental parameters aggregate together to form a vegetation type (Hansen & Churchill, 1961). Based broadly on physiognomic structural characteristics derived mainly from aerial photographic and Landsat images and prints interpretations as well as field floristic investigations, the vegetation of the Park was differentiated into ten vegetation types (fig 6), namely:

I Grasslands (G)
II Bushlands (B)
III Woodlands (W)
IV Forests (F)
V Sedge Marshes (SM)
VI Swamp Vegetation (SV)
VII Cliff/Escarpment Vegetation (CEV)

LAKE NAKURU NATIONAL PARK

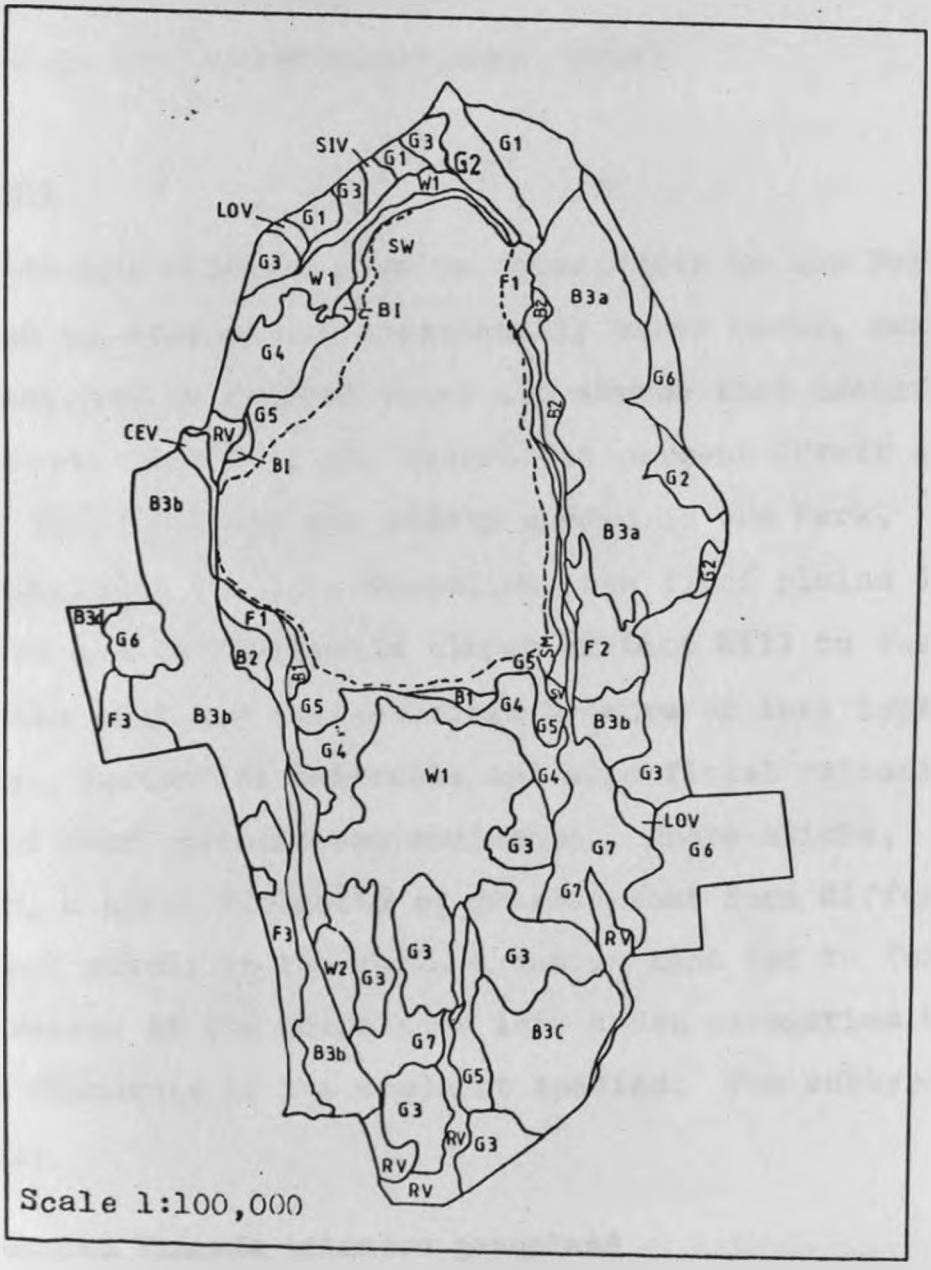


Fig. 6 Physiognomic Vegetation Types

VIII Lava Outcrops Vegetation (LOV)

IX Riverine Vegetation (RV)

X Sewage Influenced Vegetation (SIV)

Grasslands

Grasslands are referred here as those areas in the Park dominated by grasses and occasionally other herbs, sometimes with scattered or grouped trees and shrubs that contribute canopy cover that does not exceed two percent (Pratt and Gwynne, 1977). These are widely spread in the Park, particularly on the lake shoreline, the flood plains in the south and on the gentle slopes of Lion Hill to the east, with soils that are characterized by more or less impeded drainage, lacustrine sediments and superficial volcanic deposits over diatomaceous sediments. There exists, however, a great diversity of grasses that form different grassland stands in the Park, a factor that led to further subdivisions of the grasslands into seven categories based on the abundance of the dominant species. The subtypes include:

G1 : Bushed Themeda triandra grassland
G2 : Digitaria abyssinica "
G3 : Cynodon nlemfluensis "
G4 : Chloris gayana "
G5 : Sporobolus spicatus "
G6 : Cynodon-Chloris-Themeda "
G7 : Cynodon nlem fuensis-Acacia xanthophloea wooded grassland.

Gl : Bushed Themeda triandra grassland : It dominates the northern part of the Park and is characterized by tall grasses of Themeda triandra, Chloris gayana and Hyparrhenia hirta and low bushes of Lippia ukambensis, L. javonica and Lantana trifolia (Plate 2). However, there is a narrow strip of this grassland to the northern border dominated by trees of Acacia xanthophloea, A. seyal, A. hockii and A. gerrardii (Plate 3).

Grasses: Themeda triandra+, Chloris gayana+, C. pycnothrix, Digitaria abyssinica, Eragrostis ciliaris, E. superba, Sporobolus pyramidalis, S. africanus, S. confinis, Aristida adoensis, A. kenyensis, Harpachne schimperi, Rhynchelytrum repens, Cynodon nlem fuensis+, Hyparrhenia hirta, H. anamesa, Setaria pumilla, Microchloa kunthii and Pennisetum mezianum.

Trees: Acacia xanthophloea+, A. seyal, A. hockii, A. albida, Acacia gerrardii and Nuxia congesta.

High Shrubs: Acacia seyal, Tarchonanthus camphoratus and Dovyalis caffra.

Low Shrubs: Lippia ukambensis, L. javonica+, Lantana trifolia+, L. camara, Withania somnifera, Solanum incanum, Ocimum suave, Tinnea aethiopica, Steganotaenia araliacea, Heteromorpha trifoliata, Hibiscus aponeurus, H. micranthus, H. fuscus, H. cannabinus, Rhus natalensis, Clerodendron myricoides, Maytenus heterophylla, Pavonia patens, Nicotiana glauca and Erythrococca bongensis.

Plate 2. Bushed Themeda triandra grassland on the northern Central plains, with Lippia ukambensis, L. javanica and Lantana trifoliata forming the shrub composition.

Plate 3. Wooded Themeda triandra grassland. A strip of wooded grassland next to the northern boundary. The prominent tree species include Acacia xanthophoea, A. seyal, A. hockii and A. gerrardii.

Herbs: Indigofera brevicalyx, I. bogdanii, Crotalaria deserticola, C. vallicola, C. incana, C. agatiflora, Tagetes minuta, Satureja biflora, Cassia mimosoides, Astragalus atropilosulus, Gutenbergia cordifolia, Leonotis nepetifolia, Lactuca capensis, Conyza stricta, Leucas martinicensis, Senecio discifolius, Hypoestes verticillaris Monechma debile, Justicia exigua, Melhania ovata, Sida tenuicarpa, Crinum papillosum, Pentanisia ouranogyne, Pentas zanzibarica, Cycnium tubulosum, Priva curtisiae, Commelina reptans, C. africana, C. benghalensis, Aloe graminicola, A. secundiflora, Heliotropium undulatifolium, Erucastrum arabicum, Euphorbia inaequilatera, Cucumis aculeatus, Datura stramonium, Oldenlandia scopulorum, Polygala sphenoptera, Aerva lanata, Craterostigma hirsutum, Helichrysum glumaceum, H. odoratissimum, Pycnostachys deflexifolia, Plectranthus assurgens, Kohautia coccinea, Sckuhria pinnata, Blumea sp. aff. B. alata, Dychoriste perrottetii, Achyranthes aspera, Polygonum senegalensis, Rhynchosia minima and Fuerstia africana.

Sedge : Cyperus obtusiflorus

NB. The sign + denotes either dominant, frequent, abundant or common species.

G2: Digitaria abyssinica grassland : Occurs on the flat furrowed plains to the north and also on plains on the eastern slopes of Lion Hill, the region next to the Shooting

Range. The grassland is made up of short grasses of Digitaria abyssinica and Cynodon nlemfluensis and occasionally Themeda triandra (Plate 4). This grassland is extensively grazed by wildlife and has sparsely distributed trees of Acacia xanthophloea (more common on the northern plains) and A. gerrardii (more common on the eastern plains). Both high and low shrubs are missing or if present form no recognizable cover. Species composition consist of:

Grasses : Digitaria abyssinica[+], Cynodon nlemfluensis[+] Themeda triandra, Chloris gayana, Hyparrhenia anamesa, H. hirta, Sporobolus pyramidalis, S. africanus, S. frimbriatus, Aristida adoensis, A. kenyensis, Eragrostis tenuifolia, E. braunii, Microchloa kunthii, Setaria pumilla, Pennisetum procerum, Harpachne schimperi and Eleusine multiflora.

Low Shrubs : Lippia ukambensis, Solanum incanum, Hibiscus micranthus and Ocimum suave.

Herbs : Fuerstia africana, Oldenlandia scopulorum, Chlorophytum comosum, Justicia exigua, Crotalaria incana, C. vallicola, Tagetes minuta, Gutenbergia cordifolia, G. rueppellii, Achyranthes aspera, Indigofera brevicalyx, I. bogdanii, Commelina benghalensis, C. reptans, Euphorbia inaequilatera, Monechma debile, Erucastrum arabicum, Rhynchosia minima, Leucas martinicensis, Priva curtisiae, Cucumis aculeatus, Melhania ovata, Hirpicium diffusum,

Senecio discifolius, Pentanisia ouranogyne, Pentas zanzibarica, Sida cuneifolia and Craterostigma hirsutum.

G3: Cynodon nlemfluensis grassland : This forms the main grassland in the Park being widely spread in the southern and eastern regions. The grassland is mainly composed of Cynodon nlem fuensis, a short grass forming a massive cover on the ground, and a few scattered trees (Acacia xanthophloea) and shrubs (Maerua triphylla, Maytenus heterophylla and Cordia ovalis) which together with low shrubs have no significant cover (Plate 5). Species composition comprises:

Grasses: Cynodon nlem fuensis+, Themeda triandra, Aristida adoensis, A. kenyensis, Chloris gayana, C. C. pycnothrix, Hyparrhenia anamesa, Sporobolus africanus, S. confinis, S. pyramidalis, Digitaria abyssinica+, Harpachne schimperi, Setaria pumila, S. verticillata, Cenchrus ciliaris, Eragrostis cilianensis, E. tenuifolia, Pennisetum mezianum and Loudetia kagerensis.

Tree : Acacia xanthophloea.

High Shrubs: Maerua triphylla+, Maytenus heterophylla, Cordia ovalis, and Tarchonanthus camphoratus.

Low Shrubs: Lippia ukambensis, L. javonica, Lantana trifolia, Hibiscus micranthus, H. flavifolius, H. fuscus, H. aponeurus, Maytenus heterophylla, Solanum incanum, Dodonaea angustifolia, Capparis tomentosa, Cordia ovalis, Zizyphus mucronata, Maerua triphylla, Abutilon longicuspe, A. rehmannii, Ipomoea kituiensis, Erythrococca bongensis, Grewia similis, Psiadia punctulata, Tarchonanthus camphoratus, Phytolacca dodecandra, Clerodendron myricoides, Ocimum suave, Pavonia patens and Withania somnifera.

Herbs: Indigofera bogdanii, Tagetes minuta, Melhania ovata, Pentanisia ouranogyne, Crotalaria incana, C. vallicola, C. deserticola, Senecio discifolius, Priva curtisiae, Monechma debile, Justicia exigua, Gutenbergia cordifolia, Verbena bonariensis, Becium obovatum, Leucas martinicensis, Oldenlandia scopulosum, Leonotis nepetifolia, Oxygonum sinuatum, Cyphostemma orondo, Commelina reptans, C. africana, C. benghalensis, Euphorbia inaequilatera, Rhynchosia minima, Aerva lanata, Hypoestes verticillaris, Felicia muricata, Ocimum basilicum, Achyranthes aspera, Heliotropium undulatifolium, Commicarpus plumbagineus, Erucastrum arabicum, Datura stramonium, Dychoriste perrottettii, Gynandropsis gynandra, Portulaca oleracea, Amaranthus hybridus, Zaleya pentandra and Tribulus terrestris.

Plate 4. Digitaria abyssinica grasslands on the flat furrowed plains to the northern side of Lake Nakuru.

Plate 5. Cynodon nlemfuensis open grasslands.

Plate 6. Chloris gayana grasslands at the peripheral areas of the shoreline. The characteristic feature is the establishment of young Acacia xanthophloea trees at the expense of the grassland.

G4: Chloris gayana grassland : Forms peripheral grassland on the western and southern shores of the lake between the alkaline grasslands and the Acacia xanthophloea woodland. Chloris gayana, a tall grass, is the dominant grass in this zone in which although interrupted in some places by trees (Acacia xanthophloea) and bushes (Tarchonanthus camphoratus, Acacia xanthophloea, Rhus natalensis and Dodonaea angustifolia) particularly in the west, where it forms more than 95% ground cover (Plate 6). Species composition consists of:

Grasses: Chloris gayana+, C. virgata, Sporobolus spicatus, S. pyramidalis, S. africanus, Hyparrhenia anamesa, H. hirta, Cynodon dactylon, C. nlem fuensis, Themeda triandra, Digitaria abyssinica+, Microchloa kunthii, Aristida adoensis, A. kenyensis, Harpachne schimperi, Eleusine indica, Setaria pumilla, S. verticillata, Dactyloctenium aegypticum and Rhynchelytrum repens.

Trees: Acacia xanthophloea+ and Schinus molle.

High Shrubs: Rhus natalensis+, Tarchonanthus camphoratus+, Acacia xanthophloea and Dodonaea angustifolia.

Low Shrubs: Withania somnifera, Pluchea bequaertii, Solanum incanum, Rhus natalensis, Senecio petitianus, Capparis tomentosa, Psiadia punctulata, Ocimum suave, Lippia ukambensis, Hibiscus aponeurus, H. flavifolius,

Hibiscus micranthus and H. fuscus, Maerua triphylla, Tinnea aethiopica, Aloe graminicola, Dodonaea angustifolia, Grewia similis, Lycium europaeum, Acacia xanthophloea, Maytenus heterophylla, Abutilon longicuspe and Erythrococca bongensis.

Herbs: Oldenlandia scopulosum, Cycnium tubulosum, Aerva lanata, Tagetes minuta, Achyranthes aspera, Conyza tigrensis, Kalanchoe lanceolata, Hypoestes verticillaris, Gutenbergia cordifolia, Leonotis nepetifolia, Leucas martinicensis, Crotalaria vallicola, C. incana, C. deserticola, Sckuhria pinnata, Commelina benghalensis, Indigofera bogdanii, I. brevicalyx, Rhynchosia minima, Senecio discifolius, S. mesogranmoides, Artemisia afra, Justicia exigua, J. heterocarpa, Euphorbia inaequilatera, Trifolium rueppellianum, Conyza bonariensis, Sida tenuicarpa, Satureja biflora, Verbena bonariensis.

Epiphytes/Parasites: Odentella fischeri and Phragmanthera rufescens.

Sedge : Cyperus obtusiflorus.

G5: Sporobolus spicatus - Cynodon dactylon alkaline grasslands:

These are seasonally flooded areas of high alkalinity predominantly along the north, west and southern shores where the soil is composed of trona-impregnated silt. The predominant

vegetation is Sporobolus spicatus and Cynodon dactylon, a soda-resistant short grasses. The grasses are interspersed by sand bars and the muddy shoreline and patches of sedges (Cyperus laevigatus) (Plates 7 & 8). The species composition include:

Grasses: Sporobolus spicatus^{+}, S. pyramidalis, Cynodon dactylon^{+} and Chloris gayana.

Low Shrubs (mainly found on Cynodon dactylon stands): Acacia xanthophloea, Pluchea bequaertii, Erythrococca bongensis, Withania somnifera, Maytenus heterophylla, Solanum incanum and Sesbania sesban.

Herbs: Tagetes minuta, Achyranthes aspera, Gutenbergia cordifolia, Solanum nigrum, Senecio discifolius, S. mesograumoides, Bidens pilosa, Leucas martinicensis, Cycnium tubulosum, Oldenlandia scopulosum, Conyza stricta, C. tigrensis and Gomphocarpus fruticosus.

Sedge : Cyperus laevigatus^{+}.

G6: Cynodon - Chloris - Digitaria - Themeda grasslands:

These are basically Cynodon nlem fuensis grasslands but associated with other grasses (Chloris gayana, Digitaria

abyssinica and Themeda triandra) with varying degree of dominance. Thus, the dominance of each of these grasses changes from place to place and in some places they could all occur together, with Cynodon nlem fuensis still being the predominant grass. Those grasslands to the west are characterized by the presence of scattered trees such as Acacia xanthophloea, A. seyal, A. gerrardii, Cussonia holstii, Euphorbia candelabrum and Ficus wakefieldii; those to the south are characterized by High Shrubs that include Maerua triphylla, Cordia ovalis, Maytenus heterophylla and Tarchonanthus camphoratus; whereas those grasslands in the east contain no trees nor high shrubs or either low shrubs of any significant ground cover. The species composition is as follows:

Grasses: Cynodon nlem fuensis+, Themeda triandra+, Aristida kenyensis, A. adoensis, Chloris gayana+, C. pycnothrix, Harpachne schimperi, Sporobolus confinis, S. frimbriatus, Setaria verticillata, S. pumilla, Cymbopogon pospischilii, C. caesius, Eragrostis superba, E. cilianensis, Hyparrhenia anamesa, Digitaria abyssinica+ and Trichonema teneriffae.

Trees: Acacia xanthophloea, A. seyal, A. gerrardii, Euphorbia candelabrum, Cussonia holstii, Ficus wakefieldii and Olea africana.

High Shrubs: Maerua triphylla, Maytenus heterophylla, Cordia ovalis, Rhus natalensis, Dombeya burgessae, Croton dichogamus, Senecio petitianus, Opuntia sp., Tarchonanthus camphoratus and Acacia xanthophloea.

Low Shrubs: Solanum incanum, Ocimum suave, Aspilia mossambicensis, Lippia ukambensis, Psiadia punctulata, Heteromorpha trifoliata, Vernonia lasiopus, Hibiscus vitifolius, H. micranthus, H. flavifolius, H. fuscus, Dodonaea angustifolia, Maytenus heterophylla, Cordia ovalis, Rhamnus staddo, Capparis tomentosa, Erythrococca bongensis, Abutilon holstii, Ipomoea kituiensis, Pavonia patens, Tarchonanthus camphoratus and Withania somnifera.

Herbs: Senecio discifolius, Crotalaria vallicola, C. deserticola, C. incana, Monechma debile, Leucas martinicensis, Satureja biflora, Aerva lanata, Asystasia schimperi, Blumea crispata, Indigofera bogdanii, Ocimum basilicum, Pentanisia ouranogyne, Commelina benghalensis, C. reptans, C. africana, Felicia muricata, Achyranthes aspera, Rhynchosia minima, R. elegans, Melhania ovata, Hypoestes verticillaris, Justicia exigua, J. heterocarpa, Commicarpus plumbagineus, Tagetes minuta, Gutenbergia cordifolia, Conyza stricta, C. tigrensis, Priva curtisiae, Heliotropium undulatifolium, Gynandropsis gynandra, Medicago laciniata, Becium obovatum, Erucastrum arabicum, Dychoriste perrottettii, Oldenlandia scopulosum, O. corymbosa, Urtica massaica and Leonotis nepetifolia.

Plate 7. Alkaline grasslands (Sporobolus spicatus) on the lake foreshore to the northern regions.

Plate 8. Alkaline grasslands (Cynodon dactylon) along the lake foreshore.

G7: Cynodon **nlemfuensis** - Acacia xanthophloea wooded grasslands : These are mainly found in the south particularly along the Nderit and Makalia plains. The grasslands are characterized by a conspicuous stand of trees (Acacia xanthophloea) and scattered High Shrubs (Maerua triphylla, Maytenus heterophylla, Rhus natalensis and Cassia didymobotrya), with Cynodon nlemfluensis, a short grass, forming more than 90% of the ground cover (Plate 9). The species composition consists of the following:

Grasses: Cynodon nlem fuensis+, Themeda triandra, Setaria verticillata, S. pumilla, Aristida adoensis, A. kenyensis, Chloris gayana, Digitaria abyssinica+, Pennisetum mezianum, Harpachne schimperi, Eragrostis cilianensis, Hyparrhenia anamesa, Sporobolus pyramidalis, S. confinis, S. africanus and Dactyloctenium aegypticum.

Trees: Acacia xanthophloea, A. seyal, A. gerrardii.

High Shrubs: Maerua triphylla, Cordia ovalis, Maytenus heterophylla, Dombeya burgessae, Rhus natalensis, Buddleja polystachya, Cassia didymobotrya, Tarchonanthus camphoratus, Zizyphus mucronata, Teclea simplicifolia and Grewia similis.

Low Shrubs: Solanum incanum, Erythrococca bongensis, Maytenus heterophylla, Abutilon rehmannii, A. engleranum, A. longicuspe, Withania somnifera, Ocimum suave, Psiadia

Plate 9. Cynodon nlemfuensis - Acacia xanthophloea wooded grasslands. Frequently found on the southern central plains and on some areas of western Mau plateau.

punctulata, Pavonia patens, Cordia ovalis, Tarchonanthus camphoratus, Senecio petitianus, Lippia ukambensis, Ricinus communis, Phytolacca dodecandra, Capparis tomentosa, Lycium europaeum, Tinnea aethiopica, Hibiscus flavifolius and H. micranthus.

Herbs: Tagetes minuta, Atriplex semibaccata, Justicia exigua, J. flava, J. heterocarpa, Gloriosa superba, Aerva lanata, Gutenbergia cordifolia, Monechma debile, Achyranthes aspera, Urtica massaica, Gynandropsis gynandra, Verbena bonariensis, Chenopodium fasciculosum, Hypoestes verticillaris, Melhania ovata, Indigofera bogdanii, Commelina benghalensis, C. africanus, C. reptans, Plectranthus caninus, P. assurgens, Priva curtisiae, Astragalus atropilosulus, Commicarpus plumbagineus, Oxygonum sinuatum, Tribulus terrestris, Lactuca capensis, Puppalia lappacea, Crotalaria agatiflora, Vernonia galamensis, Leucas glabrata, L. martinicensis and Leonotis nepetifolia.

Sedges: Cyperus obtusiflorus.

Bushlands:

The term bushland is used here to refer to an assemblage of woody plants, mostly of shrubby habit, having a shrub canopy of less than 6 M. in height, with occasional emergents and a canopy cover of more than 20% (Pratt, Greenway and

Gwynne, 1966). The emergents, mainly trees may be present either in clumps or widely scattered. Bushlands form the most extensive vegetation in the Park much of which attains thicket density in certain areas, with Tarchonanthus camphoratus as the predominant shrub species, whereas in other areas the bushlands are characterized by scattered trees mainly Acacia xanthophloea mixed with low shrubs notably Pluchea bequaertii, Psiadia punctulata and Aspilia mossambicensis. However, the floristic range in bushlands is again very great and could only be adequately studied by subdividing the bushlands into three broad sections as follows:

B1 : Pluchea bushlands
B2 : Psiadia - Aspilia bushlands
B3 : Tarchonanthus bushlands

B1 : Pluchea bushlands: They occupy the lacustrine plains at the alkaline marginal areas of lacustrine sediments, impeded drainage and clay loam soils. These areas which are occasionally flooded are distinctly conspicuous on the northern, eastern and southern shores of the lake. Pluchea bequaertii a soda-resistant low shrub predominates the shrub layer, with Cyperus laevigatus, Cynodon dactylon and and Sporobolus spicatus contributing greatly to the ground cover (Plate 10). When the lake levels extend to these areas as a result of heavy rains, this vegetation is

Plate 10. Pluchea bequaertii bushlands.

Above: Pluchea bushlands formed on Sporobolus spicatus grassland to the north shore.

Below: Pluchea bushlands formed on Cynodon dactylon to the south shore.

denudated by saline water, a phenomenon that leads to the death of Acacia xanthophloea trees (Plate 11). The species composition is made up of the following:

Shrubs: Pluchea bequertii+, Rhus natalensis, Acacia xanthophloea, Euphorbia candelabrum, Solanum incanum, Withania somnifera, Senecio petitianus, Dodonaea angustifolia, Tarchonanthus camphoratus, Opuntia sp. and Hibiscus cannabinus.

Herbs: Tagetes minuta, Senecio discifolius, Satureja biflora, Leonotis nepetifolia, Justicia exigua, Kalanchoe cyncium tubulosum, Indigofera bogdanii and Ipomoea cairica.

Grasses: Sporobolus spicatus+, Cynodon dactylon+, Chloris gayana, Sporobolus pyramidalis, S. africanus, Rhynchelytrum repens and Aristida kenyensis.

Sedge : Cyperus laevigatus+.

Psiadia - Aspilia bushlands: These are found in the lowlands of colluvial deposition at certain areas of the footslopes of both Lion Hill (the side facing the lake) and the western escarpment. The vegetation in these areas is characterized by dense low shrubs Psiadia punctulata and Aspilia mossambicensis and Ocimum suave,

Plate 11. Death of *Acacia xanthophloea* trees along the northern shoreline.

a few scattered trees and high shrubs (Plates 12 and 13). The species composition consists of the following species:

Low Shrubs: Lippia ukambensis+, Aspilia mossambicensis+, Psiadia punctulata, Ocimum suave+, Hibiscus micranthus, H. flavifolius, H. fuscus, H. aponeurus, Abutilon rehmannii, A. engleranum, Senecio petitianus, Solanum incanum, Withania somnifera, Erythrococca bongensis, Grewia bicolor, Tinnea aethiopica, Rhus natalensis, Maytenus heterophylla and Aloe graminicola.

High Shrubs: Tarchonanthus camphoratus, Cordia ovalis, Grewia similis, G. bicolor, Maytenus heterophylla, Olea africana, Teclea simplicifolia, Rhus natalensis and Obetia pinnatifida.

Trees: Cussonia holstii, Acacia xanthophloea, A. gerrardii, Euphorbia candelabrum and Obetia pinnatifida.

Herbs: Tagetes minuta, Ocimum basilicum, Indigofera bogdanii, Melhania ovata, Felicia muricata, Hypoestes verticillaris, Achyranthes aspera, Aerva lanata, Gutenbergia cordifolia, Justicia exigua, Monechma debile, Dychoriste perrottettii and Tephrosia emeroides.

Lianes/Climbers/Twiners: Sarcostemma viminale and Cynanchum tetraptera and Senecio petitianus.

Plate 12. Psiadia punctulata bushlands at a depression near the Lion Hill Lodge.

Plate 13. Aspilia mossambicensis bushlands, on the lowlands below the cliffs of Lion Hill.

Grasses: Cynodon nlemfuensis+, Chloris gayana, C. pycnothrix, Sporobolus pyramidalis, S. africanus, S. confinis, Harpachne schimperi, Digitaria abyssinica, Aristida adoensis, A. kenyensis, Pennisetum mezianum and Panicum maximum.

Sedges: Cyperus obtusiflorus.

B3: Tarchonanthus Bushlands: Based on the dominant tree species and geographical position, four types of Tarchonanthus (**"Leleshwa"**) bushlands were recognized in the Park. These are: B3a: Tarchonanthus - Acacia gerrardii on Lion Hill

B3b: Tarchonanthus - Acacia xanthophloea on Western Mau escarpment

B3c: Tarchonanthus - Euphorbia candelabrum on the Southern plains

B3d: 'Mixed' Tarchonanthus bushland

B3a: Tarchonanthus - Acacia gerrardii Bushland: This forms the major vegetation on the Lion Hill which is characterized by ridges, faulted valleys and steep slopes. Tarchonanthus camphoratus predominates the shrub layer contributing more than 80% of the vegetation cover. The frequently occurring and notable tree species, particularly on the ridges and slopes are Acacia gerrardii and Cussonia holstii. The valleys with colluvial deposits are infilled with dense pure stands of Tarchonanthus camphoratus. A few weeks before the start

of this study, a devastating fire broke up accidentally near the Shooting Range and burnt down this vegetation to the northern section of Lion Hill, leaving behind a few trees and live stumps of Tarchonanthus stems from which a new generation of Tarchonanthus bushes started to sprout with the start of the long rains of April - September season (Plate 14). The species composition include the following species:

Trees: Acacia gerrardii*, A. seyal, A. hockii, A. xanthophloea, Cussonia holstii*, Euphorbia candelabrum*, Canthium lactescens, Combretum illairii, Nuxia congesta and Steganotaenia araliacea.

High Shrubs: Tarchonanthus camphoratus*, Rhus natalensis, Maytenus heterophylla, Cordia ovalis, Maerua triphylla, Grewia bicolor, G. similis, Acacia seyal, Rhamnus staddo, Scutia myrtina, Heteromorpha trifoliata and Euclea divinorum.

Low Shrubs: Aspilia mossambicensis, Lippia ukambensis, L. javonica, Lantana trifolia, Rhus natalensis, Clerodendron myricoides, Heteromorpha trifoliata, Steganotaenia araliacea, Solanum incanum, Aloe graminicola, A. secundiflora, A. kedongensis, Hibiscus fuscus, H. vitifolius, H. micranthus, H. aponeurus, H. flavifolius, Senecio petitianus, Tinnea aethiopica, Maytenus heterophylla, Dombeya burgessiae,

Plate 14. Tarchonanthus camphoratus - Acacia gerrardii bushlands on the top of Lion Hill. Recently burnt down by fire. In the background are Acacia gerrardii trees.

Abutilon longicuspe, A. rehmannii, A. englerannm, Olea africana, Plectranthus barbatus, Carissa edulis, Tarchonanthus camphoratus, Grewia similis, G. bicolor, Ocimum suave, Maerua triphylla.

Herbs: Aerva lanata, Plectranthus cylindracens, P. assurgens, Tagetes minuta, Gutenbergia cordifolia, Senecio discifolius, Polygala sphenoptera, Hypoestes verticillaris, Justicia exigua, J. flava, Ocimum basilicum, Indigofera bogdanii, I. brevicalyx, Leonotis nepetifolia, Commelina benghalensis, C. africana, C. reptans, Fuerstia africana, Oldenlandia corymbosa, O. scopulosum, Crotalaria vallicola, C. deserticola, C. agatiflora, C. incana, Sida teneicarpa, Solanum nigrum, Becium obovatum, Pentanisia ouranogyne, Notonia hildebrandtii, Cyphostemma orondo, Asparagus falcatus, A. aethiopicus, A. africanus, Ferula communis, Farsetia stenoptera, Pelargonium quinquelobatum, Cassia mimosoides, Rhynchosia minima, R. elegans, Pentas zanzibarica, Satureja biflora, Achyranthes aspera, Atriplex semibaccata, Leucas martinicensis, Euphorbia crotonoides, Dyschoriste perrottetti, Monsonia angustifolia and Gomphocarpus stenophyllus.

Lianes/Climbers/**Twiners:** Senecio petitianus, Sarcostemma viminale, Cyphostemma nodiglandulosum, C. nierense and Commicarpus plumbagineus.

Parasite: Viscum tuberculata.

Grasses: Themeda triandra, Aristida adoensis, Aristida kenyensis, Chloris gayana, Hyparrhenia anamesa, H. hirta, Sporobolus confinis, S. pyramidalis, S. africanus, S. frimbriatus, Harpachne schimperi, Panicum maximum, P. atrosanguineum, Eragrostis braunii, E. superba, E. racemosa, E. cilianensis, Loudetia kagerensis, Pennisetum mezianum, P. sphacelatum, Cynodon nlemfuensis, Setaria pumila, S. sphacelata, Microchloa kunthii, Rhynchelytrum repens, Cymbopogon caesius, C. nospischilii, Andropogon chinensis and Brachiaria brizantha.

B3b: Tarchonanthus - Acacia xanthophloea. The vegetation on the western Mau escarpment is a shrubland thicket of Tarchonanthus camphoratus as the dominant shrub species and Acacia xanthophloea as the prominent tree species (Plate 15). The tree density decreases on the ridges and gentle slopes of this escarpment, with Steganotaenia araliacea becoming notable in these areas where Tarchonanthus camphoratus contributes more than 80% of the total vegetation cover. On the plateau, the tree density increases significantly to make a fairly dense wooded bushland. However, at one point near 'Zacharia' region the bushland is interrupted by a patch of Acacia gerrardii (Plate 16). The species composition consists of the following species:

Trees: Acacia xanthophloea+, A. gerrardii, A. seyal, Steganotaenia araliacea, Cussonia holstii, Euphorbia candelabrum and Ficus thonningii.

High Shrubs: Tarchonanthus camphoratus+, Rhus natalensis, Maytenus heterophylla, Maerua triphylla, Zizyphus mucronata, Grewia similis, Cordia ovalis, Euclea divinorum, Acacia xanthophloea, A. seyal, Steganotaenia araliacea and Croton dichogamus.

Low Shrubs: Psiadia punctulata+, Aspilia mossambicensis+, Ocimum suave+, Grewia similis, Hibiscus micranthus, H. flavifollius, H. aponeurus, H. fuscus, H. vitifolius, Pavonia patens, Teclea simplicifolia, Cordia ovalis, Maytenus heterophylla, Lippia ukambensis, L. javonica, Lantana trifolia, Dodonaea angustifolia, Solanum incanum, Tinnea aethiopica, Tephrosia emeroides, Steganotaenia araliacea, Rhus natalensis, Plectranthus barbatus, Withania somnifera, Erythrococca bongensis, Senecio petitianus, Abutilon rehmmannii, Acacia gerrardii, A. seyal, Tarchonathus camphoratus and Dombeya burgessiae.

Herbs: Tagetes minuta, Melhania ovata, Fuersetia africana, Monechma debile, Hypoestes verticillaris, Achyranthes aspera, Crotalaria vallicola, C. deserticola, C. incana, Asparagus africanus, A. buchananii, A. aethiopicus, Kalanchoe

lanceolata, K. densiflora, Senecio petitianus, S. discifolius, Leucas glabrata, L. martinicensis, Aerva lanata, Dyschoriste perrottettii, Indigofera bogdanii, I. brevicalyx, Priva curtissiae, Heliotropium undulatifolium, Felicia muricata, Polygala sphenoptera, Satureja biflora, Aspilia mossambicensis, Commicarpus plumbagineus, Celosia anthelmintica, Plectranthus assurgens, P. cylindraceus, Commelina benghalensis, C. reptans, C. africana, Barleria ventricosa, Ocimum basilicum, Leonotis nepetifolia, Melhania ovata, M. velutina, Gutenbergia cordifolia, Pentanisia ouranogyne, Rhynchosia minima, R. elegans, Conyza volkensii and Justicia exigua.

Lianes/Climbers/Twiners: Senecio petitianus, Zehneria scrabra, Sarcostemma viminale, Cynhostemma nierense.

Parasite : Odentella fischeri.

Sedge : Mariscus obtusiflorus.

Grasses: Themeda triandra+, Aristida adoensis, A. kenyensis, Chloris gayana+, Sporobolus pyramidalis, S. africanus, S. frimbriatus, Harpachne schimperi, Panicum maximum, Cymbopogon caesius, C. nospischilii, Eragrostis superba, Rhynchelytrum repens, Trichonema teneriffae, Hyparrhenia anamesa, H. hirta, Cynodon nlemfuensis, Pennisetum mezianum, Microchloa kunthii and Setaria pumilla.

Plate 15. Tarchonanthus camphoratus - Acacia xanthophloea bushlands on the western Mau escarpment.

Plate 16. Acacia gerrardii woodland occasionally found on the western Mau escarpment.

B3c: Tarchonanthus - Euphorbia candelabrum Bushland:
This occurs on the south eastern plains of the Park, the region commonly known as Soysambu, made up of superficial volcanic deposits, over diatomaceous sediments and well drained sandy clay loam soils. The vegetation is that of a typical Tarchonanthus camphoratus thicket with Euphorbia candelabrum as the dominant tree species (Plate 17). The trees disappear gradually to the west and northern margins to give way to pure stands of Tarchonanthus bushland (Plate 18). On the east and southern margins, Tarchonanthus bushes gradually disappear, due to "poaching" for firewood by people from the neighbouring settlement, to give way to a dense cover of Tinnea aethiopica, Cordia ovalis and Grewia similis, with a closed stand of young Euphorbia candelabrum trees (Plate 19). The species composition comprises the following:

Trees: Euphorbia candelabrum+, Cussonia holstii, Acacia xanthophloea, A. gerrardii and Tarenna graveolens.

High Shrubs: Tarchonanthus camphoratus+, Cordia ovalis+, Maerua triphylla, Croton dichogamus, Maytenus heterophylla+, Euphorbia candelabrum+, Grewia similis+, Olea africana and Acacia xanthophloea.

Low Shrubs: Ocimum suave, Hibiscus fuscus, H. flavifolius, Teclea simplicifolia, Tinnea aethiopica+, Psiadia punctulata+,

Solanum incanum, Acacia xanthophloea, Euphorbia candelabrum, Lippia ukambensis+, Aspilia mossambicensis, Erythrococca bongensis, Pavonia patens, Aloe graminicola+, Tarchonanthus camphoratus, Cordia ovalis, Maerua triphylla, Maytenus and Grewia similis.

Herbs: Hypoestes verticillaris, Bidens pilosa, Commelina africana, C. reptans, Pentanisia ouranogyne, Melhania velutina, M. ovata, Becium obovatum, Cyphostemma orondo, Priva curtisiae, Fuerstia africana, Scadoxus multiflorus, Justicia exigua, J. heterocarpa, Monechma debile, Gutenbergia cordifolia, Tagetes minuta, Senecio discifolius, Asystasia schimperi, Euphorbia inaequilatera, Crotalaria incana, C. vallicola, Sansevieria robusta+, Pentas zanzibarica, Asparagus asparagoides, A. falcatus, Gloriosa superba, Polygala sphenoptera, Vigna membranacea, Chlorophytum bakeri, Oxygonum sinuatum, Craterostigma hirsutum and C. plantagineum.

Lianes/Twiners/Climbers: Senecio petitianus, Sarcostemma viminale, Cyphostemma nodiglandulosum, Capparis tomentosa, Kedrostis hirtella, Rhoicissus tridentata and Commicarpus plumbagineus.

Grasses: Themeda triandra+, Cynodon nlemfuensis+, Setaria pumilla, S. verticillata, Sporobolus pyramidalis and Digitaria abyssinica.

Plate 17. Tarchonanthus camphoratus - Euphorbia candelabrum bushland at Roysambu.

Plate 18. Tarchonanthus camphoratus bushland at Roysambu

B3d: 'Mixed' Tarchonanthus bushland: This is a narrow vegetation belt found along the western border from Nganyoi Rangers' Post to Pwani Rangers' Post that seems to interchange positions with Olea forest. The vegetation is basically Tarchonanthus camphoratus shrubland but the dominance of the associated tree species is shared among the three species, i.e. Euphorbia candelabrum, Acacia gerrardii and Acacia xanthophloea (Plates 20).
The species composition consists of the following species:

Trees: Acacia xanthophloea+, A. gerrardii+, A. seyal, Euphorbia candelabrum+, Cussonia holstii, Euclea divinorum and Olea africana.

High Shrubs: Tarchonanthus camphoratus+, Rhus natalensis+, Maerua triphylla, Maytenus heterophylla, Opuntia sp., Teclea simplicifolia, Grewia similis, Heteromorpha trifoliata, Acacia gerrardii, A. seyal, A. xanthophloea, Dombeya burgessiae, Euclea divinorum and Abutilon holstii.

Low Shrubs: Tinnea aethiopica, Psiadia punctulata+, Plectranthus barbatus, Ocimum suave+, Aloe graminicola, A. secundiflora, Hibiscus fuscus, H. micranthus, H. flavifolius H. aponeurus, H. vitifolius, Aspilia mossambicensis, Rhus natalensis, Steganotaenia araliacea, Solanum incanum+, Lantana trifolia, Lippia ukambensis, Euclea divinorum,

Plate 19. A stand of young Euphorbia candelabrum trees replacing Tarchonanthus camphoratus bushes that have been cut down for firewood by people from the surrounding settlement.

Plate 20. 'Mixed' Tarchonanthus bushland commonly found at Nganyoi and Pwani stations. The dominant tree species are Acacia xanthophloea, A. gerrardii and Euphorbia candelabrum.

Pavonia patens, Teclea simplicifolia, Acacia gerrardii, A. xanthophloea, Maytenus heterophylla, Cordia ovalis, Grewia similis and Senecio petitianus.

Herbs: Hypoestes verticillaris, Gutenbergia cordifolia, Celosia anthelmintica, Achyranthes aspera, Kalanchoe densiflora, Notonia ?hildebrandtii, Indigofera brevicalyx, I. bogdanii, Tagetes minuta, Crotalaria vallicola, C. incana, Asparagus buchananii, Commelina africana, Senecio discifolius, Leucas glabrata, Aerva lanata, Bidens pilosa, Heliotropium undulatifolium, Felicia muricata, **Fuerstia** africana, Pentanisia ouranogyne and Leonotis nepetifolia.

Grasses: Chloris gayana, C. pycnothrix, Sporobolus pyramidalis, Aristida kenyensis, Themeda triandra, Eragrostis superba, Panicum maximum and Cynodon nlem fuensis.

Parasites: Viscum tuberculatum and Odentella fischeri.

Woodlands: The term woodland has been adopted from **Pratt** and Gwynne (1977) as a stand of trees up to 20 M. in height, with an open or continuous but not thickly interlaced canopy, and a canopy cover of more than 20 percent. Shrubs, if present, contribute less than one-tenth of the canopy cover. Grasses and other herbs dominate the ground cover. Going by this definition, all that was previously known traditionally

as Acacia forest along the shoreline is hereby treated as Acacia woodland except a small section at Pelican corner commonly known as **Colobus** forest, and another one at Campi ya Nyuki near Lanet area which qualify to be treated as parts of Acacia forest. However there are two types of woodlands that were recognized during the floristic studies. These include:

(a) Acacia xanthophloea woodland (W1)
(b) Acacia seyal woodland (W2)

W1: Acacia xanthophloea woodland: This **encompasses the** entire shoreline being widely spread to the northern and southern shores. The vegetation is characterized by tall (25 m.) Acacia xanthophloea trees (Plate 21), lack of shrub layer, presence of dense ground cover and clusters of lianes, twinners and climbers. The vegetation between WCK (Wildlife Clubs of Kenya) Hostel and the main Gate to the Park Headquarters displays its uniqueness in that it lacks completely both low and high shrub layers and only with a few scattered clumps of lianes/**twiners**/ climbers. The only notable shrub species are Cassia bicapsularis (low shrub) and Vernonia auriculifera (Plate 22). The dense ground cover is formed mainly by Achyranthes aspera and Solanum incanum. The vegetation at Njoro Section is characterized by lianes/**twiners**/ climbers contributed mainly by Rhus natalensis, Grewia

Plate 21. Acacia xanthophloea woodland.

Plate 22. Acacia xanthophloea woodland between WCK and the Main Gate, characterised by lack of shrub layer and presence of dense undergrowth formed mainly by Achyranthes aspera and Solanum incanum.

similis and Senecio lyratipartitus (Plate 23). The ground cover is mainly contributed by Urtica massaica, an annual plant which dissapears during the dry spell, leaving behind bare soil with only other herbs to provide incomplete cover. The vegetation to the southern shore is in two forms: that at the centre of the woodland is characterized by frequently occurring dense clusters of lianes/twiners and climbers and dense ground cover that is provided by either low shrubs and herbs (Plate 24) or mainly climbers and twiners including Commicarpus plumbagineus, Cynanchum altiscandens, Dregea schimperi, Capparis tomentosa, Toddalia asiatica and Senecio petitianus (Plate 25). The vegetation at the peripheral region of the woodland does not contain many clusters of lianes, twiners and climbers and the dense ground cover is mainly due to Achyranthes aspera and Solanum incanum. Another striking feature is the death of Acacia trees at the margins of the woodland (Plate 26). The species composition of Acacia xanthophloea woodland in general consists of the following species.

Trees: Acacia xanthophloea+, Grevillea robusta, Schinus molle, Eucalyptus citriodora, Dombeya rotundifolia, Warburgia ugandensis, Ehretia cymosa, Ekebergia capensis and Croton megalocarpus.

Plate 23. Acacia xanthophloea woodland around the Njoro camping site. The vegetation is characterised by lianes and incomplete ground cover. During the wet season the undergrowth is dense forming a complete ground cover, contributed by Urtica massaica, Hypoestes verticillaris and Justicia flava. During the dry season most of these annual species disappear leaving behind patches of bare soil.

Plate 24. Acacia xanthophloea woodland at the southern lake shore. The inside of the woodland consists of a dense undergrowth of shrubs (contributed mainly by Abutilon longicuspe, Solanum incanum and Erythrococca bongensis) and lianes and climbers that belong mainly to Commicarpus plumbagineus, Dregea schimperi, Capparis tomentosa, Toddalia asiatica and Senecio petitianus.

Plate 25. Acacia xanthophloea woodland at the southern lake shore. Sometimes the undergrowth is formed mainly by lianes climbers twiners such as Commicarpus plumbagineus, Cynanchum altiscandens, Dregea schimperi, Capparis tomentosa, Pterolobium stellatum and Senecio petitianus.

Plate 26. Death of Acacia xanthophloea trees at the margins of the Southern Acacia xanthophloea woodland. The cause of the die back of these trees has not been established yet but the current opinion is the frequent fluctuations in the water table causing salinity problems that result in the death of Acacia trees.

High Shrubs: Maytenus heterophylla+, Rhus natalensis+, Maerua triphylla+, Vernonia auriculifera, Dovyalis caffra, Abutilon holstii, A. longicuspe, Ricinus communis, Obetia pinnatifida, Dombeya burgessiae, Calpurnia subdecandra, Scutia myrtina, Buddleja polystachya, Lantana camara, Erythrococca bongensis, Grewia similis, Hibiscus calyphyllus, Crassocephalum mannii, Teclea simplicifolia and Cordia ovalis.

Low Shrubs: Hibiscus fuscus, H. micranthus, H. vitifolius, Solanum incanum+, Erythrococca bongensis+, Pluchea bequaertii, P. ovalis, Ocimum suave, Cassia bicapsularis, Senecio petitianus, Warburgia ugandensis, Rubus niveus, Maytenus heterophylla, Lantana trifolia, Withania somnifera, Pavonia patens, Abutilon engleranum, Psiadia punctulata and Lycium europaeum.

Herbs: Achyranthes aspera+, Tagetes minuta+, Urtica massaica+, Vernonia galamensis, Crotalaria agatiflora, C. incana, Hypoestes verticillaris+, Physalis peruviana, P. ixocarpa, Leonotis nepetifolia, Justicia flava, J. heterocarpa, J. exigua, Commelina benghalensis, Leucas glabrata, Atriplex semibaccata, Asystasia schimperi, Galinsoga parviflora, Bidens pilosa, Blumea crispata, Kalanchoe densiflora, K. lanceolata, Amaranthus spinosa, Plectranthus assurgens, Gutenbergia cordifolia, Celosia anthelmintica, Plumbago zeylanica.

Lianes/Twiners/Climbers: Senecio petitianus, S. hyratiparritus, Cynanchum altiscandens, C. tetrapterum, Periploca linearifolia, Dregea schimperi, Pergularia daemia, Momordica foetida, Zehneria scabra, Crassocephalum vitellinum, Stephania abyssinica, Cyathula cylindrica, Capparis tomentosa+, C. fascularis, Commicarpus plumbagineus, Toddalia asiatica, Clematis hirsuta, Phytolacca dodecandra, Rhus natalensis, Grewia similis and Pterolobium stellatum.

Grasses: Setaria pumilla, Chloris gayana, C. pycnottorix, Digitaria abyssinica, D. velutina, Cynodon nlemfuensis+, S. frimbriatus.

W2: Acacia seyal Woodland: This is found on one of the ridges west of Naishi Sub-Headquarters at the footslopes of western Mau escarpment. The vegetation is characterized by lack of shrub layer, closely located trees (Acacia seyal, A. hockii) and poor ground cover. The species composition consists of the following species:

Trees: Acacia seyal+, A. hockii+, A. gerrardii and A. xanthophloea.

High Shrubs: Tarchonanthus camphoratus, Zizyphus mucronata, Cordia ovalis, Maerua triphylla, Rhus natalensis and Maytenus heterophylla.

Low Shrubs: Psiadia punctulata, Ocimum suave, Senecio petitianus, Lippia ukambensis, Cordia ovalis, Solanum incanum, Hibiscus flavifolius, H. fuscus, H. micranthus, Tinnea aethiopica, Aspilia mossambicensis+, Grewia bicolor and G. similis.

Herbs: Gutenbergia cordifolia, Aerva lanata, Abutilon engleranum, Senecio discifolius, Justicia exigua, Achyranthes aspera, Monechma debile, Hypoestes verticillaris and Chenopodium album.

Grasses: Cynodon nlemfuensis+, Setaria verticillata and Themeda triandra.

Forests:

A forest is a continuous stand of trees with canopy that varies from 10 to 50 m. in height and usually consists of one or more storeys, with an interlaced upper canopy and ground cover that is dominated by herbs, shrubs, lianes and epiphytes (Platt and Gwynne, 1977; White, 1983). Three forest types were recognized in the Park and they include:

F1: Acacia xanthophloea forest

F2: Euphorbia candelabrum forest

F3: Olea africana forest.

F1: Acacia xanthophloea forest: As indicated above this forest occurs in small patches within the Acacia xanthophloea woodland that encroaches the lake shoreline, and becomes more prominent at Kampi ya Nyuki and Pelican Corner regions. The vegetation at Kampi ya Nyuki region to the north east of the Park is made up of tall (30 m) trees of Acacia xanthophloea, dense shrub layer dominated by Grewia similis, G. bicolor, Rhus natalensis, Pluchea bequaertii and Erythrococca bongensis and dense clusters of lianes, climbers and twiners. The other characteristic tree species include Grevillea robusta, Eucalyptus citriodora, Schinus molle and Warburgia ugandensis (Plate 27). The species composition for this region include:

Trees: Acacia xanthophloea, Warburgia ugandensis, Eucalyptus citriodora, Schinus molle and Grevillea robusta.

High Shrubs: Grewia similis+, G. bicolor+, G. trichocarpa, Rhus natalensis+, Ricinus communis+, Maytenus heterophylla, Tarchonanthus camphoratus, Dombeya burgessiae, Erythrococca bongensis, Teclea simplicifolia, Vernonia auriculifera, Cassia didymobotrya, Cordia ovalis+, Maerua triphylla, Olea africana, Acacia xanthophloea and Dovyalis caffra.

Low Shrubs: Ocimum suave+, Pavonia patens, Erythrococca bongensis, Pluchea bequertii, Hibiscus fuscus, H. micranthus,

Plate 27. Acacia xanthophloea Forest.

Abutilon longicuspe, A. engleranum, Cassia bicapsularis, Vernonia galamensis, Maerua triphylla, Withania somnifera, Solanum incanum, Rhus natalensis, Teclea simplicifolia, Maytenus heterophylla, Acacia xanthophloea.

Herbs: Hypoestes verticillaris+, Asystasia schimperi+, Commelina benghalensis, Gutenbergia cordifolia, Tagetes minuta, Kalanchoe lanceolata, Bidens pilosa, Urtica massaica and Leonotis nepetifolia.

Lianes: Pterolobium stellatum+, Achyranthes aspera, Maerua triphylla, Senecio petitianus, Commicarpus plumbagineus+, Pergularia daemia, Periploca linearifolia, Capparis tomentosa, Cynanchum tetrapterum, Phytolacca dodecandra, Clematis hirsuta, Grewia similis+, Rubus nivens and Sarcostemma viminale.

Grasses: Chloris gayana, Setaria pumilla, Aristida kenyensis, Sporobolus pyramidalis, Cynodon nlemfluensis and Panicum maximum.

The forest at Pelican Corner commonly known as Colobus forest has a dense shrub layer dominated by Teclea simplicifolia, Pluchea bequertii, Rhus natalensis and Hibiscus calyphyllus; clusters of lianes, twiners and climbers,

mainly Pterolobium stellatum and very tall (35 m.) old trees of Acacia xanthophloea. The species composition in this region include:

Trees: Acacia xanthophloea+, Cussonia holstii, Teclea simplicifolia and Euclea divinorum.

High Shrubs: Hibiscus calyphyllus+, Pluchea bequertii+, Teclea simplicifolia+, Rhus natalensis+, Grewia bicolor, Obetia pinnatifida, Calpurnia subdecandra, Maerua triphylla, Cordia ovalis and Dombeya burgessiae.

Low Shrubs: Solanum incanum, Pavonia patens, Grewia similis, Abutilon longicuspe, A. engleranum, A. holstii, Tarchonanthus camphoratus, Hibiscus vitifolius, Maerua triphyla, Cordia ovalis and Acacia xanthophloea.

Herbs: Achyranthes aspera, Cyathula cylindrica, Urtica massaica, Justicia heterocarpa, J. flava, Tagetes minuta, Hypoestes verticillaris, Celosia anthelmintica, Kalanchoe lanceolata and Vernonia galamensis.

Lianes: Senecio petitianus, Toddalia asiatica+, Pterolobium stellatum+, Cynanchum altiscandens, Grewia similis, Sarcostemma viminale, Capparis tomentosa, Phytolacca dodecandra, Clematis hirsutum, Pergularia daemia, Rhus

natalensis, Cyathula cylindrica and Crassocephalum vittellimum.

Grasses: Cynodon nlemfluensis, Setaria pumilla, Panicum maximum and Chloris gayana.

F2: Euphorbia candelabrum forest: The forest displays a unique picturesque of a well preserved natural forest, perhaps the best of its kind in East Africa. The area is on steep basaltic slopes and ridges with a vegetation cover dominated by a dense stand of Euphorbia candelabrum trees (Plate 28). Other characteristic tree species include Acacia xanthophloea, Cussonia holstii and Obetia pinnatifida. The open spaces are filled by Obetia pinnatifida. The shrub layer inside the forest is not dense but exists dominated by Teclea simplicifolia, Rhus natalensis, Cordia ovalis, Tarenna graveolens and Obetia pinnatifida. Other notable shrubs include Dombeya burgessiae, Psydrax schimperiana, Iboza multiflora, Maytenus heterophylla and Grewia bicolor. The herbaceous layer is contributed mainly by Hypoestes verticillaris and Achyranthes aspera. At the margins of the forest the shrubs form a dense shrub layer with Rhus natalensis, Grewia similis, G. bicolor, Maytenus heterophylla, Cordia ovalis, Obetia pinnatifida and Tarchonanthus camphoratus as prominent shrub species (Plate 29). A small section of one of the south-facing slopes is inhabited by another

species of Euphorbia trees, Euphorbia nyikae (dubiously distinct from E. kibwezensis, Dale and Greenway, 1961) that stands out in the midst of Tarchonanthus bushland (Plate 30). The species composition of Euphorbia forest comprises of the following species:

Trees: Euphorbia candelabrum+, E. nyikae, Acacia xanthophloea, Obetia pinnatifida, Cussonia holstii, Ficus wakefieldii, Olea africana, Grewia bicolor, Maytenus heterophylla, Euclea divinorum, Steganotaenia araliacea Warburgia ugandensis, Tarenna graveolens, Teclea simplicifolia and Canthium lactescens.

High Shrubs: Teclea simplicifolia+, Iboza multiflora+, Obetia pinnatifida+, Cordia ovalis, Maytenus heterophylla, Crassocephalum mannii, Rhus natalensis, Maerua triphylla, Psydrax schimperianum, Dombeya burgessiae, Grewia bicolor, G. similis, Erythrococca bongensis and Salix subserrata.

Low Shrubs: Obetia pinnatifida+, Erythrococca bongensis, Psiadia punctulata, Abutilon holstii, Ocimum suave, Tinnea aethiopica, Aloe graminicola, A. kedongensis, Grewia bicolor, G. similis, Teclea simplicifolia, Plectranthus barbatus, Helinus integrifolius, Vernonia cinerea, V. brachycalyx, Aspilia mossambicensis and Lippia ukambensis.

Plate 28. Euphorbia candelabrum Forest on the western steep slopes of the Lion Hill, showing also Acacia stand on the foreground.

Plate 29. The marginal areas of Euphorbia candelabrum forest characterised by dense shrubs (Rhus natalensis, Tarchonanthus camphoratus, Maytenus heterophylla, Cordia ovalis and Grewia similis).

Plate 20. Euphorbia mythae on the southern slopes of the Lion Hill.

Herbs: Hypoestes verticillaris+, Gutenbergia cordifolia, Achyranthes aspera+, Justicia heterocarpa, J. flava, Pellaea viridis, Plectranthus cylindriceus, P. assurgens, Commelina benghalensis, C. africana, Sansevieria robusta, Gloriosa superba, Polystachya striata, Peperomia stuhlmannii.

Lianes/Twiners/Climbers: Grewia similis+, Cynanchum altiscandens+, Pterolobium stellatum+, Senecio petitianus, Sarcostemma viminale, Cyphostemma nierense, C. nodiglandulosum, Peponium vogelii, Vigna membracea.

Sedge : Mariscus impubes.

Grasses: Digitaria velutina, Panicum maximum, Ehrharta erecta, Oplismenus hirtellus Chloris gayana and C. pycnottorix

F3: Olea africana forest: This is part of the Kenya Dry Highland Oleaceous forest, virgin, intact and representing a climax vegetation as it has been protected from man and domestic livestock by the Government for many years even before the creation of the Park. The forest structure consists of a forest layer of closed canopy mainly contributed by Teclea simplicifolia, Olea africana and Euclea divinorum with Cussonia holstii forming the emergents (Plate 31); a dense shrub layer that forms a thicket stand of high shrubs including mainly Rhus natalensis, Maytenus

heterophylla, Cordia ovalis, Teclea simplicifolia, Grewia similis and Tarchonanthus camphoratus, entangled with massive clumps of lianes/twinners/climbers contributed mainly by Senecio petitianus, Rhus natalensis, Grewia similis, Cyphostemma nodiglandulosum, Gynura scandens, Pterolobium stellatum and Sarcostemma viminale (Plate 32); and herbaceous layer that is rather poor in species composition, with the main ground cover contributed by Sansevieria parva, Hypoestes verticillaris, Asystasia schimperi, Monothecium glandulosum, Notonia ?hildebrandtii and Plectranthus assurgens and P. cylindriaceus. In open spaces, low shrubs dominated by Aspilia mossambicensis, Gnidia subcordata, Tinnea aethiopica, Helinus integrifolia and Vernonia brachycalyx form dense bushes. The species composition include the following species:

Trees: Olea africana+, Cussonia holstii+, Teclea simplicifolia+, Euclea divinorum+, Obetia pinnatifida, Tarrena graveolens+, Schrebera alata, Psydrax schimperiana, Acacia gerrardii, Acacia brevispica, Maytenus heterophylla and Acacia xanthophloea.

High Shrubs: Euclea divinorum+, Teclea simplicifolia+, Maytenus heterophylla+, Tarchonanthus camphoratus+, Acacia xanthophloea, Nicotiana glauca, Croton dichogamus, Grewia similis+, Cordia ovalis+, Dombeya burgessiae+,

Plate 31. Olea africana forest on the southern Mau Plateau.

Plate 32. Olea forest. A dense shrub layer inside the Olea forest formed by Rhus natalensis, Maytenus heterophylla Cordia ovalis, Teclea simplicifolia. The shrubs are entangled with numerous clumps of lianes/twiners/ climbers contributed mainly by Senecio petitianus, Rhus natalensis, Grewia similis, Sarcostemma viminale, Gynura scandens, Pterolobium stellatum and Cyphostemma nodiglandulosum.

Warburgia ugandensis, Rhus natalensis[+], Maerua triphylla[+] and Rhamnus staddo.

Low Shrubs: Hibiscus fuscus[+], H. micranthus, H. vitifolius, H. calyphyllus[+], Obetia pinnatifida, Erythrococca bongensis, Abutilon longicuspe, A. holstii, Pavonia patens, Helinus integrifolius, Plectranthus barbatus, Lippia ukambensis, Tinnea aethiopica, Aloe kedongensis, A. graminicola, Aspilia mossambicensis[+], Teclea simplicifolia, Solanum incanum, Gnidia subcordata[+], Psiadia punctulata[+], Ocimum suave, Dodonaea angustifolia, Vernonia brachycalyx and Clerodendron myricoides.

Lianes/Twiners/Climbers: Senecio petitianus[+], Gynura scandens[+], Sarcostemma viminale[+], Grewia similis[+], Rhus natalensis[+], Cyphostemma nodiglandulosum[+], Peponium vogelii, Pterolobium stellata[+], Basela alba, Vigna membracea, Coccinia trilobata, Cyathula cylindrica, Thunbergia alata,

Herbs: Sansevieria parva[+], Achyranthes aspera, Commelina benghalensis, Bidens pilosa, Tagetes minuta, Hypoestes verticillaris, Asystasia schimperi, Monothecium glandulosum, Notonia ?hildebrandtii[+], Plectranthus cylindraceum, P. assurgens, Justicia stricta, J. heterocarpa, J. flava, Senecio discifolius, Conyza pedunculata, Gutenbergia cordifolia, Leonotis nepetifolia, Aerva lanata, Crotalaria

incana, Barleria submollis, Kalanchoe densiflora and Datura stramonium.

Grasses: Digitaria velutina, Sporobolus agrostoides Themeda triandra, Setaria verticillata, S. orthostida, Aristida kenyensis.

Parasites/Epiphytes: Phyragmanthera ziziphifolius, Viscum tuberculatum, Polystachya striata (Orchidaceae).

Sedge Marshes:

These are waterlogged areas of alluvial deposits found mainly along the north and east shores and are regularly flooded by the lake except during dry periods. Their vegetation is dominated by Cyperus laevigatus, a soda-resistant sedge (Plate 33). Species composition consists of the following species:

Sedges: Cyperus laevigatus+, C. dichrostachys.

Grasses: Sporobolus spicatus+, Pennisetum clandestinum, Chloris gayana+, C. pycnothrix, Cynodon dactylon+, C. nlem fuensis, Setaria verticillata and Hyparrhenia hirta.

Low Shrubs: **Pluchea bequaertii**+, Solanum incanum, Nicotiana glauca, Ocimum suave, Acacia xanthophloea and Sesbania sesban.

Plate 33. Alkaline sedge marshes dominated by Cyperus laevigatus. During the dry season these areas become the potential grazing zones for most of the wildlife particularly Water bucks, Impalas and Buffalos.

Plate 34. Typha domingensis fresh water swamp.

Herbs: Cirsium vulgare, Senecio mesogrammoides, S. discifolius, Hibiscus cannabinus, Leucas martinicensis, Gutenbergia cordifolia, Vernonia galamensis and Lepidium bonariensis.

Fresh Water Swamps: These are indicative of where fresh water seeps into the Lake. Where Nderit River enters the south east end of Lake Nakuru, an extensive swamp vegetation projects out over the lake-bed flats. Swamp herbage also occurs around the springs on the North shore (Baharini region), the only fresh water springs in the area ($P^{H}7 \cdot 5$) believed to be the mouth outlets of Ngosur River that disappears a few kilometers away from the Lake as it drains the Bahati catchment zones. Typha domingensis is the dominant plant in the swamp at the South-east end of the lake (Plate 34). The extent of the Typha stand varies according to the level of the lake, and to the extent that it is flooded by alkaline water. The species composition of the swamp vegetation consists of the following species:

Rush : Typha domingensis

Sedges: Cyperus immensus*, C. laevigatus.

Grasses: Cynodon dactylon, Pennisetum clandestinum, Setaria pumila S. verticillata and Sporobolus spicatus.

Low Shrubs: Sesbania sesban, Pluchea bequertii, Hibiscus diversifolius, Polygonum senegalensis and Nicotiana glauca.

Herbs: Cirsium vulgare, Senecio discifolius, Gomphocarpus fruticosus, G. integer, Achyranthes aspera, Crassocephalum picridifolium, Ipomoea cairica, Conyza bonariensis, C. stricta and C. tigrensis.

Cliff/Escarpment Vegetation:

There are a considerable number of basaltic cliffs and escarpments in the Park created by the rifting effect of the Rift Valley. They are partly devoid of vegetation with large boulders, screes and rocky out-croppings (Plate 35). The vegetation is undifferentiated being made up of characteristic shrubs such as Aspilia mossambicensis, Iboza multiflora, Cordia ovalis, Maytenus heterophylla, Obetia pinnatifida, Maerua triphylla and Tarchonanthus camphoratus. Notable scattered trees include Cussonia holstii, Steganotaenia araliacea, Acacia xanthophloea and Ficus thonningii and F. wakefieldii. The major grasses are Cynodon nlemfuensis, Sporobolus consimilis and Pennisetum squamulatum. Species composition is made up of the following species:

Trees: Acacia xanthophloea, A. gerrardii, Cussonia holstii, Tarenna graveolens, Steganotaenia araliacea.

Ficus thonningii, F. sur, F. wakefieldii, Obetia pinnatifida and Euphorbia candelabrum.

High Shrubs: Cordia ovalis, Rhus natalensis, Grewia similis, G. bicolor, G. trichocarpa, Maytenus heterophylla, Tarchonanthus camphoratus, Maerua triphylla, Iboza multiflora*, Acacia xanthophloea, Obetia pinnatifida, Erythrocca bongensis, Teclea simplicifolia, Dombeya burgessiae and Steganotaenia araliacea.

Low Shrubs: Pluchea bequertii, Senecio petitianus, Erythrococca bongensis, Aspilia mossambicensis*, Solanum incanum, S. nakurense, Pavonia patens, Cordia ovalis, Hibiscus fuscus, H. micranthus, H. vitifolius, H. calyphyllus, Grewia similis, Maytenus heterophylla, Ocimum suave, Psiadia punctulata, Tinnea aethiopica, Abutilon rehmannii, A. engleranum, Maerua triphylla, Acacia xanthophloea, Teclea simplicifolia, Lippia ukambensis, Plectranthus barbatus, Aloe kedongensis, Rhus natalensis, Steganotaenia araliacea, Croton dichogamus, Lycium europaeum and Polygonum senegalensis.

Herbs: Achyranthes aspera, Gutenbergia cordifolia, Farsetia stenoptera*, Kalanchoe lanceolata, K. laciniata, K. densiflora, Chenopodium procerum, C. opulifolium, Commelina benghalensis, C. reptans, Tragia insuavis, Asparagus falcatus, A. africanus, A. aethiopicus, Commicarpus pedunculosus, Plumbago zeylanica,

Tagetes minuta, Melhania ovata, Justicia heterocarpa, Plectranthus assurgens, P. cylindraceus, P. caninus, Portulaca kermesina, Leucas glabrata, L. martinicensis, L. grandis, Ocimum basilicum, Bidens pilosa, Dyschoriste perrottettii, Indigofera bogdanii, Scadoxus multiflorus, Pupalia lappacea, Cyathula sp. 'A' of "Upland Kenya Wild Flowers", Urtica massaica.

Lianes/**Twiners/Climbers:** Cynanchum altiscandens, Senecio petitianus, Cyphostemma nierense, Sarcostemma viminale, Pterolobium stellatum, Crassocephalum vitellinum, Capparis tomentosa, Peponium vogelii, Grewia similis.

Grasses: Chloris gayana, C. pycnothrix, Setaria pumilla, S. verticillata, Themeda triandra, Panicum maximum*, Cynodon nlem fuensis*, Sporobolus pyramidalis, S. confinis, S. consimilis*, S. fimbriatus, Digitaria abyssinica, Aristida adoensis, A. kenyensis, Harpachne schimperi, Hyparrhenia hirta, Cymbopogon caesius, C. pospichilii, Pennisetum squamulatum*, P. mezianum, P. sphacelatum, P. hohenackeri, P. procerum* and Rhynchelytrum reptans*.

Sedge : Cyperus obtusifolius.

Epiphytes/Parasites: Pellaea viridis, Actinopteris semiflabellata (**Adiantaceae**), Phragmanthera ziziphifolius.

Plate 35. Cliff/Escarpment vegetation formations, Tarchonanthus camphoratus, Aspilia mossambicensis, Acacia xanthophloea and Steganotaenia araliacea dominate the shrubs and trees composition. The dominant grasses are Cynodon nlemfuensis, Sporobolus consimilis and Pennisetum squamulatum

Lava Outcrop Vegetation:

The most striking of the lava outcrops in the Park is the Honeymoon Hill to the north-west, which is a remnant of tuff cones formed in the middle pleistocene. The other prominent outcrops include the Buffalo Hill near Naishi and lava ridges next to Nakuru Lodge. These landforms support undifferentiated characteristic vegetation that received special attention and is treated separately from that of the rest of the Park.

Honeymoon Vegetation: The vegetation on the eastern slope is characterized by lack of high shrubs and trees and presence of low bushes dominated by Aspilia mossambicensis with the ground cover contributed mainly by Aloe secundiflora (Plate 36). Species composition consists of the following species:

Low Shrubs: Aspilia mossambicensis*, Withania somnifera, Lippia ukambensis, Hibiscus fuscus, H. flavifolius, H. cannabinus, Rhus natalensis, Polygonum senegalensis, Maerua triphylla, Senecio petitianus, Abutilon rehmannii, Dodonaea angustifolia, Lantana trifolia and Rumex usambarensis.

Herbs: Pentanisia ouranogyne, Aloe secundiflora*, Commelina africana, Leucas grablata, Polygala sphenoptera, Aerva lanata,

Leonotis nepetifolia, Pelargonium quinquelobatum, Chenopodium album, Notonia ?hildebrandtii, Plectranthus assurgens, P. cylindraceus, Oxygonum sinuatum, Tagetes minuta, Osteospermum vaillantii, Cyphostemma nierense, Actiniopteris semiflabellata (Pteridophyte), Crotalaria vallicola and Monechma debile, Portulaca kermesina, P. oleracea, Delosperma nakurense, Silene macrosolem and Rumex usambarensis.

Grasses: Hyparrhenia anamesa*, Pennisetum procerum*, P. mezianum* P. squamulatum*, Diplosgma camerocus, Rhynchelytrum repens*, Themeda triandra*, Cynodon nlemfluensis, Chloris gayana, Harpachne schimperi, Andropogon chinensis.

Sedges: Cyperus obtusiflorus and Mariscus amauropus.

The vegetation on the western slope is formed by a dense wooded bushland dominated by Rhus natalensis, Heteromorpha trifoliata, Maytenus heterophylla, Clerodendron myricoides and Acacia seyal as high shrubs; Aspilia mossambicensis and Tinnea aethiopica as low shrubs; with scattered trees mainly Acacia seyal, A. hockii and Steganotaenia araliacea (Plate 37). The species composition comprises the following species:

Trees: Acacia seyal*, A. hockii*, A. gerrardii and Steganotaenia araliacea.

High Shrubs: Rhus natalensis, Heteromorpha trifoliata, Maytenus heterophylla, Clerodendron myricoides and Acacia seyal.

Low Shrubs: Aspilia mossambicensis, Hibiscus micranthus, H. fuscus, H. aponeurus, H. calyphyllus, Maerua triphylla, Lippia ukambensis, Ocimum suave, Rhus natalensis, Heteromorpha trifoliata, Polygonum senegalensis, Tinnea aethiopica, Tarchonanthus camphoratus, Dodonaea angustifolia, Clerodendron myricoides, Psiadia punctulata, Acacia seyal, Grewia similis and Rumex usambarensis.

Herbs: Indigofera bogdanii, Aloe graminicola, A. secundiflora, Commelina benghalensis, C. reptans, Monechma debile and Oxygonum sinuatum. Achyranthes aspera, Justicia flava, Leucas glabrata, L. martinicensis, Fuerstia africana, Notonia hildebrandtii, Senecio petitianus, P. cylindrica, Cyphostemma nierense, Aerva lanata, Hypoestes verticillaris, Indigofera brevicalyx, Euphorbia inaequilatera, E. crotonoides, Polygala sphenoptera, Pentas zanzibarica and Pycnostachys umbrosa.

Grasses: Themeda triandra*, Diplosigma camerosus, Hyparrhenia anamesa, Chloris gayana, Andropogon chinensis, Pennisetum procerum, Rhynchelytrum repens and Trichonema teneriffae.

Sedges: Cyperus impubes and C. obtusiflorus.

Plate 36. Honey Moon Vegetation: The north -eastern facing slopes of Honey Moon Hill covered with low shrubs of Aspilia mossambicensis. The ground cover is mainly contributed by Aloe secundiflora.

Plate 37. Honey Moon Vegetation: The western facing concave slopes of Honey Moon hill with a dense vegetation cover formed mainly by Rhus natalensis, Heteromorpha trifoliata, Maytenus heterophylla, Clerodendron myricoides, Acacia hockii, A. seyal and Steganotaenia araliacea.

The vegetation of Buffalo Hill is characterized by dense bush thicket and scattered trees. The characteristic shrubs are Maytenus heterophylla, Grewia bicolor, Iboza multiflora, Tarchonanthus camphoratus, Ocimum suave, Tinnea aethiopica and Rhus natalensis. The notable trees include Ficus wakefieldii, F. thonningii and Zizyphus mucronata. Species composition include:

Trees: Ficus wakefieldii, F. thonningii and Zizyphus mucronata.

High Shrubs: Tarchonanthus camphoratus, Maytenus heterophylla, Grewia bicolor, Iboza multiflora, Cordia ovalis.

Low Shrubs: Ocimum suave, Tinnea aethiopica, Rhus natalensis, Cordia ovalis, Aspilia mossambicensis, Psiadia punctulata, Hibiscus aponeurus, Helinus integrifolia, Grewia similis, Withania somnifera, Maerua triphylla, Ficus thonningii, Steganotaenia araliacea, Plectranthus barbatus, Senecio petitianus, Solanum incanum, Salix subserrata.

Herbs: Hirpicium diffusum, Oldenlandia scopulosum, Felicia muricata, Nicolasia nitens, Portulaca oleracea, Scadoxus multiflorus, Melhania ovata, Indigofera bogdanii, I. brevicalyx, Crotalaria vallicola, Justicia exigua, Ocimum basilicum, Leucas martinicensis, Senecio discifolius, Commicarpus plumbagineus, Erythrococca bongensis and Coccinia adoensis.

Sedge : Mariscus amaurorus.

Grasses: Themeda triandra, Harpachne schimperi, Hyparrhenia anamesa, Cymbopogon pospichilii, Eragrostis superba, Sporobolus stapfianus, Enneapogon schimperianus, Aristida adoensis, A. kenyensis, Pennisetum mezianum and Cynodon nlemfuensis*.

The lava ridges on Nakuru Lodge Hill form characteristic vegetation of dense bushland dominated by Cordia ovalis, Maytenus heterophylla, Senecio petitianus, Grewia bicolor and Tarchonanthus camphoratus. The scattered trees include Acacia xanthophloea, A. seyal, Euphorbia candelabrum and and Ficus cordata. Other notable low shrubs include Tinnea aethiopica, Lippia ukambensis, Ocimum suave and Cordia ovalis. The ground cover is formed by grasses. The dominant grasses include Themeda triandra and Panicum maximum. Other dominant plant species are Aloe graminicola and Sansevieria volkensii. The species composition consists of the following species:

Trees: Acacia xanthophloea, A. seyal, Euphorbia candelabrum and Ficus cordata.

High Shrubs: Cordia ovalis*, Maytenus heterophylla*, Iboza multiflora, Grewia bicolor, G. similis, Rhus natalensis, Tarchonanthus camphoratus, Opuntia sp. and Senecio petitianus.

Low Shrubs: Tinnea aethiopica*, Hibiscus micranthus, Aloe kedongensis, A. graminicola*, Erythrococca bongensis, Pavonia patens, Solanum incanum, Ziziphus mucronata, Polygonum senegalensis, Lippia ukambensis, Lantana trifolia, Senecio petitianus, Ocimum suave, Cordia ovalis, Plectranthus barbatus and Sansevieria robusta.

Herbs: Justicia exigua, Achyranthes aspera, Plectranthus caninus, P. assurgens, Plumbago zeylanica, Cyphostemma nodiglandulosum, Commelina benghalensis, Ocimum basilicum, Hypoestes verticillaris, Pellaea viridis, P. adiantoides, Cyathula cylindrica, Phragmanthera ziziphifolius, Becium obovatum, Indigofera bogdanii.

Sedges: Cyperus rigidifolius, Mariscus impubens and M. amauropus.

Grasses: Cymbopogon caesius, C. pospischilii, Cynodon nlem fuensis, Sporobolus pyramidalis, S. africanus, S. confinis, Aristida adoensis, A. kenyensis, Chloris gayana, Themeda triandra*, Cenchrus ciliaris, Panicum maximum, Hyparrhenia anamesa and Harpachne schimperi.

Riverine Vegetation:

This occurs along the river banks and floodplains, areas with alluvial deposition, clay/sandy loam soils and excessive moisture during the wet season. Larmudiac River

to the north west forms a floodplain immediately it enters the Park. The floodplain is frequently flooded during the wet season and supports a rich vegetation with a dense undergrowth. The trees include Acacia xanthophloea and Dombeya burgessiae. The characteristic shrubs include Ricinus communis, Maerua triphylla, Dombeya burgessiae, Rhus natalensis, Solanum incanum and Grewia similis. The dense herbaceous cover is contributed mainly by Urtica massaica. Other herbs include Justicia flava, Hypoestes verticillaris, Achyranthes aspera and Datura stramonium. Lianes/Climbers and twinners include Capparis tomentosa, Phytolacca dodecandra, Grewia similis and Zehneria scabra.

The Njoro River to the north west, enters into a dense Acacia xanthophloea woodland immediately it crosses the Park boundary and therefore has no chance of forming a distinct vegetation of itself for as soon as it leaves from the woodland it enters into the lakeshore. However, Acacia xanthophloea, Ficus cordata, F. thonningii and F. sur are the major tree species found along its watercourse. Shrubs include Dombeya burgessiae, Nicotiana glauca, Cassia didymobotrya, Sesbania sesban, Buddleja polystachya, Rhus natalensis, Abutilon holstii, Ricinus communis, Hibiscus calyphyllus, and Solanum incanum. Herbs include Crotalaria agatiflora, Phaulopsis imbricata, Hypoestes verticillaris, Urtica massaica, Cyathula cylindrica, Galinsoga parviflora, Kalanchoe lanceolata, Conyza bonariensis, Spilanthes mauritianus,

Tagetes minuta, Amaranthus spinosa, Datura stramonium, Verbena bonariensis, Ageratum conyzoides, Gnaphalium luteo-album and Achyranthes aspera. Pteridophytes included Adiantum thalictroides and Doryopteris concolor. Grasses included Cynodon nlem.fuensis, C. dactylon and Sporobolus spicatus.

The vegetation along Makalia river to the south is the most typical of a riverine vegetation in the Park and with a wide floristic variation. However, it was conveniently subdivided into two sections:

(a). **Makalian Falls Vegetation Complex**: It consists of a scrub forest, a term used by White (1983) to denote a vegetation that is intermediate in structure between true forest and bushland and thicket; trees with well-defined and upright boles are usually present but do not form a closed canopy, the bushes and shrubs contributing at least as much as the trees to the appearance of the vegetation and its phytomass (Plate 38). The tree species include Acacia xanthophloea, Cussonia holstii, Olea africana, Warburgia ugandensis, Euphorbia candelabrum, Tarenna graveolens, Ficus sur and F. wakefieldii. High shrubs include Maytenus heterophylla, Cordia ovalis, Tarchonanthus camphoratus, Teclea simplicifolia, Rhus natalensis, Grewia similis, Opuntia sp., Buddleja polystachya,

Plate 38. Riverine vegetation. Makalian Falls Vegetation Complex at the top of the River Makalia Falls.

Plate 39. Riverine Vegetation along Makalia River (downstream).

Obetia pinnatifida, Maerua triphylla, Dombeya burgessiae and Psydrax schimperianum. Low shrubs are Tinnea aethiopica, Zizyphus mucronata, Maytenus heterophylla, Aspilia mossambicensis, Aloe kedongensis, Plectranthus barbatus, Psiadia punctulata, Rhus natalensis, Maerua triphylla, Acacia xanthophloea, Lippia ukambensis, Ocimum suave, Helinus integrifolia, Pavonia patens, Abutilon longicuspe and Carissa edulis. Lianes include Phytolacca dodecandra, Hyppocratea africana, Dregea schimperi, Senecio petitianus, Pterolobium stellatum, Sarcostemma viminale, Cyphostemma nierense, Gynura scandens and Basella alba. Undergrowth plants include Sansevieria parva, S. volkensii, Plectranthus cylindraceus, Commelina benghalensis, Hypoestes verticillaris, Tagetes minuta, Leucas glabrata, Notonia hildebrandtii, Crotalaria incana and Indigofera brevicalyx. The grasses consist of Themeda triandra, Chloris gayana, Aristida kenyensis, A. adoensis, Sporobolus pyramidalis, Setaria verticillata and Cynodon nlem fuensis.

(b). Makalian Vegetation Downstream: The high and low shrubs, the lianes, climbers and twiners form a dense vegetation cover on the river banks with trees as emergents (Plate 39). The trees include Acacia xanthophloea, A. albida, Ficus sur, Albizia gummifera, Ekebergia capensis, Ehretia cymosa, Salix subserrata and Euclea divinorum. The high shrubs comprised Maerua triphylla, Buddleja polystachya, Hibiscus

calyphyllus, Grewia similis, Cordia ovalis, Teclea simplicifolia, Canthium lactescens, Rhus natalensis, Nicotiana glauca, Cassia didymobotrya, Dombeya burgessiae, Euclea divinorum, Dovyalis caffra and Vernonia auriculifera. Low shrubs include Ricinus communis, Teclea simplicifolia, Solanum incanum, Erythrococca bongensis, Abutilon longicuspe, A. holstii, Helinus integrifolius, Ocimum suave, Rhus natalensis, Dombeya burgessiae, Maytenus heterophylla, Pavonia patens, Sesbania sesban, Zizyphus mucronata and Withania somnifera. Lianes include Pterolobium stellatum, Capparis tomentosa, Senecio petitianus, S. lyratipartitus, Hyppocratea africana, Phytolacca dodecandra, Periploca linearifolia, Stephania abyssinica, Cyphostemma nierense, C. nodiglandulosum, Dregea schimperi, Zehneria scabra, Ipomoea cairica and Toddalia asiatica. Herbaceous cover is contributed by Hypoestes verticillaris, Kalanchoe lanceolata, Commelina benghalensis, Gutenbergia cordifolia, Tagetes minuta, Achyranthes aspera, Urtica massaica, Tephrosia emeroides, Crotalaria agatiflora, Leonotis nepetifolia, Leucas grandis, Datura stramonium, Notonia hildebrandtii and Verbena bonariensis. Grasses are Pennisetum holenaekeri, Panicum maximum, Setaria verticillata, Cynodon nlem f.uensis, Digitaria velutina, Sporobolus confinis and Chloris pycnothrix.

The vegetation of Nderit river to the south east is characterized by the presence of unique stand of Acacia albida and Acacia abyssinica trees, absence of dense high

shrub layer, absence of clumps of lianes (except a few) and presence of dense undergrowth cover (Plate 40). Other tree species include Acacia xanthophloea, Cussonia holstii, Schinus molle, Euphorbia candelabrum, Warburgia ugandensis and Ficus sur. The high shrubs comprised Buddleja polystachya, Maytenus heterophylla, Teclea simplicifolia, Rhus natalensis, Cassia didymobotrya, Dovyalis caffra, Grewia similis, Acacia xanthophloea, Warburgia ugandensis, Maerua triphylla and Cordia ovalis. Low shrubs include Maerua triphylla, Solanum incanum, Abutilon engleranum, Opuntia sp., Erythrococca bongensis, Helinus integrifolia, Aloe graminicola, Maytenus heterophylla, Hibiscus fuscus, H. aponeurus, H. vitifolius, Crotalaria agatiflora, Pavonia patens, Ricinus communis, Rhus natalensis, Acacia xanthophloea, Teclea simplicifolia, Sesbania sesban, Aspilia mossambicensis, Psiadia punctulata, Sansevieria parva, Euphorbia candelabrum, and Withania somnifera. Lianes include Pergularia daemia, Pterolobium stellatum, Dregea schimperi, Phytolacca dodecandra, Zehneria scabra, Rhus natalensis, Hyppocratea africana, Senecio petitianus, Capparis tomentosa and Cyphostemma nierense. Herbs include Commelina benghalensis, Achyranthes aspera, Melhania ovata, Hypoestes verticillaris, Celosia anthelmintica and Kalanchoe densiflora. Grasses consist of Pennisetum hohenaekeri, Setaria verticillata, Panicum maximum and Cynodon nlemfuensis.

Naishi river system to the south west consists of a dry rivercourse with characteristic riparian vegetation. The

Plate 40. Riverine vegetation along Nderit River characterised by *Acacia albida* and *Acacia abyssinica* trees.

trees include Acacia xanthophloea, Euclea divinorum, Ficus sur, Cussonia holstii, Warburgia ugandensis and Olea africana. High shrubs are Acacia xanthophloea, Cassia didymobotrya, Maerua triphylla, Teclea simplicifolia and Tarchonanthus camphoratus. Low shrubs include Acacia xanthophloea, Solanum incanum, Helinus integrifolia, Gnidia subcordata, Abutilon longicuspe, Ocimum suave, Erythrococca bongensis, Grewia similis, Dombeya burgessiae, Rhus natalensis, Pavonia patens, Ricinus communis, Maytenus heterophylla and Maerua triphylla. Lianes include Cyphostemma nierense, Clematis brachiata, Stephania abyssinica, Phytolacca dodecandra, Dregea schimperi, Capparis tomentosa, Ipomoea cairica, Basella alba, Pterolobium stellatum, Momordica foetida, Zehneria scabra, Rhus natalensis, Grewia similis, Grewia similis, Senecio petitianus, Pergularia daemia, Hyppocratea africana and Sarcostemma viminale. Herbs are characterized by Achyranthes aspera, Hypoestes verticillaris, Sida tenuicarpa, S. rhombifolia, Justicia flava, J. heterocarpa, J. exigua, Cyathula cylindrica, Urtica massaica, Commelina benghalensis and Gloriosa superba. Grasses include Cynodon nlemfuensis and Setaria verticillata.

Sewage Influenced Vegetation

This covers a small area to the north where"Sukuma Wiki" farmers were utilizing 'Sewage Catchment' area to grow

vegetables but were evicted later (1986) to give way to natural vegetation. The abandoned farmland has attracted many species particularly grasses, annual and perennial colonizers that exhibit a rapid preoccupation to form a secondary succession vegetation (Plate 41). However occasional flooding of the sewage discharge occurs, the effect of which promotes exuberant vegetation undergrowth in the Acacia xanthophloea woodland next to the lake (Plate 42). The vegetation is characterized by shrubs dominated by Ricinus communis, Cassia didymobotrya, Vernonia auriculifera, Dombeya burgessiae, Solanum aculeastrum, S. mauense, Datura stramonium, Lantana camara, Nicotiana glauca, Scutia myrtina, Solanum incanum, Withania somnifera, Abutilon longicuspe, A. engleranum, A. holstii, Cassia bicapsularis, Warburgia ugandensis and Pavonia patens; trees of Acacia xanthophloea, Erythrina lysistemon, Schinus molle and Croton megalocarpus; Lianes that include Ipomoea cairica, I. wightii, Pergularia daemia, Cyathula cylindrica, Cyphostemma nierense, Lagenaria siceraria, Cynanchum altiscandens, Stephania abyssinica, Phytolacca dodecandra, Zehneria scabra, Commicarpus plumbagineus, Achyranthes aspera, Senecio lyratipartitus, Crassocephalum vitellinum and Periploca linearifolia; herbs composed of Kalanchoe densiflora K. laciniata, Physalis peruviana, P. ixocarpa, Leonotis nepetifolia, Achyranthes aspera, Tagetes minuta, Urtica massaica, Amaranthus spinosa, A. hybridus,

Vernonia galamensis, Solanum nigrum, Galinsoga parviflora, Tribulus terrestris and Commelina benghalensis. Grasses include Cynodon dactylon, C. nlemfuensis, Setaria pumila and Pennisetum clandestinum.

Plate 41. Sewage influenced vegetation and disturbed land. Vegetation formation is mainly Cassia didymobotrya, Ricinus communis, Datura stramonium and Cynodon nlemfuensis.

Plate 42. Sewage influenced vegetation. Along the sewage pathway in Acacia xanthophloea forest there is an exuberant vegetation undergrowth dominated by Ricinus communis.

4. 2. VEGETATION CLASSIFICATION AND MAPPING

Plant communities are abstracts of vegetation types that group together a number of particular plant communities by some characteristics they share (Whittaker, 1975). The practical purpose of vegetation classification analysis in this study was to define the vegetation types described above to evidence the various plant communities which could be used as mapping units. The classification was determined using physiognomic structural and floristic characteristics derived from the field data collected from 78 releves in which 220 species were identified and their abundance cover values recorded on a six-unit scale given below:

1 = Cover less than	5 %
2 = Cover	5 - 10 %
3 = Cover	10 - 25 %
4 = Cover	25 - 50 %
5 = Cover	50 - 75 %
6 = Cover more than	75 %

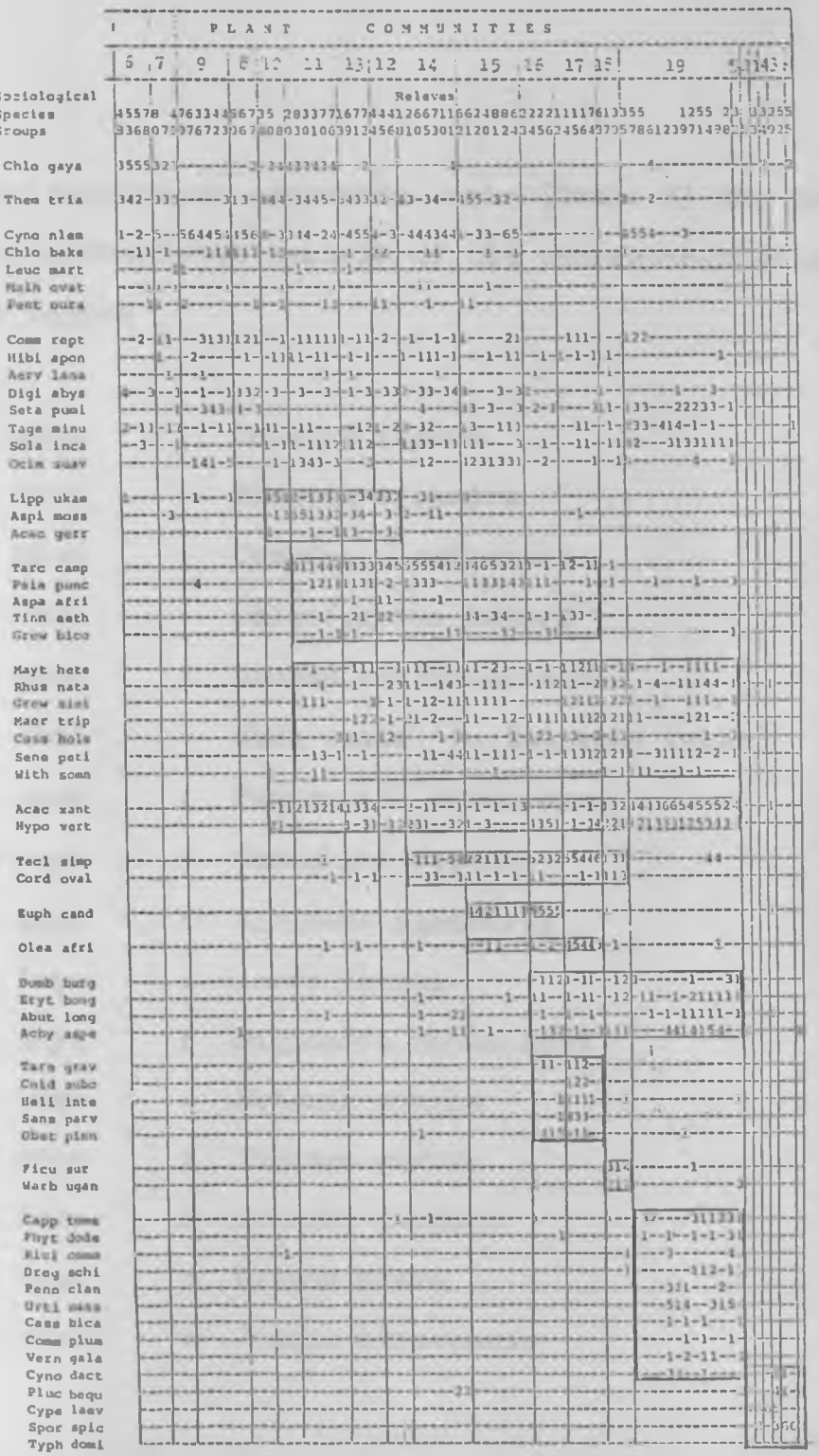
A Twinspan computer ordination programme (Hill, 1979), based on Braun-Blanquet tabulation technique (Mueller - Dombois and Ellenberg, 1974; Loth and Prins, 1986) was used to determine the sociological species groups - species

with similar distribution patterns in the releve matrix, which could be used to characterize plant communities. Out of the total 220 species only 61 species were used in the construction of the vegetation community table (Table 2). The rest of the species were either rare (occurring less than three times) or of uncertain occurrence and were omitted from the table for clarity.

The vegetation community table was arranged in a matrix format in which the rows are plant species and the columns the releves. Both the species and the releves were rearranged several times so as to obtain a matrix with clusters of species (sociological species groups) and clusters of releves (Plant Communities). The distribution of species in the table was studied with particular attention to species that are present neither in almost all the releves (indicative of high constancy), nor in very few releves (indicative of low constancy). This is because for grouping releves series into plant communities, neither the species with a high constancy nor those with a low constancy are usually useful. The species with a high constancy are more or less characteristic for the entire releve' series under comparison. The species with a low constancy may be considered as more or less accidental occurrences (Mueller-Dombois and Ellenberg, 1974). Species and groups of species that could be used to characterize different kinds of plant

communities represented in the vegetation community table were diligently sought. Finally sets of diagnostic species (those outlined in boxes) were distinguished as character-species that were centred in a particular kind of plant community.

Table 2. Vegetation Differentiation Table showing various plant communities.



In the vegetation community table (Table 2) the full names of the abbreviated symbols of the character-species are shown below:

Chlo gaya	:	Chloris gayana
Them tria	:	Themeda triandra
Cyno nlem	:	Cynodon nlemfuensis
Chlo bake	:	Chlorophytum bakeri
Leuc mart	:	Leucas martinicensis
Sida ovat	:	Sida ovata (= Melhania ovata)
Pent oura	:	Pentanisia ouranogyne
Comm rept	:	Commelina reptans
Hibi apon	:	Hibiscus aponeurus
Aerv lana	:	Aerva lanata
Digi abys	:	Digitaria abyssinica
Seta pumi	:	Setaria pumila
Tage minu	:	Tagetes minuta
Sola inca	:	Solanum incanum
Ocim suav	:	Ocimum suave
Lipp ukam	:	Lippia ukambensis

Aspi moss	:	Aspilia mossambicensis
Acac gerr	:	Acacia gerrardii
Tarc camp	:	Tarchonanthus camphoratus
Psia punc	:	Psiadia punctulata
Aspa farc	:	Asparagus falcatus
Tinn aeth	:	Tinnea aethiopica
Grew bico	:	Grewia bicolor
Mayt hete	:	Maytenus heterophylla
Rhus nata	:	Rhus natalensis
Grew simi	:	Grewia similis
Maer trip	:	Maerua triphylla
Cuss hols	:	Cussonia holstii
Sene peti	:	Senecio petitianus
With somn	:	Withania somnifera
Acac xant	:	Acacia xanthophloea
Hypo vert	:	Hypoestes verticillaris
Tecl simp	:	Teclea simplicifolia
Cord oval	:	Cordia ovalis
Euph cand	:	Euphorbia candelabrum
Olea afri	:	Olea africana
Domb burg	:	Dombeya burgessiae
Eryt bong	:	Erythrococca bongensis
Abut long	:	Abutilon longicuspe
Achy aspe	:	Achyranthes aspera
Tare grav	:	Tarenna graveolens
Gnid subc	:	Gnidia subcordata

Heli inte : Helinus integrifolia
Sans parv : Sansevieria parva
Obet pinn : Obetia pinnatifida
Ficu sur : Ficus sur
Warb ugan : Warburgia ugandensis
Capp tome : Capparis tomentosa
Phyt dode : Phytolacca dodecandra
Rici comm : Ricinus communis
Dreg schi : Dregea schimperi
Penn clan : Pennisetum clandestinum
Urti mass : Urtica massaica
Cass bica : Cassia bicapsularis
Comm pedu : Commicarpus pedunculosus
Vern gala : Vernonia galamensis
Cyno dact : Cynodon dactylon
Pluc bequ : Pluchea bequaertii
Cype laev : Cyperus laevigatus
Spor spic : Sporobolus spicatus
Typh domi : Typha domingensis

Thorough investigation on the distribution patterns of the character-species within the releve series led to the differentiation of the Vegetation of the Park into nineteen plant communities and six groups of plant communities all of which are embodied in the Vegetation Community table (Table 2). The vegetation classification was summarized as follows:

Group of Plant Communities	No.	Plant Community
I Alkaline Grasslands	1	Cyperus laevigatus Community
	2	Sporobolus spicatus - Cyperus laevigatus Community
	3	Sporobolus spicatus Community
	4.1	Pluchea **bequaertii** - Cyperus laevigatus Community
	4.2	Pluchea **bequaertii** - Sporobolus spicatus Community
	5	Pluchea **bequaertii** - Typha domingensis Community
II Plain Grasslands	6	Chloris **gayana - Digitaria abyssinica** Community
	7	Chloris gayana - Themeda triandra Community
	8	Cynodon nlemfuensis - Digitaria abyssinica Community
	9	Cynodon nlemfuensis - Themeda triandra Community
	10	Complex: Chloris gayana and Cynodon nlemfuensis with Acacia garrardii and A. seyal

Group of Plant Communities	No.	Plant Community
IIa Plain Wooded Grassland	11	Cynodon nlemfuensis - Acacia xanthophloea Community
	12	Tarchonanthus camphoratus - Acacia gerrardii Community
	13	Tarchonanthus camphoratus - Acacia xanthophloea Community
III Tarchonanthus Bushlands	14	Tarchonanthus camphoratus - Psiadia punctulata Community
	15	Tarchonanthus camphoratus - Euphorbia candelabrum Community
IV Euphorbia forest	16	Euphorbia candelabrum - Teclea simplicifolia Community
V Olea forest	17	Olea africana - Teclea simplicifolia Community
VI Acacia xanthophloea forest	18	Acacia xanthophloea - **Ficus** sur Community
	19	Acacia xanthophloea - Urtica massaica Community

In the course of vegetation survey, site characteristics such as water availability, drainage conditions, surface stoniness, slope steepness, erosion type, soil type, depth, texture, consistence, colour, pH and salinity, were estimated in the field for every releve studied. Terrain features outside the releves were determined solely by aerial photograph interpretation. A further particularly useful source of information was the quarter degree geological map of Nakuru Area prepared by McCall (1967) for the Mines and Geology Department. The landscape characteristics were integrated with the vegetation classification interpretations contained in Table 2 to develop an ecological vegetation map of the Park.
For the purpose of vegetation mapping, the landscape was subdivided into twenty nine map units that were grouped into five main geological formations i.e. Lacustrine basin, Plains, Volcanic ridge (Lion Hill), Tuff cones and Step-faulted plateau (Lower Mau escarpment). The distribution of the classified plant communities were seen to coincide with the landscape subdivisions.

The vegetation structure of each plant community and the proportion of the total area covered by that community in the Park is shown on the map. The vegetation structure of various plant communities of woody species is indicated

on the map by hatching - also shown on the map sheet as "Key to Vegetation structure". The cover by trees is plotted on the abscissa, while the cover of shrubs is plotted on the ordinate. Starting from grassland (G) with total cover of woody species less than 2 percent, an increase of shrub cover leads via bushed grassland (B G, total cover of woody species 2 to 20 percent, predominantly shrubs), bushlands (B, 20 to 40 percent, also predominantly shrubs), dense bushland (Bd, 40 to 80 percent) to bush thicket (Bt, more than 80 percent). A total cover exceeding 100 percent is possible if some trees also occur. Similarly, increase in cover predominantly by trees leads from grassland via wooded grassland (WG), woodland (W), dense woodland (Wd) to forest (F, more than 100 percent). If the proportion of shrubs and trees in the total cover was approximately equal, the sequence from grassland became wooded and bushed grassland (W B G), wooded bushland (WB), dense wooded bushland (WBd) and wooded bushland thicket (WBt). When the total cover exceeded 100 percent, the cover by trees approximated a closed canopy and was therefore classified as forest (Loth and Prins, 1986).

4. 3. VEGETATION STRUCTURE

The purposes of quantitative analysis was to characterise more adequately floristic interrelationships between the forests and the bushlands in terms of the predominant woody elements. As most species of the woody plants were widely distributed in the twenty four transects studied, the data from P.C.Q. records were compiled and computed using Reciprocal Averaging Ordination technique. The data were analysed using an Importance Value characterisation that was obtained by the summation of the relative density and Relative dominance. Relative frequency was not included in the summation as it is similar to the Relative density in P.C.Q. records (Agnew, Payne and Waterman, 1983).

A total of 59 species were considered as woody species components of the vegetation and their respective relative importance values analysed using tabulation method obtained by Reciprocal Averaging (Table 3a). A hierarchy was produced after the rearrangement of the species in the order of their Relative Importance Values (RIV), starting with the species with the highest value to that with the lowest value (Table 3b). The RIV order explains the floristic significance of each woody species in the Park. Moreover, the hierarchic rating also reveals the overall position of each species in relation to the rest of the woody elements.

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Table 3a. Computer print out showing the total records of relative importance values scored by each woody species sampled. In the table, the full names of the abbreviated symbols of the plant species are shown in Table 3b.

RECIPROCAL AVERAGING BY HILLS 1973 J.ECOL. PROCEDURE

NAKURU VEGETATION 1987

SPECIES NAME	TOTAL RECORDS	FIRST AXIS	RANK	SECOND AXIS
ABUTILON LONG	15	34.03701	50	65.90764
ACACIA GERRAR	2	76.7302	17	90.20768
ACACIA XANTHO	56	12.96673	53	67.10272
ASPILIA MOSSA	11	76.3602	18	94.4571
CANTHIUM SCHI	6	77.99709	15	92.16876
CAPPARIS TOME	6	9.012209	56	39.36957
CELOSIA ANTHE	5	36.47497	49	72.27663
CLERODEN MYRI	5	92.1826	11	99.99999
COMMICAR.PLU	6	17.44124	51	46.36484
CORDIA OVALI	26	55.19485	42	85.23573
CRASSOCE.MAN	4	56.67283	41	82.26966
CROTON DICHO	1	41.91081	35	70.16355
CUSSONIA HOLS	12	64.97611	31	85.3[illegible]
CYPHOSTE.NODI	3	75.49571	19	74.6631
DOMBEYA BURG	12	59.87628	36	73.55827
DREGIA SCHIMP	5	7.074493	57	33.16816
ERYTHROC BONG	22	43.57518	47	69.1119
EUCLEA DIVINO	10	74.2015	20	74.6799
EUPHORBIA CAN	44	68.09257	30	83.02556
GREWIA SIMILI	44	59.47566	37	71.6424
GNIDIA SUBCOR	7	73.35402	22	67.22
HELINUS INTEG	7	71.29364	24	70.55615
HETEROMO.TRI	1	83.17209	10	72.67048
HIBISCUS CALY	2	78.17555	14	64.64983
HIBISCUS FUSC	20	69.54701	28	71.90255
HIBISCUS MICR	18	84.07831	8	77.25078
IBOZA MULTIFL	4	59.23391	39	70.42583
LIPPIA UKAMBE	26	85.86388	5	77.759
LYCIUM EUROPE	1	10.33585	55	45.27241
MAERUA TRYPHY	27	64.39788	33	64.20355
MAYTENUS HETE	44	53.04438	44	62.43084
OBETIA PINNAT	19	62.4877	34	63.64805
OCIMUM SUAVE	26	82.58425	12	69.32746
OLEA AFRICANA	32	73.9361	21	65.36256
OSYRIS COMPRE	1	59.35178	38	64.22131
PAVONIA PAT	13	49.51741	46	47.18879
PEPONIUM VOGE	14	69.99424	25	62.67085
PHYTOLACCA DO	1	80.20088	13	51.44582
PLECTRAN BART	2	84.63906	7	83.21726
PSIADIA PUNCT	31	84.07152	9	68.[illegible]042
PTEROLOB STEL	4	37.78906	48	36.56217
RHUS NATALENS	40	49.52414	45	45.28721
RICINUS COMMU	2	0	59	9.855794
SARCOST VIMIN	14	69.4283	29	50.44641
SCHREBERA ALA	2	100	1	57.23956
SENECIO PETIT	41	71.12038	25	51.32146
SOLANUM INCAN	30	69.7107	27	48.33452
STEGANOT ARAL	4	54.6375	43	46.65172
CYNANCH ALTIS	9	56.73551	40	54.49696
TARCHON CAMPH	71	87.56836	3	59.00929
TARENNA GRAVE	23	76.95863	16	55.87272
TECLEA SIMPLI	44	71.64783	23	51.[illegible]6413
TINNEA AETHIO	21	87.14762	4	61.27783
TODDALIA ASIA	5	16.58266	52	9.[illegible]2161
VERNONIA BRAC	4	85.51104	6	52.04359
VERNONIA GALA	4	12.51987	54	1.724567
WARBURGIA UGA	1	64.6168	32	51.[illegible]6241
WITHANIA SOMN	1	2.171348	58	0
ZIZYPHUS MUCR	1	96.85913	2	59.06071

From Table 3b, Tarchonanthus camphoratus assumes the first position (RIV = 71), followed by Acacia xanthophloea (RIV = 56). The third position is shared among four plant species namely, Euphorbia candelabrum, Grewia similis, Maytenus heterophylla and Teclea simplicifolia (RIV = 44 each). The fourth and five positions are taken by Senecio petitianus (RIV = 41) and Rhus natalensis (RIV = 40) respectively.

Table 3b. Revised order of Table 3a, showing the hierarchy of Species Importance.

Species	RIV	Position
Tarchonanthus camphoratus	71	1
Acacia xanthophloea	56	2
Euphorbia candelabrum	44	3
Grewia similis	44	
Maytenus heterophylla	44	
Teclea simplicifolia	44	
Senecio petitianus	41	4
Rhus natalensis	40	5
Olea africana	32	6
Psiadia punctulata	31	7
Solanum incanum	30	8
Maerua triphylla	27	9
Cordia ovalis	26	10
Lippia ukambensis	26	
Ocimum suave	26	

Tarenna graveolens	23	11
Erythrococca bongensis	22	12
Tinnea aethiopica	21	13
Hibiscus fuscus	20	14
Obetia pinnatifida	19	15
Hibiscus micranthus	18	16
Abutilon longicuspe	15	17
Peponium vogelii	14	18
Sarcostemma viminale	14	
Pavonia patens	13	19
Cussonia holstii	12	20
Dombeya burgessiae	12	
Aspilia mossambicensis	11	21
Euclea divinorum	10	22
Cynanchum altiscandens	9	23
Gnidia subcordata	7	24
Helinus integrifolia	7	
Capparis tomentosa	6	25
Canthium (Psydrax) schimperianus	6	
Commicarpus plumbagineus	6	
Celosia anthelmintica	5	26
Clerodendron myricoides	5	
Dregea schimperi	5	
Toddalia asiatica	5	

Crassocephalum mannii	4	
Iboza multiflora	4	
Pterolobium stellatum	4	27
Steganotaenia araliacea	4	
Vernonia brachycalyx	4	
Vernonia galamensis	4	
Cyphostemma nodiglandulosum	3	28
Acacia gerrardii	2	
Hibiscus calyphyllus	2	
Plectranthus barbatus	2	29
Ricinus communis	2	
Schrebera alata	2	
Croton dichogamus	1	
Heteromorpha trifoliata	1	
Lycium europaeum	1	
Osyris abyssinica	1	
Phytolacca dodecandra	1	30
Warburgia ugandensis	1	
Withania somnifera	1	
Zizyphus mucronata	1	

The number of individuals, basal area and height measurements of each woody species with RIV equals or greater than 10 are given in Table 4. Tarchonanthus camphoratus has the highest

Table 4. Number of individuals, basal area and height measurements of woody species with relative importance value equal or more than ten.

Species	Individual Total	Basal Area cm^2 Total	Mean	Average Height (M)
Tarchonanthus camphoratus	303	889813	2937	3·5
Acacia xanthophloea	183	732224	4001	3·5
Euphorbia candelabrum	180	248732	1382	20
Grewia similis	175	26047	149	3 (liane)
Maytenus heterophylla	155	14858	96	3·5
Teclea simplicifolia	291	19022	65	10·0
Senecio petitianus	186	13207	71	3 (liane)
Rhus natalensis	161	21469	133	7 (liane)
Olea africana	81	74941	925	16
Psiadia punctulata	254	3138	12	1·6
Solanum incanum	202	325	2	1·5
Maerua triphylla	167	25491	153	4 (liane)
Cordia ovalis	70	68468	978	5
Lippia ukambensis	162	2750	17	2
Ocimum suave	190	2446	13	1·4
Tarenna graveolens	80	9411	118	6·5
Erythrococca bongensis	128	7888	62	2·5
Tinnea aethiopica	182	7732	42	2·5
Hibiscus fuscus	106	313	3	1·5
Hibiscus micranthus	99	342	3	1·5
Obetia pinnatifida	118	20458	173	13
Abutilon longicuspe	137	1563	11	2
Peponium vogelii	58	514	9	liane
Sarcostemma viminale	61	739	12	liane
Pavonia patens	46	117	3	1·7
Cussonia holstii	18	39582	2199	20
Dombeya burgessiae	62	7379	119	3·5
Aspilia mossambicensis	88	3609	41	2
Euclea divinorum	48	19086	398	14

number of individuals (303) followed by Teclea simplicifolia (291), Psiadia punctulata (254), Solanum incanum (202) and Ocimum suave (190). Tarchonanthus camphoratus also dominates the total basal area measurements (889,813 cm^2) followed by Acacia xanthophloea (732,224 cm^2) Euphorbia candelabrum (248,732 cm^2), Olea africana (74941 cm^2) and Cordia ovalis (68,468 cm^2). However, following the mean basal area, Tarchonanthus camphoratus still leads with (29,370 cm^2) followed by Acacia xanthophloea (4,001 cm^2), Cussonia holstii (2,199 cm^2), Euphorbia candelabrum (1,382 cm^2) and Cordia ovalis (978 cm^2).

The tallest tree species is Acacia xanthophloea with an average height of 35 m. tall followed by Cussonia holstii and Euphorbia candelabrum which are up to 20 m. tall each. The majority of the high shrubs have an average height of 3·5 metres and the low shrubs more or less 2 metres. Some species (i.e. Grewia similis, Senecio petitianus, Rhus natalensis and Maerua triphylla) have been found to exist in two forms; as a bushy shrub as well as a liane.

The floristic analysis in terms of relative importance value of the woody species in each of the twenty four transects (quadrats) is given in Table 5. The information

QUADRAT NUMBER	TOTAL RECORDS	FIRST AXIS	RANK	SECOND AXIS
1	50	77.5877	10	65.1201
2	36	92.14483	3	67.76715
3	43	76.25528	11	54.36864
4	48	75.84986	12	73.27841
5	34	22.55623	20	39.59097
6	36	24.82808	19	9.346336
7	38	17.08451	22	0
8	42	59.1761	18	89.93066
9	37	68.16372	15	64.41381
10	51	64.54186	16	74.34821
11	50	62.65844	17	71.43789
12	40	90.07934	4	83.86571
13	33	95.86498	2	61.58032
14	27	100	1	63.02534
15	41	78.13378	9	81.50068
16	42	84.38849	6	89.90894
17	45	83.0263	7	99.21909
18	41	86.73094	5	100
19	36	82.0208	8	69.74592
20	34	69.86366	13	60.55559
21	34	68.89763	14	84.30068
22	27	8.880958	23	3.873552
23	28	19.96538	21	43.91446
24	19	0	24	86.90051

Table 5. Computer print out showing the total records of Relative Importance Values scored in each transect (referred in the table as quadrat) sampled.

contained in this table was also obtained using Reciprocal Average Ordination tabulation technique. The five transects with the leading RIV total records include Transect Number 1, RIV = 50; 4, RIV = 48; 10, RIV = 51; 11, RIV = 50 and 17, RIV = 49. Transects 1 and 4 were located in Olea forest, 10 and 11 occurred in Euphorbia candelabrum forest and transect 17 was situated in Euphorbia candelabrum - Tarchonanthus camphoratus bushland. However, low RIV values were recorded particularly in all Acacia xanthophloea habitats. In Acacia xanthophloea forest, transects 5, 6, 7 and 22 scored 34, 36, 38 and 27 RIV total records respectively. Transects 19, 20 and 21 in Acacia xanthophloea - Tarchonanthus camphoratus bushland scored 36, 34 and 34 respectively whereas transects 23 and 24 located in Acacia xanthophloea woodland (sometimes referred to as wooded Acacia xanthophloea grassland) scored 28 and 19 RIV total records respectively.

The species abundance among the major plant communities was estimated to assess the degree of occurrence as well as the floristic contribution of each species to the general vegetation cover (Table 6).

In order to illustrate the general physiognomy and structural stratification of the major forest and bushland vegetation types, namely Acacia xanthophloea forest,

Table 6. Absolute frequency of the woody species showing the occurrence of each species in the five major vegetation types. The values are expressed as percentages (%).

Species	Acacia Forest	Euphorbia Forest	Olea Forest	Acacia Tarchon. Bushland	Euphorbia Tarchon. Bushland
Abutilon longicuspe	78	17	21	23	
Acacia gerrardii				13	5
Acacia xanthophloea	98	14		90	
Aspilia mossambicensis			11	37	40
Canthium schimperianum		9	14		18
Capparis tomentosa	75				
Celosia anthelmintica	13	17			
Clerodendron myricoides					35
Commicarpus plumbagineus	53				
Cordia ovalis		34	4	13	50
Crassocephalum mannii		34			
Croton dichogamus				7	
Cussonia holstii		23	14		10
Cyphostemma nodiglandulosum			39		
Dombeya burgessiae	3	69	46		
Dregea schimperi	40				
Erythrococca bongensis	45	26	36	43	13
Euclea divinorum		9	79		
Euphorbia candelabrum		91			93
Grewia similis	28	69	68	20	75
Gnidia subcordata	3		50		
Helinus integrifolia		9	36		
Heteromorpha trifoliata				3	
Hibiscus calyphyllus					
Hibiscus fuscus	5	49	71	17	43
Hibiscus micranthus				60	45
Iboza multiflora		20			

Species	Acacia Forest	Euphorbia Forest	Olea Forest	Acacia Tarchon. Bushland	Euphorbia Tarchon. Bushland
Lippia ukambensis			7	37	85
Lycium europaeum	5				
Maerua triphylla	33	54	79	10	30
Maytenus heterophylla	38	11	25	67	70
Obetia pinnatifida	3	100	25		
Ocimum suave	10			43	80
Olea africana		63	79		8
Osyris compressa		3			
Pavonia patens	33	20	36		
Peponium vogelii		57	57	3	
Phytolacca dodecandra	5				
Plectranthus barbatus					8
Psiadia punctulata		43		57	98
Pterolobium stellatum	5	11			
Rhus natalensis	35	74	46	47	15
Ricinus communis	8				
Sarcostemma viminale	8	6	82	13	
Schrebera alata			7		
Senecio petitianus	63	17	93	50	63
Solanum incanum	63		18	63	48
Steganotaenia araliacea				20	
Cynanchum altiscandens	8	54			
Tarchonanthus camphoratus		11	43	100	95
Tarenna graveolens		57	57		15
Teclea simplicifolia	25	94	96	7	70
Tinnea aethiopica		9	21		98
Toddalia asiatica	45				
Vernonia brachycalyx			29		
Vernonia galamensis	38				
Warburgia ugandensis		6			
Withania somnifera	8				
Zizyphus mucronata					

Euphorbia candelabrum forest, Olea africana forest, Acacia xanthophloea - Tarchonanthus camphoratus bushland and Euphorbia candelabrum - Tarchonanthus camphoratus bushland, profile diagrams (figs 7a, b, c, d and e) were prepared from the field sketches. The floristic characteristics of each of these plant communities are given in Table 7 (a, b, c, d and e) using representative transects.

It is clear from the floristic information inferred in this section that the vegetation types differ in structure as well as in species composition. The Acacia forest is made up of a homogeneous stand of Acacia xanthophloea trees with an occurrence frequency of 98 percent start to branch off beyond the height of 20 m, the zone where branches interlace together to form a closed canopy of about 30 m. high. Due to the small size of the leaves and their leaflets, enough sunlight is allowed to penetrate the tree canopy to give live to the dense undergrowth (fig 7a). The shrub layer is almost lacking save a few shrubs that are sparingly scattered comprised mainly of Erythrococca bongensis, Maytenus heterophylla, Rhus natalensis, Pavonia patens, Maerua triphylla, Teclea simplicifolia and Grewia similis, with low occurrence frequency values between 20 and 50 percent.

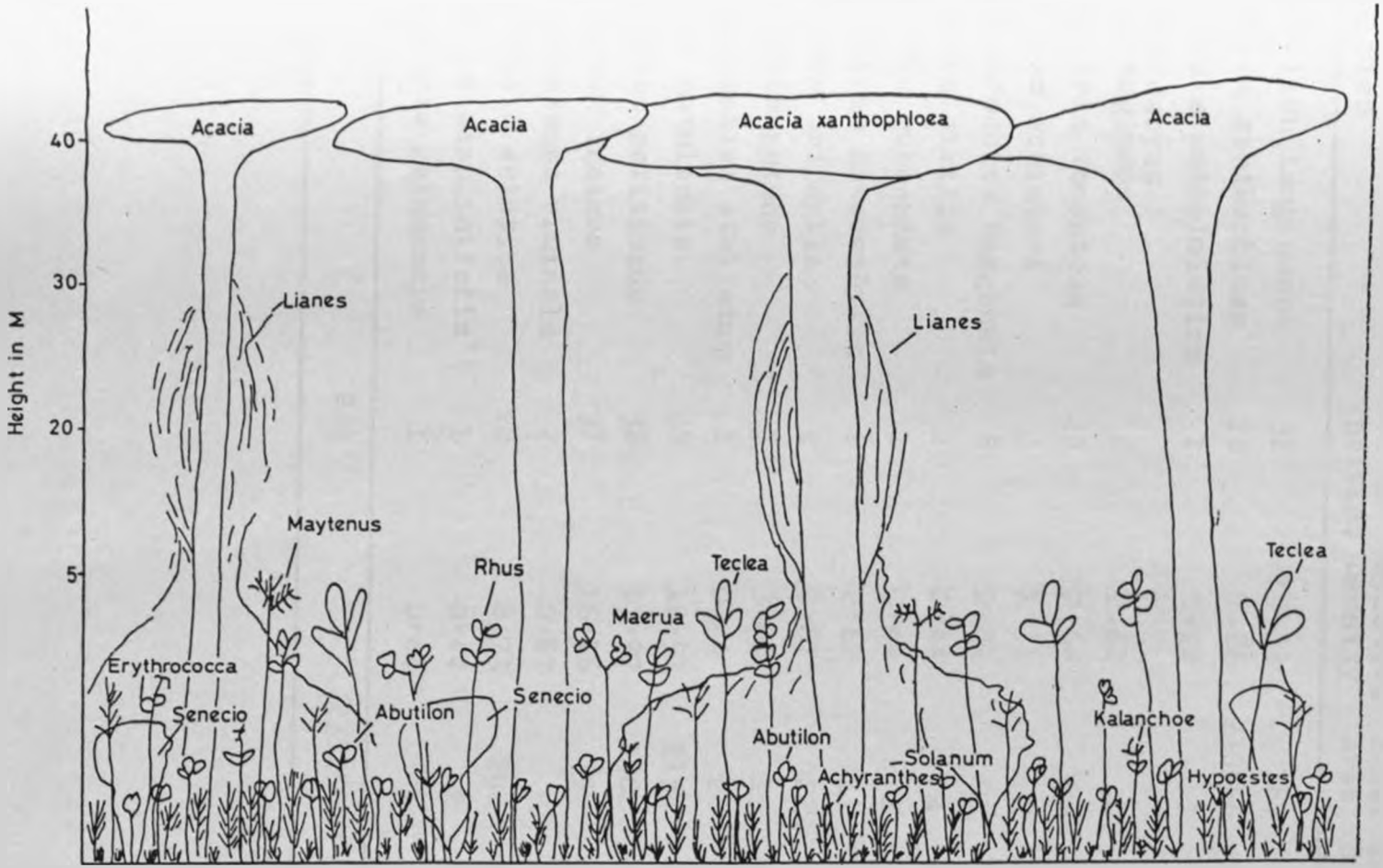


Fig. 7a Vegetation structure : Profile diagram showing the vertical stratification of Acacia xanthophloea Forest

Table 7 a. Floristic characteristics of Acacia xanthophloea Forest (Transect 6).

Species	No. of Individ.	Relative Density	Total Basal Area	Relative Dominance	Relative Importance Value
Abutilon longicuspe	31	13·53	187	0·08	13·61
Acacia xanthophloea	18	7·86	230566	98.01	105·87
Celosia anthelmintica	1	0·44	1	0.00	0·44
Commicarpus plumbagineus	6	2·62	40	0·02	2·64
Capparis tomentosa	29	12·66	393	0·17	12·83
Dregea schimperi	3	1·31	2	0·00	1·31
Erythrococca bongensis	5	2·83	21	0·01	2·84
Grewia similis	1	0·44	4	0·00	0·44
Gnidia subcordata	1	0·44	1	0·00	0·44
Maytenus heterophylla	6	2·62	211	0·09	2·71
Maerua triphylla	2	0·87	921	0·39	1·26
Pavonia patens	7	3·06	15	0·01	3·07
Pterolobium stellatum	1	0·44	28	0·01	0·45
Rhus natalensis	25	10·91	1154	0·49	11·40
Senecio petitianus	32	13·97	1361	0·58	14·55
Solanum incanum	37	16·16	50	0·02	16·18
Sarcostemma viminale	2	0·87	9	0·00	0·87
Toddalia asiatica	20	8·73	292	0·12	8·85
Teclea simplicifolia	1	0·44	2	0·00	0·44
Vernonia galamensis	1	0·44	1	0·00	0·44
	229		235259		

The forest is characterized by the presence of clumps of lianes that hang on the trunks of Acacia trees and in some cases dominates the undergrowth. The dominant lianes include Capparis tomentosa, Commicarpus plumbagineus, Dregea schimperi, Senecio petitianus and Toddalia asiatica having an occurrence frequency between 45 and 75 percent. The undergrowth, apart from lianes, is dominated by Abutilon longicuspe and Solanum incanum with a frequency of 78 and 63 percent respectively. However, other dominant species in the herbaceous layer include the annuals, Achyranthes aspera, Hypoestes verticillaris, Justicia flava, Kalanchoe densiflora and Urtica massaica.

Euphorbia forest, like Acacia forest, is predominantly made up of a homogeneous stand of Euphorbia candelabrum trees with an occurrence frequency of 91 percent. The trees are succulent, dark green with a white latex. The tree starts to branch from 3 M. high forming long branches that project upwards with repeated fork-branching. The branches curve inwards towards the main shoot to form a dome-like closed crown. The Euphorbia trees contributes 90 percent of the tall tree canopy, the rest comes from Cussonia holstii, Acacia xanthophloea and Obetia pinnatifida. Immediately below the Euphorbia canopy, another semiclosed

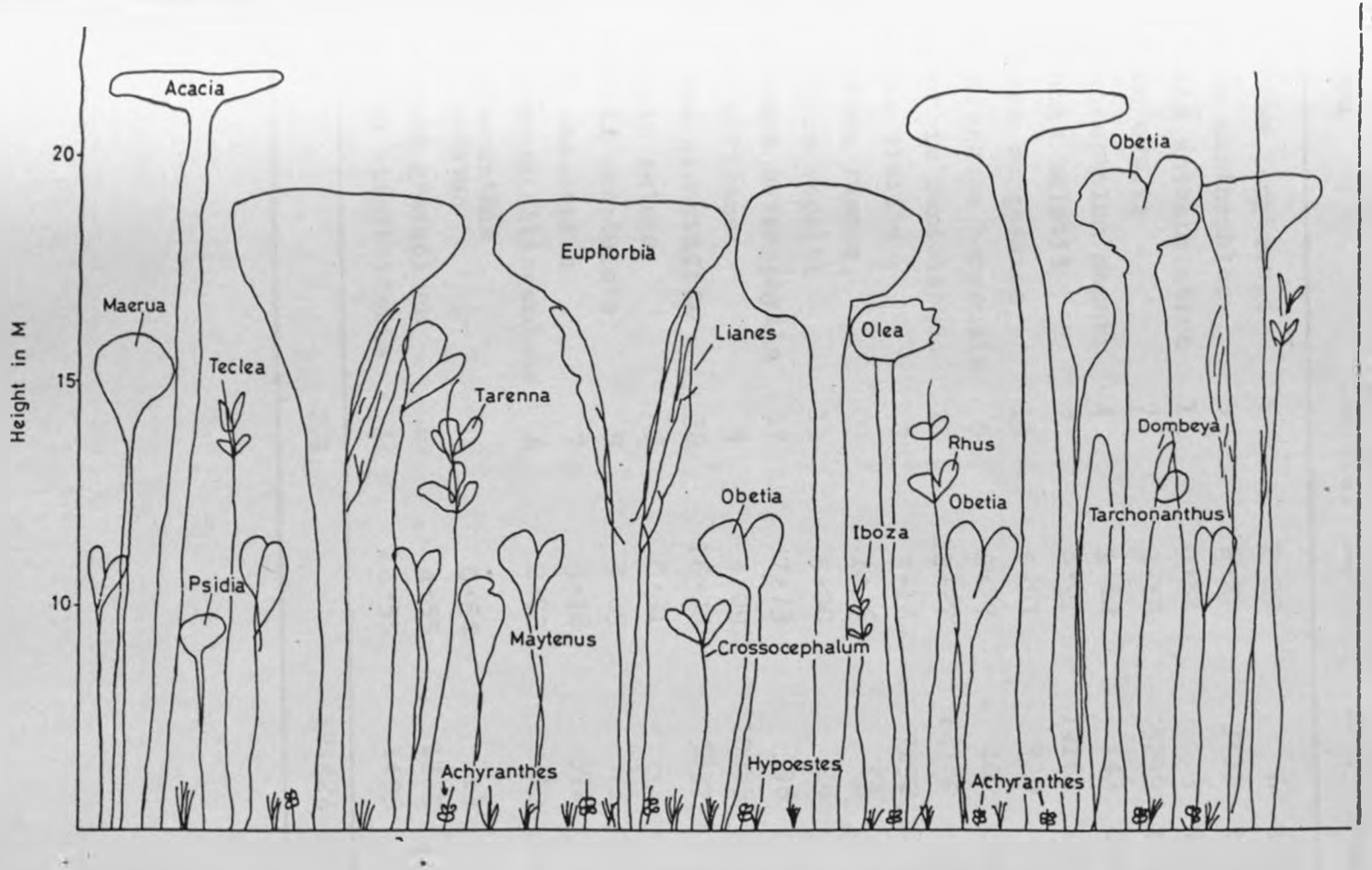


Fig. 7b Vegetation structure : Profile diagram showing vertical stratification of Euphorbia candelabrum forest

Table 7b. Floristic characteristics of Euphorbia candelabrum Forest (Transect 8).

Species	No. of Individ.	Relative Density	Total Basal Area	Relative Dominance	Relative Importance Value
Abutilon longicuspe	5	2·27	6	0·00	2·27
Acacia xanthophloea	5	2·27	3436	2·83	5·10
Celosia anthelmintica	1	0·54	3	0·00	0·54
Cordia ovalis	7	3·18	5299	4·36	7·54
Crassocephalum mannii	4	1·82	143	0·12	1·94
Cussonia holstii	2	0·91	19164	15·78	15·97
Dombeya burgessiae	13	5·91	730	0·60	6·51
Erythrococca bongensis	5	2·27	402	0·33	2·60
Euphorbia candelabrum	27	12·27	64780	53.35	65·62
Grewia similis	7	3·18	7292	6·01	9·19
Hibiscus fuscus	3	1·36	3	0·00	1·36
Peponium vogelii	11	5·00	98	0·08	5·08
Maytenus heterophylla	17	7·73	396	0·33	8·06
Olea africana	9	4·09	10285	8·47	12·56
Obetia pinnatifida	36	16·36	5837	4·81	21·17
Pavonia patens	2	0·91	3	0·00	0·91
Psiadia punctulata	9	4·09	73	0·06	4·15
Rhus natalensis	7	3·18	578	0·48	3·66
Cynanchum altiscandens	6	2·73	19	0·02	2·75
Tarchonanthus camphoratus	1	0·54	13	0·01	0·55
Tarenna graveolens	10	4·55	1369	1·13	5·68
Teclea simplicifolia	32	14·55	1495	1·23	15·78
	221		121424		

canopy is formed by small and medium sized trees that include Tarenna graveolens, Olea africana, Teclea simplicifolia, Dombeya burgessiae, Rhus natalensis and Maerua triphylla, all with occurrence frequency ranging from 54 to 94 percent. The shrub layer is predominantly Obetia pinnatifida with 100 percent occurrence and contributing more than 80 percent of the shrub canopy cover. The rest 20 percent canopy cover comes from other shrubs such as Psiadia punctulata, Cordia ovalis, Crassocephalum mannii and Iboza multiflora. The canopy of trees and shrubs intercept much of the sunlight, allowing very little light penetration, a factor that contributes greatly to the poor undergrowth cover (fig 7b). The herbaceous layer is contributed mainly by Achyranthes aspera and Hypoestes verticillaris. Lianes in this forest are mainly Peponium vogelii, Pterolobium stellatum and Cynanchum altiscandens.

Olea forest unlike the first two Acacia and Euphorbia forests, is made up of three dominant tree species namely, Teclea simplicifolia, Olea africana and Euclea divinorum each with occurrence frequency of 96, 79 and 79 respectively. Another notable tree species is Cussonia holstii. The trees form a closed canopy of about 95 percent cover. The high shrubs and small trees such as Teclea simplicifolia, Cordia ovalis, Maerua triphylla, Tarenna graveolens, Dombeya burgessiae

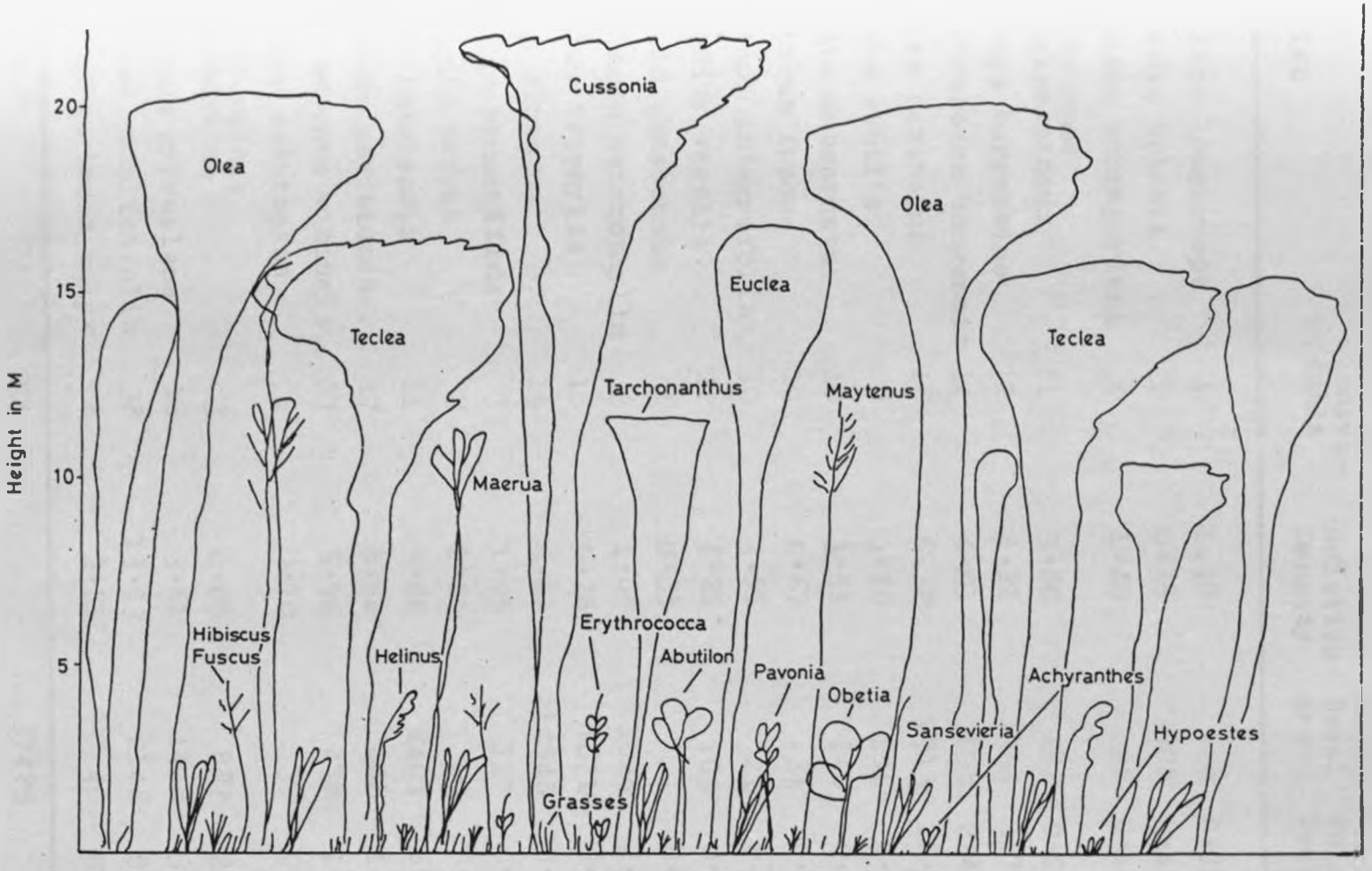


Fig. 7c Vegetation . structure: Profile diagram showing vertical stratification of Olea africana Forest.

Table 7 c. Floristic characteristics of Olea africana Forest (Transect 4).

Species	No. of Individuals	Relative Density	Total Basal Area	Relative Dominance	Relative Importance Value
Abutilon longicuspe	4	1.40	6	0·02	1·42
Cussonia holstii	1	0·35	908	2·43	2·78
Canthium schimperiana	4	1·40	46	0·12	1·52
Cyphostemma nodiglandulosum	11	3·86	193	0·52	4·38
Dombeya burgessiae	12	4·21	1394	3·72	7·93
Erythrococca bongensis	14	4·91	898	2·40	7·31
Euclea divinorum	18	6.32	6913	18·47	24·79
Grewia similis	9	3·16	956	2·55	5·71
Gnidia subcordata	10	3·51	240	0·64	4·15
Hibiscus fuscus	19	6·67	31	0·08	6·75
Helinus integrifolia	10	3·51	21	0.06	3·57
Peponium vogelii	12	4·21	109	0·29	4·50
Lippia ukambensis	1	0·35	7	0·02	0·37
Maytenus heterophylla	3	1·05	1024	2·74	3·79
Maerua triphylla	15	5·26	1871	5·00	10·26
Olea africana	19	6·67	14546	38·86	45·53
Obetia pinnatifida	3	1·05	117	0·31	1·36
Pavonia patens	8	2·81	10	0·03	2·84
Rhus natalensis	11	3·86	2401	6·41	10·27
Senecio petitianus	17	5·96	698	1·86	7·82
Sarcostemma viminale	17	5·96	478	1·28	7·24
Tinnea aethiopica	2	0·70	39	0·10	0·80
Tarchonathus camphoratus	3	0·05	887	2·37	2·42
Tarenna graveolens	16	3·61	1448	3·87	7·48
Teclea simplicifolia	38	13·33	2148	5·74	19·07
Vernonia brachycalyx	8	2·81	40	0·11	2·92
	285		37429		

and Maytenus heterophylla form a secondary tree layer with a canopy cover of about 70 percent. The low shrubs that include Helinus integrifolia, Gnidia subcordata, Abutilon longicuspe, Aspilia mossambicensis, Erythrococca bongensis and Hibiscus fuscus form a significant canopy of more than 40 percent below the secondary tree canopy. Lianes are characteristic in this forest hanging on trees and high shrubs. The common liane species include Senecio petitianus, Peponium vogelii and Cyphostemma nodiglandulosum. However, there were other species behaving like lianes such as Rhus natalensis, Grewia similis and Maerua triphylla. The total canopy cover contributed by trees, shrubs and lianes has a profound effect on light penetration resulting to a poor undergrowth vegetation cover (fig 7C) that is made up mainly of Sansevieria parva, Urtica massaica and Hypoestes verticillaris.

In the Acacia xanthophloea - Tarchonanthus camphoratus bushland, the tree layer forms an open canopy cover of about 40 percent contributed predominantly by Acacia xanthophloea trees that had an occurrence frequency of 90 percent. The shrub layer was dominated by Tarchonanthus camphoratus contributing over 75 percent shrub canopy cover and an occurrence frequency of 100 percent. The other 25 percent shrub cover came from other shrub species such as Abutilon

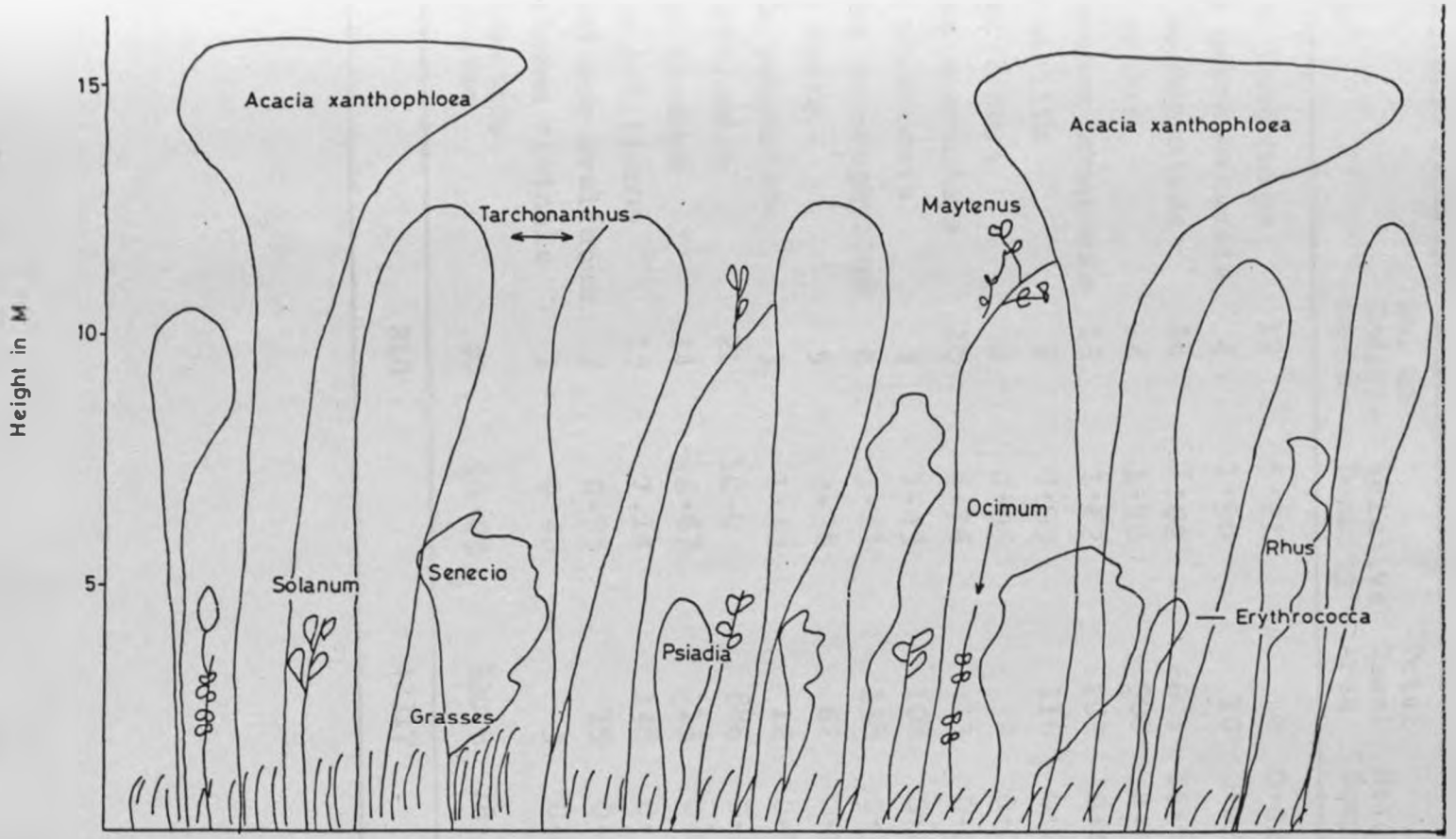


Fig. 7d Vegetation structure : Profile diagram showing vertical stratification of Acacia xanthophloea – Tarchonanthus camphoratus Bushland

Table 7 d. Floristic characteristics of Acacia xanthophloea - Tarchonanthus camphoratus bushland (Transect 20).

Species	No. of Individuals	Relative Density	Total Basal Area	Relative Dominance	Relative Importance Value
Abutilon longicuspe	12	5·71	9	0·02	5·73
Aspilia mossambicensis	4	1·90	10	0·02	1·92
Acacia xanthophloea	16	7·62	6604	15·61	23·23
Cordia ovalis	4	1·90	900	2·13	4·03
Erythrococca bongensis	16	7·62	202	0·48	8·10
Grewia similis	2	0·95	116	0·27	1·22
Hibiscus fuscus	2	0·95	2	0·00	0·95
Hibiscus micranthus	10	4·76	13	0·03	4·79
Lippia ukambensis	3	1·43	108	0·26	1·69
Maytenus heterophyllus	8	3·81	138	0·33	4·14
Ocimum suave	5	2·38	62	0·15	2·53
Psiadia punctulata	3	1·43	12	0·03	1·46
Rhus natalensis	21	10·0	886	2·09	12·09
Solanum incanum	14	6·67	13	0·03	6·70
Senecio petitianus	15	7.14	148	0·35	7·49
Steganotaena araliacea	2	0·95	15	0·04	0·99
Sarcostemma viminale	1	0·48	3	0·01	0·49
Tarchonanthus camphoratus	40	19·05	33078	78·17	97·22
	210		42317		

longicuspe, Aspilia mossambicensis, Erythrococca bongensis, Grewia similis, Hibiscus fuscus, H. micranthus, Lippia ukambensis, Maerua triphylla, Maytenus heterophylla, Ocimum suave, Psiadia punctulata, Rhus natalensis, Senecio petitianus and Solanum incanum, all with occurrence frequency ranging from 10 to 67 percent. The undergrowth cover comes mainly from grasses with dominant species such as Themeda triandra, Chloris gayana and Cynodon nlemfuensis (fig 7d).

Finally Euphorbia - Tarchonanthus bushland is made up of Euphorbia candelabrum trees that form the tree layer with about 45 percent canopy cover. Euphorbia trees were found to have variable heights from 3 M. up to 15 M. and in some cases saplings were also recorded. The occurrence frequency of Euphorbia was 93 percent. The high shrubs were dominated by Tarchonanthus camphoratus and Tinnea aethiopica with occurrence frequency of 95 and 98 percent respectively. Other high shrubs included Grewia similis, Cordia ovalis, Maytenus heterophylla, Senecio petitianus, Tinnea aethiopica and Teclea simplicifolia, with occurrence frequency ranging from 50 to 75 percent. The low shrubs were dominated by Psiadia punctulata, Ocimum suave, Lippia ukambensis, Aspilia mossambicensis, Hibiscus fuscus, H. micranthus, Solanum incanum and Clerodendron myricoides with occurrence frequency ranging from 35 to 98 percent. The total shrub layer contributed by both low and high shrubs formed more

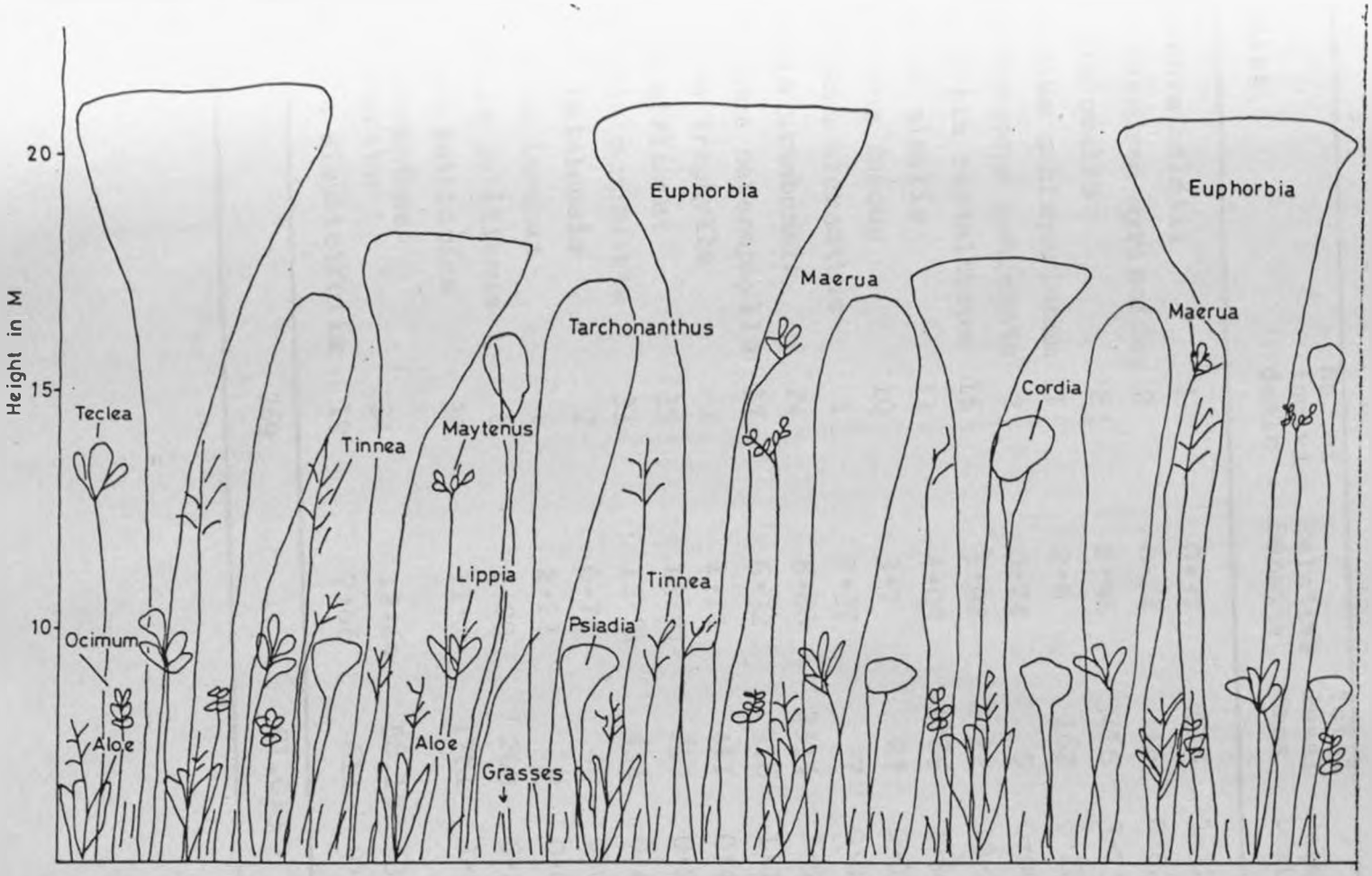


Fig. 7e Vegetation structure : Profile diagram showing vertical stratification of Euphorbia candelabrum - Tarchonanthus camphoratus bushland

Table 7 e Floristic characteristics of Euphorbia candelabrum - Tarchonanthus camphoratus bushland (Transect 16).

Species	No. of Individuals	Relative Density	Total Basal Area	Relative Dominance	Relative Importance Value
Cussonia holstii	1	0·37	3018	3·32	3·69
Clerodendron myricoides	2	0·74	14	0·02	0·76
Cordia ovalis	8	2·96	3416	3·75	6·71
Canthium schimperianum	7	2·6	162	0·18	2·78
Erythrococca bongensis	2	0·74	5	0·00	0·74
Euphorbia candelabrum	16	5·92	1722	19·14	25·06
Grewia similis	11	4·09	1786	1·96	6·05
Hibiscus fuscus	10	3·7	27	0·03	3·73
Hibiscus micranthus	1	0·37	7	0·00	0·37
Lippia ukambensis	24	8·88	2334	2·56	11·44
Maytenus heterophylla	17	6·32	916	1·01	7·33
Maerua triphylla	3	1·11	411	0·45	1·56
Olea africana	35	13·01	257	0·28	13·29
Psiadia punctulata	33	12·21	431	0·47	12·68
Rhus natalensis	2	0·74	40	0·05	0·79
Solanum incanum	6	2·22	9	0·00	2·22
Senecio petitianus	8	2·09	209	0·23	3·19
Tinnea aethiopica	30	11·1	1781	1·96	13·06
Tarchonanthus camphoratus	34	12·64	58,157	63·9	76·54
Teclea simplicifolia	19	7·06	611	0·67	7·73
	269		91,013		

than 80 percent vegetation canopy cover (fig 7 e). The undergrowth cover again comes mainly from grasses such as Themeda triandra, Cynodon nlemfuensis and Aloes (Aloe graminicola).

4. 4. SOIL - VEGETATION ANALYSIS

This analysis was intended to investigate the floristic distribution patterns in relation to the prevailing environmental parameters such as climate, grazing, burning and soils. The soil factors however, were considered to be of the greatest importance in the control of the vegetation distribution, structure and composition in the Park. Therefore, detailed studies on certain salient soil properties and floristic characteristics were carried out along a catenary sequence from the saline lake to the surrounding terrestrial habitats using profile transects (fig. 8). The different zones of the catena were primarily defined by the general physiognomic appearance of the vegetation evidenced from field observations and Landsat/aerial photographic interpretations. The data obtained from the soil analyses are summarized in Table 8 (a, b, c and d).

Profile Transects 1 and 3 were located on the central plains (TR1)to the southern plains and TR3 to the north-western plains) where they traversed various vegetation types, starting from the Lake shore outwards to the surrounding terrestrial habitats. Transect 1 (TR1) to the south passed from the lakeshore (mudflats) through the alkaline grasslands (Cynodon dactylon and Sporobolus spicatus) interspersed by Pluchea bequaertii low shrubs, open and wooded grasslands

of Chloris gayana, Acacia xanthophloea forest and finally Tarchonanthus camphoratus - Euphorbia candelabrum bushlands (fig 8a). The soil textural analyses showed four main soil classes, i.e. Clay loam, Sandy loam, Sandy clay and Clay (Table 8a). The shoreline soils are composites of clay loam, clay, loamy sand, sandy loam and sandy silt loam. This is considered to be due to inconsistent lake and rivers' depositions along the shoreline. The Acacia xanthophloea forest and Cynodon nlemfuensis open grassland stand on clay soils. The Acacia woodlands (or Cynodon nlemfuensis wooded grasslands) and Tarchonanthus camphoratus - Euphorbia candelabrum bushlands occupy an area of clay loam soils. The p^H values decrease from the lake to the surrounding terrestrial habitats. The alkaline conditions are restricted to the shoreline (p^H >) with Acacia forest demarcating between alkaline and acidic soil conditions (p^H 7). The Cynodon nlemfuensis grasslands and Tarchonanthus bushlands further away from the lakes influence stand on moderately acidic soils.

Profile Transect 3 (TR3) to the north west, next to the Presidential Pavilion start from the lake shore across the alkaline grasslands, Pluchea bushland, Chloris gayana grasslands, Acacia xanthophloea woodland, Digitaria abyssinica grasslands and finally into the Acacia xanthophloea forest, next to Njoro River (fig 8c). The soil analysis produced

Table 8a. Soil - Vegetation Relationships. Profile Transect 1 running from the lakeshore through the southern Central plains.

SAMPLE NO.	SOIL LAYER U=Upper L=Lower	SOIL TEXTURAL CLASS	SOIL PH	PLANT COMMUNITY
1	U	Clay loam	10·27	Mudflats
	L	Clay	10·31	
2	U	Sandy clay loam	9·15	Pluchea Community
	L	Clay loam	10·21	
3	U	Loamy sand	7·50	Chloris gayana grassland
	L	Sandy loam	7·56	
4	U	Sandy silt loam	7·70	Wooded Chloris gayana grassland.
	L	Clay	8.70	
5	U	Clay	6.91	Acacia Forest
	L	Clay	6·71	
6	U	Clay	6·97	Acacia Forest
	L	Clay	6·66	
7	U	Clay	6·87	Open Grassland (Cynodon nlemfuensis - Chloris gayana)
	L	Clay	7·43	
8	U	Clay	6·00	Wooded Cynodon nlemfuensis grasslands.
	L	Clay	6·81	
9	U	Clay	6·33	Open grassland (Cynodon nlemfuensis)
	L	Clay	6·74	
10	U	Clay	6·82	Riverine vegetation
	L	Clay	6·80	
11	U	Sandy clay loam	5·09	Riverine vegetation Acacia woodland
	L	Sandy clay loam	5·84	

SAMPLE NO.	SOIL LAYER U=Upper L=Lower	SOIL TEXTURAL CLASS	SOIL PH	PLANT COMMUNITY
12	U	Clay loam	5·74	Riverine vegetation *Acacia* woodland
	L	Clay	5·83	
13	U	Clay	6.03	Open Grassland
	L	Clay loam	7·28	
14	U	Clay loam	5·73	*Acacia* Woodland (closed)
	L	Clay loam	7·54	
15	U	Clay loam	5·80	*Acacia* Woodland (closed
	L	Clay loam	6·61	
16	U	Clay loam	6·30	Open Grassland
	L	Clay loam	7·40	
17	U	Clay	6·34	Wooded Grassland (*Cynodon nlemfuensis* - *Themeda triandra*)
	L	Clay		
18	U	Clay	5·17	*Tarchonanthus* Bushland
	L	Clay	5·72	
19	U	Clay	6·13	*Tarchonanthus* - *Euphorbia* Bushland
	L	Clay	6·38	
20	U	Clay loam	6.20	*Tarchonanthus* - *Euphorbia* Bushland
	L	Clay	6·30	
21	U	Clay loam	6.00	*Tarchonanthus* - *Euphorbia* Bushland
	L	Clay loam	6·34	
22	U	Sandy clay loam	6·33	Open Grassland (*Cynodon nlemfuensis*)
	L	Clay loam		

five soil classes i.e. clay loam, sandy loam, sandy clay, sandy clay loam and silt clay loam. This shows a wide soil textural variation within a relatively small area. Pure clay soils are apparently missing. The soils at the foreshore (mudflats and alkaline grasslands) are made up of clay loam to silty clay loam. The soils under Pluchea bequaertii bushland and Chloris gayana grasslands are sandy loam whereas those occupied by Acacia xanthophloea woodland are sandy clay loam. The soils covered by Digitaria abyssinica grasslands are clay loam and those under Acacia xanthophloea forest are silty clay loam. Generally the soils in this part of the Park are characteristically alkaline in nature ($pH > 7 \cdot 5$) except only a small area occupied by Acacia forest where the top soils are almost neutral (pH 6·8) and the bottom soils show alkaline conditions (pH 8·3). The soil texture and reaction in this region indicate lacustrine characteristics meaning that the whole area was once under the Lake water.

Profile Transect 2 was located on the south east lake shore running eastwards where it traversed various vegetation types from the mudflats through the alkaline grasslands and sedge marshes, Pluchea bushland, young Acacia xanthophloea woodland that demarcates the shoreline from the terrestrial habitats. The transect then continued through Cynodon nlemfuensis - Chloris gayana grasslands at the gentle

slopes of Lion Hill up to the Euphorbia candelabrum forest on the steep slopes and down into the valley right in the middle of the Lion Hill covered with Tarchonanthus camphoratus bushland and then up again into the Euphorbia candelabrum forest on the ridges of Lion Hill (fig 8b). The soil textural analyses distinguished five classes of soils along this transect, i.e. clay, loamy sand, sandy clay, sandy clay loam and sandy loam (Table 8b). The soils to the foreshore occupied by the mudflats, alkaline grasslands and sedge marshes are of clay type. The top soils under Pluchea bequaertii community are loamy sand and the bottom soils sandy clay. The top soils under the young Acacia xanthophloea woodland are sandy clay and the bottom soils clay loam.

On the gentle slopes of Lion Hill under Cynodon nlemfuensis - Chloris gayana grasslands, the soils are sandy clay whereas on the steep slopes under Euphorbia candelabrum forest the soils are sandy clay loam to sandy loam, the soil types that extend down into the Tarchonanthus camphoratus bushlands in the valleys situated in the middle of the Lion Hill. The P^H values decrease with increase in the altitude. The shoreline vegetation including the mudflats, alkaline grasslands (Cynodon dactylon and Sporobolus spicatus), sedge marshes (Cyperus laevigatus), Pluchea bequaertii bushlands and the young Acacia xanthophloea

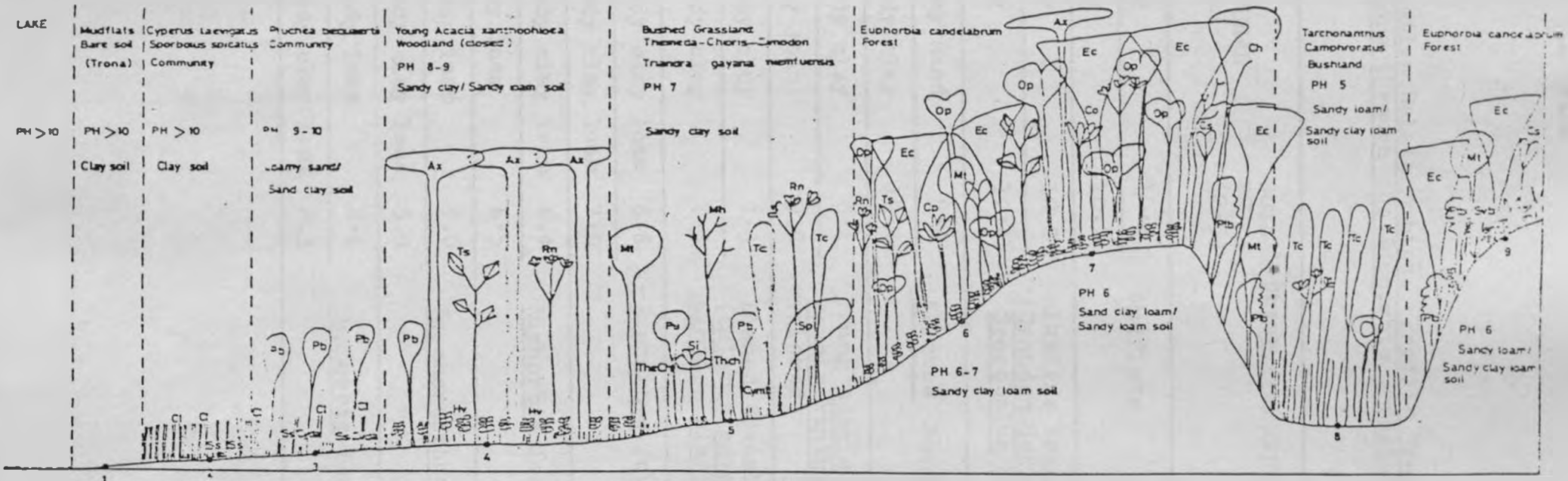


Fig. 8 b. PROFILE TRANSECT 2 SOIL - VEGETATION RELATIONSHIP

(NB. The full names of the abbreviated symbols of species are given on pages 194 and 195).

Table 8b: Soil - Vegetation Relationships. Profile Transect 2, running from the Lakeshore through the Euphorbia candelabrum Forest.

SAMPLE NO.	SOIL LAYER U=Upper L=Lower	SOIL TEXTURAL CLASS	SOIL PH (2·5)	PLANT COMMUNITY
1	U	Clay	10·2	Mudflats
	L	Clay	10·2	
2	U	Clay	10·2	Alkaline Grasslands (*Cynodon dactylon* - *Sporobolus spicatus*)
	L	Clay	10·4	
3	U	Loamy sand	9·4	*Pluchea* Community
	L	Sandy clay	10·4	
4	U	Sandy clay	8·4	Young *Acacia* Woodland *Acacia xanthophloea* (closed)
	L	Clay loam	9.5	
5	U	Sandy clay	7·3	Bushed Grassland (*Chloris gayana* - *Cynodon nlemfuensis*)
	L	Sandy clay	7·3	
6	U	Sandy clay loam	6·8	*Euphorbia* forest
	L	Sandy clay loam	7·0	
7	U	Sandy clay loam	6.4	*Euphorbia* forest
	L	Clay loam	6·5	
8	U	Sandy loam	5.6	*Tarchonanthus* bushland
	L	Sandy clay loam	5.9	
9	U	Sandy loam	6·6	*Euphorbia* forest
	L	Sandy clay loam	6.3	

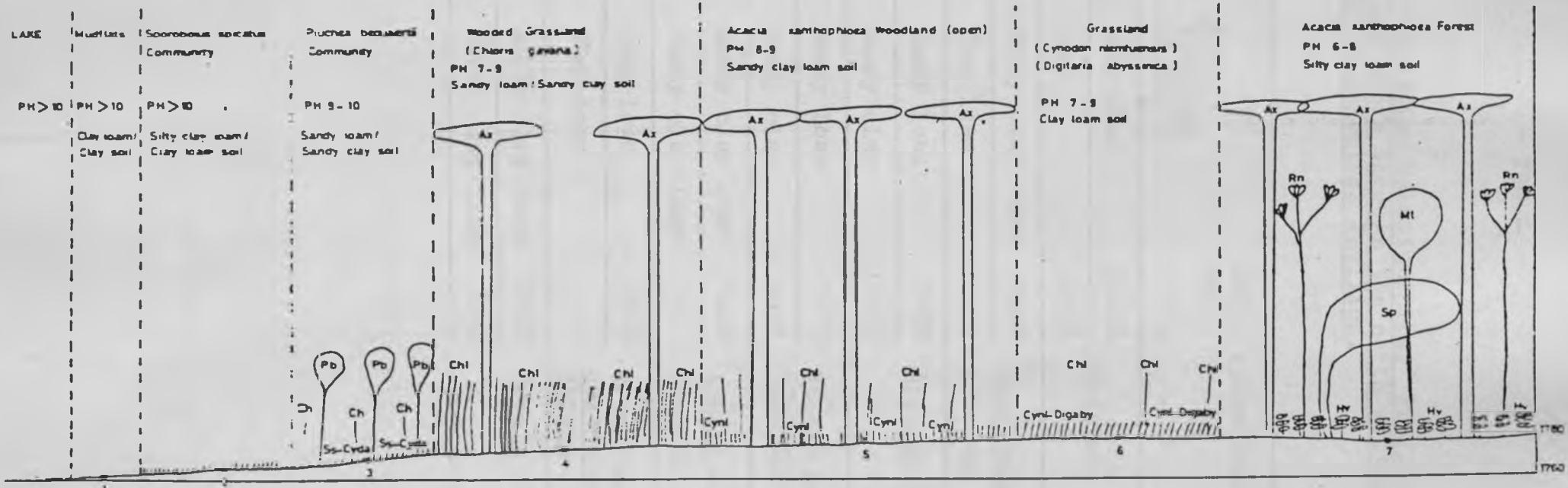


Fig 8c: PROFILE TRANSECT 3 SOIL - VEGETATION RELATIONSHIP

(NB. The full names of the abbreviated symbols of species are given on pages 194 and 195).

Table 8c: Soil - Vegetation Relationships. Profile Transect 3 running from the Lakeshore through the north western Central Plains next to the Presidential Pavilion.

SAMPLE NO.	SOIL LAYER U=Upper L=Lower	SOIL TEXTURAL CLASS	SOIL PH	PLANT COMMUNITY
1	U	Clay loam	10.31	Mudflats
	L	Clay	10·32	
2	U	Silty clay loam	10.65	*Sporobolus spicatus*
	L	Clay loam	10·54	alkaline grassland
3	U	Sandy loam	9·82	Pluchea community
	L	Sandy clay	10·11	
4	U	Sandy loam	7·70	Wooded grassland (*Chloris gayana*)
	L	Sandy clay	9·41	
5	U	Sandy clay loam	8.45	*Acacia* woodland
	L	Sandy clay loam		(open)
6	U	Clay loam	7·82	Grassland *Digitaria abyssinica* - *Chloris gayana*
	L	Clay loam		
7	U	Silty clay loam	6·80	*Acacia* forest
	L	Silty clay loam	8·30	

woodland, stand on alkaline soils (PH>7.8). The soils under the bushed Cynodon nlemfuensis - Chloris gayana grasslands on the gentle slopes of the Lion Hill are free from alkaline conditions (PH 7) whereas those on the steep slopes under Euphorbia candelabrum forest and also those in the valleys under Tarchonanthus camphoratus bushlands show acidic conditions (PH <7).

Profile Transect 4 was situated on the south west lake shore running westwards from the mudflats across the alkaline grasslands, Pluchea bushland dense Acacia xanthophloea forest (Colubus forest), Psiadia punctulata bushlands, Tarchonanthus camphoratus bushlands on the gentle slopes of the western escarpment up to the Acacia xanthophloea - Tarchonanthus camphoratus bushlands on the Western Mau Plateau (fig 8d). Three soil classes were identified along this transect namely, clay, sandy loam and sandy clay loam. The top soils of the mudflats are clay type while the bottom soils are sandy clay. Similarly the top soils of the alkaline grasslands and Pluchea bushlands are sandy loam while the bottom soils in alkaline grasslands are clay type and those under Pluchea bushlands are sandy clay loam in nature. The soils occupied by Acacia xanthophloea forest and Psiadia punctulata bushland are of sandy clay loam type. The top

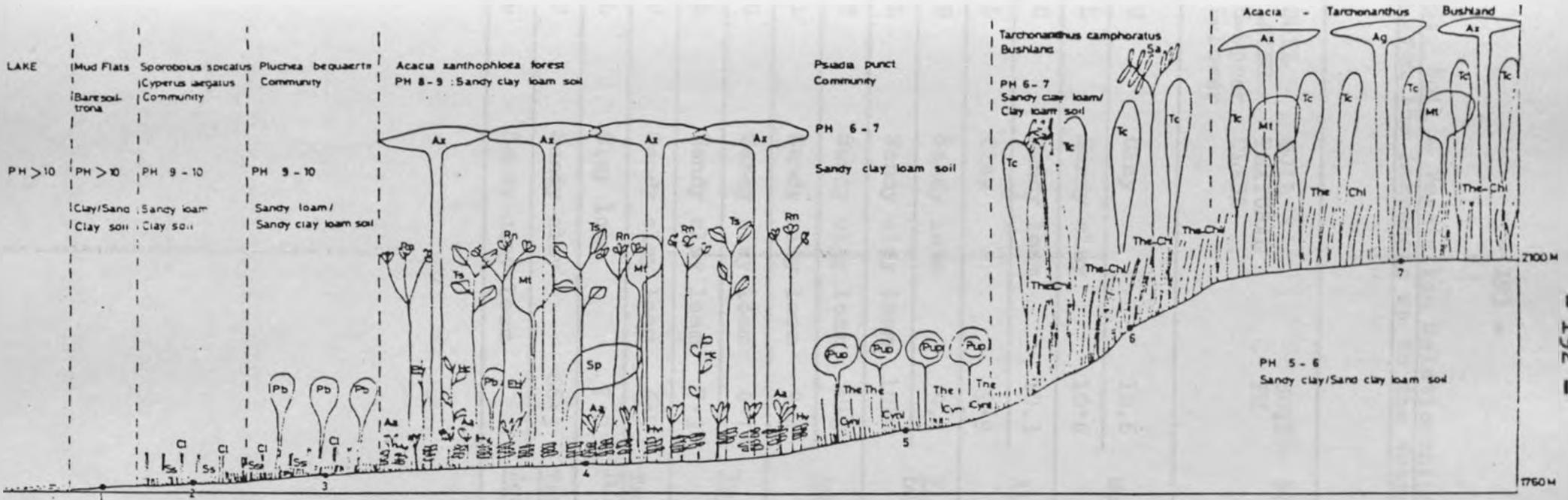


Fig 8 d: PROFILE TRANSECT 4 : SOIL-VEGETATION RELATIONSHIP

(NB. The full names of the abbreviated symbols of species are given on pages 194 and 195).

Table 8d: Soil - Vegetation Relationships. Profile Transect 4 running from the Lakeshore up to the Western Mau escarpment.

SAMPLE NO.	SOIL LAYER U=Upper L=Lower	SOIL TEXTURAL CLASS	SOIL PH	PLANT COMMUNITY
1	U	Clay	10.6	Mudflats
	L	Sandy clay	10·6	
2	U	Sandy loam	10.3	Alkaline Grasslands
	L	Clay	9·9	
3	U	Sandy loam	9.4	Pluchea - Cyperus bushland
	L	Sandy clay loam	10·2	
4	U	Sandy clay loam	8·3	Acacia Forest
	L	Sandy clay loam	9·4	
5	U	Sandy clay loam	6·7	Psiadia Bushland
	L	Sandy clay loam	7·3	
6	U	Sandy clay loam	6·9	Tarchonanthus Bushland
	L	Clay loam	7·0	
7	U	Sandy clay	66·3	Tarchonanthus - Acacia Bushland
	L	Sandy clay loam		

soils under Tarchonanthus camphoratus bushland are of sandy clay loam while the bottom soils are of clay loam. Likewise, the top soils covered with Acacia xanthophloea - Tarchonanthus camphoratus bushlands on the Mau Plateau are sandy clay while the bottom soils are of sandy clay loam type (Table 8d). The shoreline vegetation (mudflats, alkaline grasslands, Pluchea bushland and Acacia forest) stands on soils characterised by alkaline conditions (PH>8). The Psiadia bushland (PH7) is on the transitional zone between alkaline and acidic characteristics. The Tarchonanthus bushlands on the western escarpment (including Acacia - Tarchonanthus community on the Mau Plateau) are characterised by acidic soils (PH<7).

Salinity measurements through electrical conductivity tests around the shoreline soils produced values in the range of 4,000 to 8,000 us, an indication of salinity properties. Elsewhere in the Park, the soils showed saline-free characteristics, with electrical conductivity values of less than 3,000 us.

The full names of the abbreviated symbols of plant species used in fig 8 (a, b, c and d) are as follows:

Aa = Achyranthes aspera

Ag = Acacia gerrardii

Al = Abutilon longicuspe

Ax = Acacia xanthophloea

Ch = Cussonia holstii

Chl = Chloris gayana

Cl = Cyperus laevigatus

Co = Cordia ovalis

Cs = Canthium schimperianum

Cynda = Cynodon dactylon

Cynl = Cynodon nlemfuensis

Digiaby = Digitaria abyssinica

Eb = Erythrococca bongensis

Ec = Euphorbia candelabrum

HC = Hibiscus calyphyllus

HV = Hypoestes verticillaris

Mh = Maytenus heterophylla

Mt = Maerua triphylla

OP = Obetia pinnatifida

Pb = Pluchea bequaertii

Plb = Plectranthus barbatus

Pup = Psiadia punctulata

Rn = Rhus natalensis

Sa = Steganotaenia araliacea

Si = Solanum incanum

Sp = Senecio petitianus

Ss = Sporobolus spicatus

Ta = Tinnea aethiopica

Tc = Tarchonanthus camphoratus

The = Themeda triandra

Ts = Teclea simplicifolia

CHAPTER FIVE

D I S C U S S I O N

Though a relatively small area (148 km^2 dry land and 40 km^2 under Lake water), Lake Nakuru National Park hosts an extraordinary large numbers of plant species (556) spread over 305 genera and 85 families (Table 9). The Park, characterized by *Acacia* - *Tarchonanthus* bushland vegetation, shares more or less similar numbers of plants with Meru National Park, the latter with a total of 530 plant species that make *Acacia* - *Commiphora* bushland vegetation. 80 percent of the plant species found in the study area are Dicotyledons and exist either as herbs, shrubs, climbers/lianes or trees. 25 percent of species in Dicotyledons belong to Papilionaceae (41) and Compositae (68) whereas Gramineae (63) constitutes 60 percent of the species components in Monocotyledons. The lower plants are either absent or poorly represented in the flora of the Park (Appendix I) except a few drought resistant species of Pteridophytes found growing in the shade provided by rock crevasses.

New records of plant species that have never been reported or collected from the Park prior to this study were made with reference to the collections in the East African Herbarium. Some of such taxa include *Conyza*

pedunculata, Senecio mesograumoides, Pycnostachys umbrosa, Caylusea abyssinica and Vernonia karanguensis. One of the major objectives of this work is the enumeration of plant species in all the major terrestrial habitats as stipulated in each of the vegetation types (fig. 6) described in the results under the section on floristic composition. With this information and a few other short species lists from various collectors in the Park, a full plant Check list was compiled (see Appendix I).

Table 9. Number of Families, Genera and Species collected from Lake Nakuru National Park.

	Number of Families	Number of Genera	Number of Species
Pteridophytes	3	6	9
Dicotyledons	73	250	439
Monocotyledons	9	49	108
Total	85	305	556

Vegetation classification carried out through integration of floristic and landscape characteristics defined 19 plant communities embodied in 6 groups of plant communities

on the basis of phytosociological species groups (Table 2). Each plant community is further characterized by one or more principal species that constitute(s) more than 20 percent vegetation cover in that plant community (Table 10). These plant communities are environmentally controlled and spread across the landscape in a high degree of harmony with the mosaics of the physical environments (Bailey and Poulton, 1968). The distribution patterns of various plant communities over the landscape is shown on the attached Landscape Ecological Vegetation Map of Lake Nakuru National Park prepared as a result of this study.

Differentiation of the vegetation into physiognomic vegetation types and further into plant communities brought to notice the concept of floristic overlap as no clear cut distinctions could readily separate the vegetation stands without the exercise of a considerable amount of subjective judgement. This was mainly due to the ecotones found joining together two or more plant communities particularly in bushlands and forests. Therefore it soon became apparent in the current work that the first requirement was a scheme for organizing or arranging the vegetation stands of bushlands and forests so that suitable comparisons of quantitative

Table 10. Principal Species to various Plant Communities

SPECIES	GROUP OF PLANT COMMUNITIES																		
	I					II				IIa		III			IV	V	VI		
	PLANT COMMUNITIES																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Cyperus laevigatus	+	-		-															
Sporobolus spicatus		-	+	-															
Fluchea bequaertii				+										+					
Typha domingensis				-	+														
Chloris guyana				-		+	+						-	-					
Sida (Lelhania) ovata						-	-	-	-	-	-	-	-	-	-				
Digitaria abyssinica						-	-	-	-	-	-	-	-	-	-	-	-	-	
Cynodon nlemfuensis								+	+	-	+	-	+	+	-				
Themeda triandra							-		-	-	-	-	-		-				
Acacia gerrardii										-	-	-	-						
Acacia xanthophloea										-	-	-	-	-	-		-	-	+
Maytenus heterophylla												-	-	-	-	-	-	-	
Tarchonanthus camphoratus												+	+	+	+	-	-		
Teclea simplicifolia													-	-	-	-	+	-	
Euphorbia candelabrum															-	+			
Olea africana																	-	+	
Dombeya burgessiae														-		-	-	-	-
Ficus sur																		-	
Capparis tomentosa																		-	+
Urtica massaica																			+

+ Species of this species group must occur; combined cover of species 20 percent

- Species of this species group must occur or frequently occur.

Cyperus laevigatus Community

Sporobolus spicatus - Cyperus laevigatus Community

Sporobolus spicatus Community

Fluchea bequaertii Community

Typha domingensis Community

Chloris guyana - Digitaria abyssinica Community

Chloris guyana - Themeda triandra Community

Cynodon nlemfuensis - Digitaria abyssinica Community

Cynodon nlemfuensis - Themeda triandra Community

Cynodon: Chloris guyana and Cynodon nlemfuensis Community

Cynodon nlemfuensis - Acacia xanthophloea Community

Tarchonanthus camphoratus - Acacia gerrardii Community

Tarchonanthus camphoratus - Acacia xanthophloea Community

Tarchonanthus camphoratus - Fluchea bequaertii Community

Tarchonanthus camphoratus - Euphorbia candelabrum Community

Euphorbia candelabrum - Teclea simplicifolia Community

Olea africana - Teclea simplicifolia Community

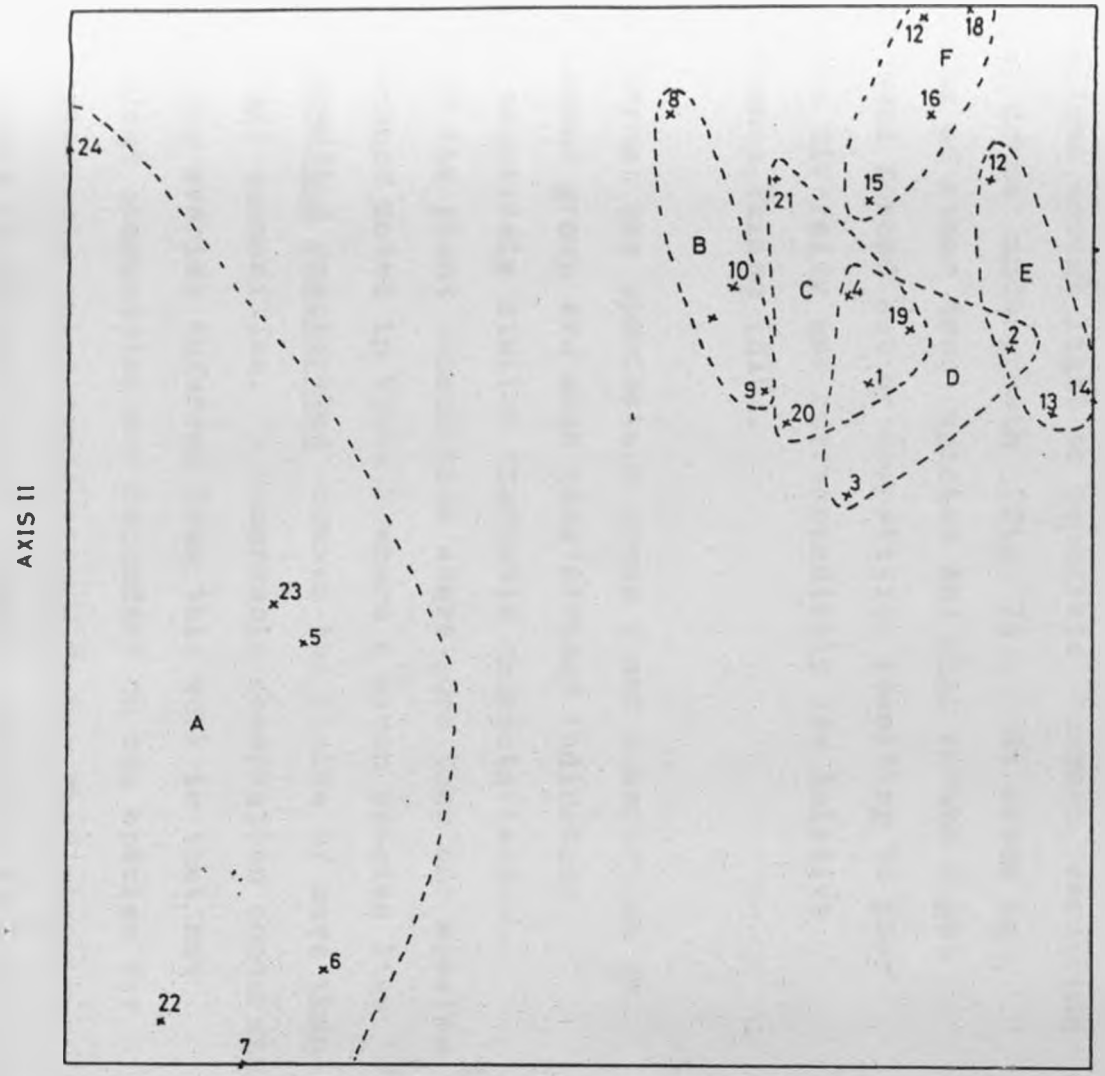
Acacia xanthophloea - Ficus sur Community

Acacia xanthophloea - Urtica massaica Community

data could be made to bring to light the floristic interrelationships of various plant communities.

To this end an attempt was made to classify the vegetation stands on the basis of woody elements into groups which had similar structure and composition. The plot ordination immediately **divided** the stands into two distinctive groups (fig 9). The first group labelled A on the left side of the diagram consists of field plots taken from Acacia forest along the shoreline. The second group on the right labelled B, C, D, E, and F is made up of Euphorbia forest, Acacia - Tarchonanthus bushland, Olea forest, Tarchonanthus bushland and Euphorbia - Tarchonanthus bushland respectively. The two groups which are **strongly devided demonstrating** their phytosociological heterogeneity.

Species **spatial** distribution ordination (fig 10) reveals the marked differences that exist in quantitative representations between the Acacia forest and the rest of the woody plant communities. Acacia forest is mainly associated **with** climbers/lianes that include Commicarpus plumbagineus (CP), Capparis tomentosa (CT), Dregea schimperi (DS) and Toddalia asiatica. Other characteristic species include Lycium europaeum (LE), Ricinus communis (RC), Vernonia galamensis (VG) and Withania somnifera. All these species that



Legend : Vegetation Types

A Acacia xanthophloea Forest / Woodland

B Euphorbia Forests

C Acacia xanthophloea Tarchonanthus Bushland

D Olea Forest

E Tarchonanthus Bushland

F Euphorbia Tarchonanthus Bushland

Fig. 9: Plot Ordination Interrelationships between Vegetation Types

represent Acacia forest are of very low floristic importance showing less than 5 percent relative importance value (Table 3 b) each due to their poor occurrence hence low species density or low relative dominance values as a result of their inconspicuous basal areas. Acacia xanthophloea is the only tree species in Acacia forest with the trees forming a closed canopy of about 30 m. high but allows enough light to penetrate through resulting in a dense undergrowth (fig. 7a). It seems as species of other tree species and high shrubs might have been forced out by competition resulting to poor species diversity and correspondingly low Relative Importance Values (RIV).

In contrast the species and hence plant communities in the second group are much less divided indicating their relatively similar floristic characteristics. Some of the plant communities share more than one species an evidence noted in Table 2 where a given species like Tarchonanthus camphoratus crosses the limits of more than one plant communities. A remarkable observation concerning floristic overlap inferred from this work is that not many plant communities are dependant on one species for their floristic characterization a factor that minimizes the dangers of extinction of a plant community as a unit due

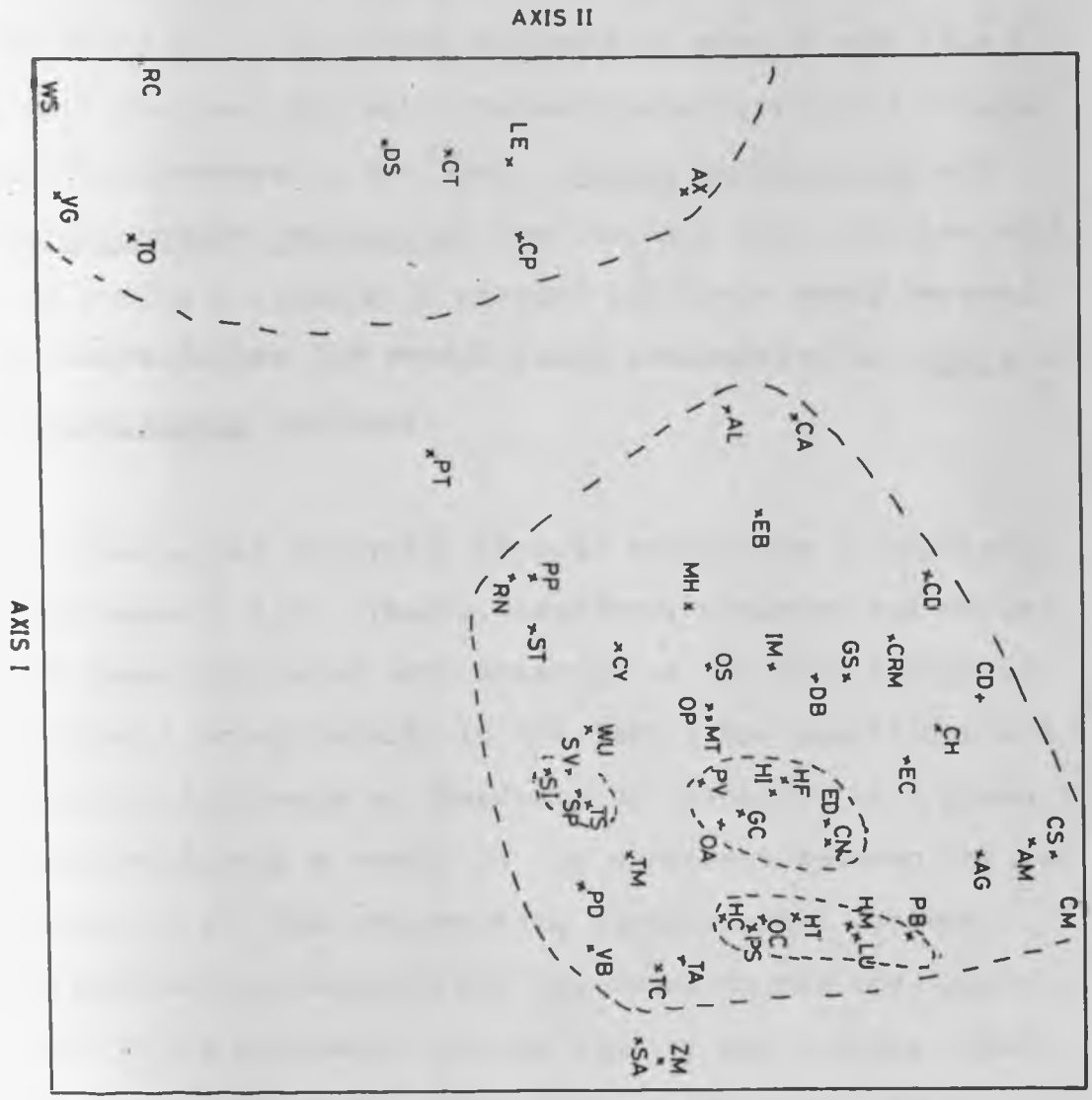


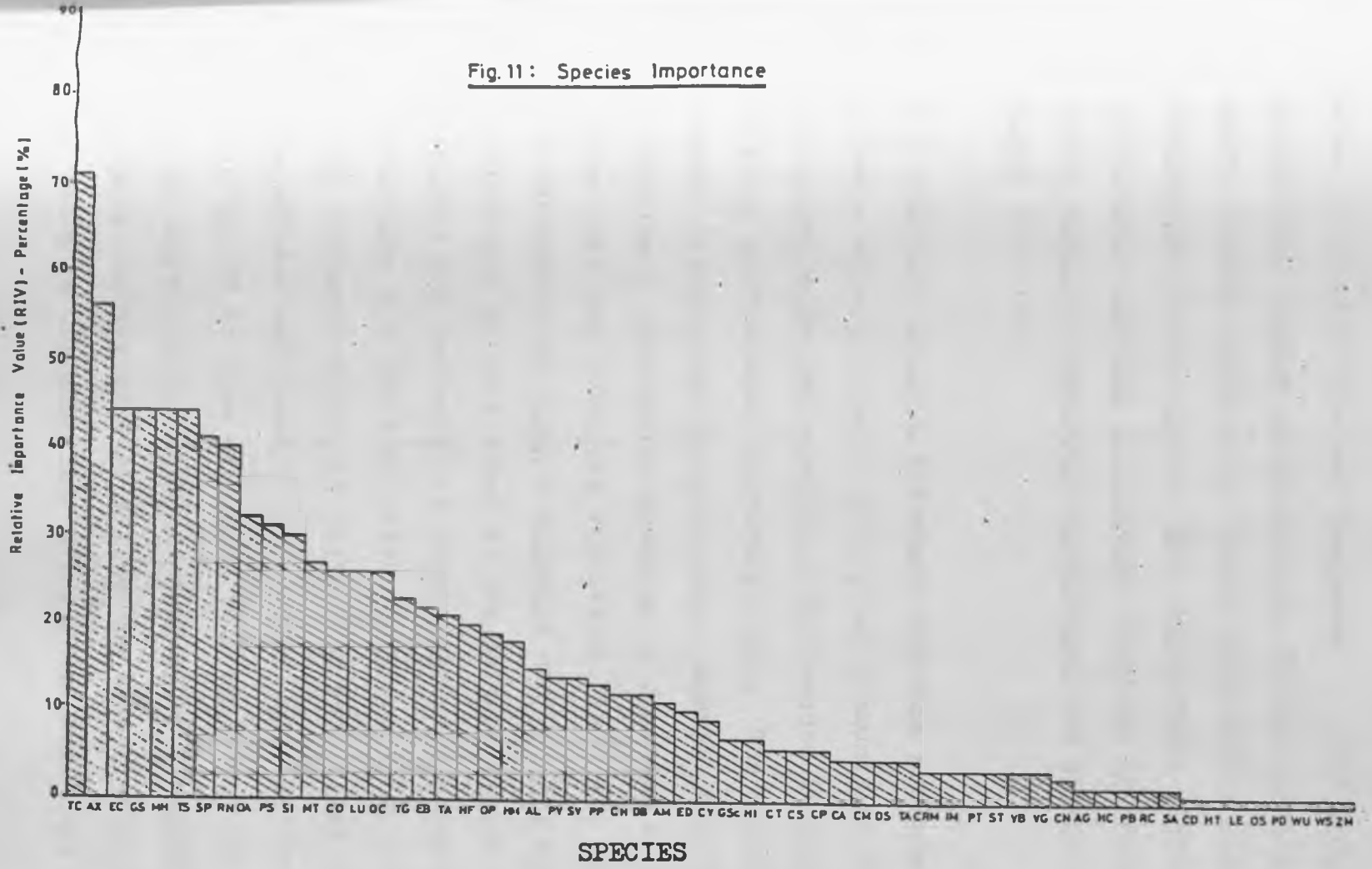
Fig.10 : Species ordination : Correlation between woody species

(NB. The full names of the abbreviated symbols of species are given on page 228).

to external environmental forces acting on a particular species within that plant community. However, close examinations of the RIV of all woody components soon showed that few species ever attained the high levels of importance. The majority of the plant species never occurred as important elements in many stands (fig 11) hence the need for well planned conservation and management programmes in the Park. Acacia xanthophloea and Tarchonanthus camphoratus are the only plant species with RIV values exceeding 50 percent and alone **could be used to characterize the wooded plant communities as Acacia - Tarchonanthus bushland.**

The ecological diversity (due to variations in physical environment, i.e. climate, landform, drainage and soils) and human influence were observed as the main causes of floristic heterogeneity in the Park. The occurrence and relative dominance or abundance of a species on a given site is largely a result of the agreement between the net effect of all the interracting environmental factors (effective environment) and the requirements and tolerances of the available species (Bailey and Poulton, 1968). The species abundance therefore, could be used as a measure of success in ecological distribution adaptations as well as floristic stability in a plant community. Among the most successful plant species in the Park in

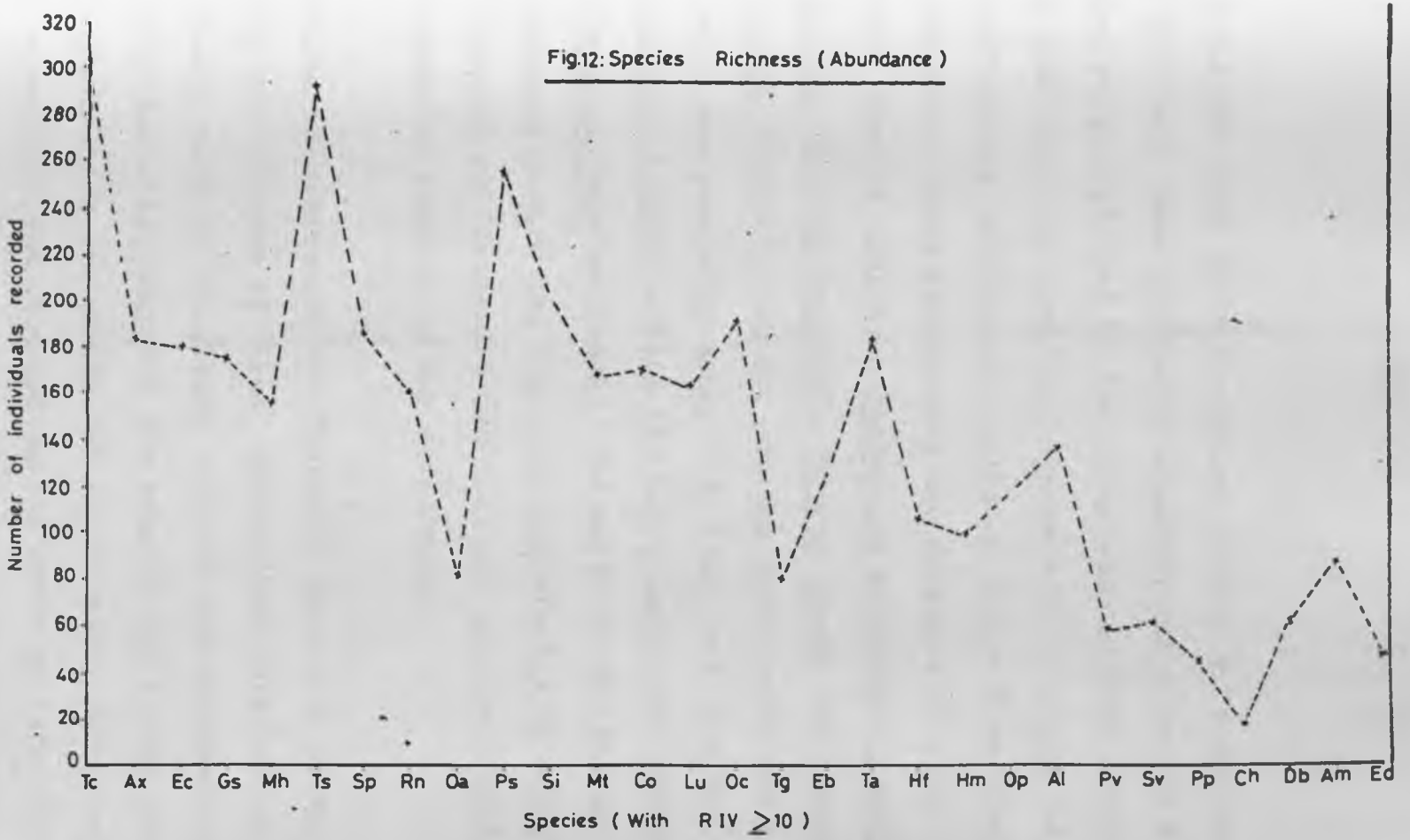
Fig. 11 : Species Importance



(NB. The full names of the abbreviated symbols of species are given on page 228).

terms of distribution and frequency are Tarchonanthus camphoratus, Teclea simplicifolia, Solanum incarnum, Ocimum suave, Psiadia punctulata, Tinnea aethiopica, Lippia ukambensis, Cordia ovalis, Rhus natalensis, Senecio petitianus, Abutilon longicuspe, Maytenus heterophylla, Grewia similis, Euphorbia candelabrum and Acacia xantho-phloea (fig 12).

Soil analysis along a caternary sequence produced convincing evidence which indicated that plant communities were largely coincident with the underlying differences in soil PH, salinity and textural characteristics. The vegetation is broadly distributed symmetrically around the lake displaying a spectacular spectrum of zonation in such a manner that the shoreline vegetation gives way northwards and southwards to Themeda triandra and Cynodon nlemfuensis respectively on both sides of the central plains and eastwards and westwards to Tarchonanthus bushlands interrupted here and there by patches of forests on the escarpments, volcanic hills and plateau on both sides of the lake. This pattern was found to have direct correlation with soil pH salinity and to some extent on soil texture. The vegetation on the shoreline is mainly controlled by alkalinity and salinity influences that follow the lake water levels. The soils on the shoreline are highly saline and alkaline



(NB. The full names of the abbreviated symbols of species are given on page 228).

(PH > 9) and are made up of a mixture of clay silt and fine sand that make them physically unstable and prone to wind erosion as illustrated by the occurrence of huge clouds of dusts that blow off from the lakeshore to be deposited in the surrounding settlements including Nakuru Town itself. The shoreline plant communities are composed of salt tolerant species including Sporobolus spicatus, Cyperus laevigatus, Cynodon dactylon, Chloris gayana and Pluchea bequaertii (Table 8, fig 8). On the escarpments and hills, the soils are generally sandy clay loam, well drained, leached and slightly acidic (PH 5-6), conditions suitable for Tarchonanthus bushlands. The soils on the Plateau and the volcanic plains are clay loam imperfectly to moderately well drained, mildly acidic (PH 5-6) and provide suitable environmental conditions for grasslands.

The human influences on the floristic diversity in the Park involve the effects of fires, grazing and cultivation. Fire is usually used in rangelands to clear the bushlands to increase the area available for grazing but in the process full grown trees and shrubs are deliberately destroyed. This phenomenon was observed on the north eastern slopes of Lion Hill which are burned regularly by accidental fires that originate either from outside or inside the Park. In this region Cynodon nlemfuensis, Digitaria abyssinica, Themeda triandra grasslands and Tarchonanthus camphoratus - Acacia

gerrardii bushland are probably maintained by fires or have developed some adaptations to fires as a recurrent environmental factor. On contrary a quite number of trees belonging to Acacia gerrardii, A. seyal, A. hockii and Cussonia holstii are scarred or heavily pollarded by fire. Unless they are controlled fires in this Park would do more harm than good put into considerations the low important values of woody species in this Park. Actually many trees of Acacia gerrardii were destroyed by 1987 fire on the Lion Hill and this brought to RIV of this species to less than 2 percent **(Table 3b)** instead than the expected 20 percent or even more (estimated from unburned patches of the bushland in the same area). The human occupation in the Park, evidenced through **the noble residential houses** in the Park (now utilized as Research Houses) Irrigation terraces in the grasslands, old fencing lines in the Tarchonanthus bushlands, the presence of exotic plants grown on commercial basis such as sisal on the western escarpments, the occurrence and dominance of fodder plants for cattle food, are all indications of the previous land use patterns meaning that the present vegetation is not original but secondary. However, Acacia, Olea and Euphorbia forests are **indigineous forests with climax** vegetation and it is from this habitats that the highest number of species were **recorded.**

Floristic investigations suggest that there are possibilities that woodlands were cleared to produce bushlands and bushlands were burned to give way to grasslands. The present studies show that there is a reverse process taking place in these habitats where re-establishments of trees particularly Acacia xanthophloea and bushes is tremendous at the expense of the grasslands (Plates 5 and 7). This phenomenon is also noticeable at Moysambu region where young Euphorbia trees and seedlings are taking over from the bushlands (Plate 19).

The rate of death of Acacia xanthophloea trees along the lakeshore and those of Euphorbia candelabrum in Euphorbia forest on the southern slopes of Lion Hill is a matter of great environmental concern. The Acacia xanthophloea trees demonstrate a marked dieback (Plates 11 and 26) suggested to be caused by salinity and impeded drainage problems as a result of seasonal fluctuations in water table with periodic climatic changes (Barkham and Rainy, 1976). In Euphorbia forest, Euphorbia candelabrum trees on the steep slopes are falling frequently (probably due to old age) but no regeneration of this species was noted in the area. The openings left by the fallen trees are quickly colonized by other species predominantly Obetia pinnatifida (Plate 28). Investigations as to the cause of death of Euphorbia and Acacia trees need further details.

The current high mortality rates of animal populations coupled with occasional translocations into the Park of threatened and endangered animal species like giraffes and Rhinoceros, without a correspondingly increase in land surface area and food supplies also pose an environmental concern as the present understanding of the vegetation status in the Park is that there are low plant densities and correspondingly low RIV of the woody species. The increase in numbers of browsers beyond certain limits might lead to prevention of further vegetation regeneration and consequently disappearance of some plant species. Therefore further additions of animals in the Park should be halted until studies on holding capacities of each plant community are carried out. However, the grasslands are still stable floristically and do not show indications of immediate dangers and threats of overgrazing. The construction of the numerous tracks everywhere and any how as just happened towards the end of the field work (1987) is not a desirable exercise as it causes disturbance not only to the animals but also to the vegetation cover and the soils.

Finally, the following account pertains to brief descriptions of the derived groups of plant communities and their associated plant communities based on salient features obtained from Tables 2 & 10 and the attached Landscape Ecological Vegetation Map sheet.

I Alkaline Grasslands

The alkaline grasslands encircle Lake Nakuru on lacustrine plains with alkaline and saline, mostly clayey soils of impeded drainage. The area covered by this vegetation formation is subject to frequent or rare flooding by strongly alkaline and saline lake water, a factor that seems to control and regulate the distribution of plant communities of alkaline grasslands along the shoreline. The plant species that characterize this group of plant communities include Cynodon dactylon, Pluchea bequaertii, Cyperus laevigatus, Sporobolus spicatus - all soda-resistant plants, and Typha domingensis (confined to fresh water swampy areas). The group is differentiated into five plant communities that include Cyperus laevigatus community (A1), Sporobolus spicatus - Cyperus laevigatus community (A2), Sporobolus spicatus community (A3), Pluchea bequaertii community (which is further subdivided into Pluchea bequaertii - Cyperus laevigatus community (A4) and Pluchea bequaertii - Sporobolus spicatus community (A5) and Typha domingensis community (A6).

Cyperus laevigatus community (A1) occurs on the permanently

wet marshes found on the north, south-east and south-west shores. The vegetation cover is predominantly Cyperus laevigatus sedge that is occasionally interrupted by patches of bare sand. These open areas are sometimes invaded by other plant species such as Sporobolus spicatus, Cynodon dactylon, Pluchea bequaertii, Chloris gayana, C. pycnothrix, Cyperus dichrostachys, Sesbania sesban and Circium vulgare. Sporobolus spicatus - Cyperus laevigatus community (A2) occurs along the immediate foreshore areas of high alkalinity and frequent flooding, the major vegetation being Cyperus laevigatus and Sporobolus spicatus. This vegetation community is also found on the mudflats (extremely saline bare sandy areas close to the lake) where it occurs in patches on sand banks (AO). Sporobolus spicatus community (A3) occurring on the north-west and south west shores is conspicuously distinguished by the short grass Sporobolus spicatus that forms a mat-like vegetation cover on the sandy occasionally flooded areas. Other plant species that sparingly occur in these areas include Chloris gayana, Cyperus laevigatus, Solanum incanum, Oldenlandia scopulorum, Tagetes minuta and Cycnium tubulosum, C. volkensii. Pluchea bequaertii - Cyperus laevigatus community (A4) is found at some places in the middle lacustrine plains with permanent swampy conditions caused by seepage. The vegetation is predominantly Pluchea bequaertii a low shrub (up to 2 m.), the sedge Cyperus laevigatus and grass Cynodon dactylon.

Other prominent plant species include Tagetes minuta, Sporobolus spicatus, Chloris gayana, Circium vulgare, Senecio mesograumoides, Senecio discifolius, Solanum incanum, Acacia xanthophloea, Setaria verticillata, Nicotiana glauca, Leucas martinicensis, Ocimum suave, Gutenbergia cordifolia, Vernonia galamensis, Cyncium tubulosum, Commelina reptans, Achyranthes aspera, Rhynchosia elegans and Gomphocarpus fruticosus. Pluchea bequaertii Sporobolus spicatus community (A5) is actually what has been referred to as Pluchea bushland in the floristic description given above. It borders the Acacia forest being more prominent on the eastern side of the Lake where it forms an extensive belt along the shoreline. The dominant plant species are Pluchea bequaertii, Sporobolus spicatus and Cynodon dactylon. Other notable species include Acacia xanthophloea, Solanum incanum, Rhus natalensis, Chloris gayana, Sporobolus pyramidalis, S. africanus, Withania somnifera, Nicotiana glauca, Tagetes minuta, Senecio discifolius, S. petitianus, Ipomoea cairica, Hibiscus cannabinus, Dodonaea angustifolia, Indigofera bogdanii, Cyperus laevigatus, Rhynchelytrum repens, Tarchonanthus camphoratus and Cycnium tubulosum. Typha domingensis swamp community (A6) covers a relatively small area of permanent swamp at the south-eastern side of the lake shore. The area is characterized by dense bulrush and sedge vegetation growing on alluvial and waterlogged soils with less alkalinity and salinity conditions due to occasional flushing effect by fresh water

from Nderit river particularly during the wet season. The characteristic plant species in the swamp include Typha domingensis, Cyperus immensus, C. laevigatus and Pluchea bequaertii as dominant species. Other dominant species include Sporobolus spicatus, Hibiscus diversifolius, Sesbania sesban, Gomphocarpus fruticosus, G. semilunatus, Nicotiana glauca, Conyza stricta, C. bonariensis, C. tigrensis, Cirsium vulgare, Achyranthes aspera, Ipomoea cairica, Senecio discifolius and Cynodon dactylon.

II Plain Grasslands

These are mainly open grasslands that form part of the major vegetation formations in the Park where their distribution is confined to the Plains. The classification of grasslands was rather difficult particularly because of the wide range of variations in species composition, dominance and recombinations within a given area. As a result many grassland units where no clear vegetation boundaries could be drawn were grouped together and treated as complexes with the most dominant species taken to denote each complex group, for example, Complex: Cynodon nlemfuensis and Chloris gayana grasslands (D1). However, two categories of plain open grasslands were distinguished, i.e. those grasslands that are found on the lacustrine sediments near

the Lake and those grasslands found on superficial volcanic deposits over diatomaceous sediments away from the Lake. The grasslands of the high lacustrine plains (on lacustrine sediments) were again subdivided further into two groups. The first group comprises of peripheral grasslands found on the north-western, south-western and south-eastern shores, areas of high lake levels where flooding by the lake could occur once after many years. This group consists of only one plant community namely, Chloris gayana - Digitaria abyssinica community, C. gayana variant (B1). The vegetation formation is predominantly Chloris gayana, a tall grass and Digitaria abyssinica, a short grass. Other plant species easily notable include Sporobolus spicatus, S. africanus, S. pyramidalis, Hyparrhenia hirta, H. anamesa, Themeda triandra, Solanum incanum, Acacia xanthophloea, Rhus natalensis, Pluchea bequaertii, Aloe graminicola, Withania somnifera, Dodonaea angustifolia, Tarchonanthus camphoratus, Psiadia punctulata, Lippia ukambensis, Hibiscus fuscus, H. aponeurus, Senecio petitianus, S. discifolius, S. mesograumoides, Tagetes minuta, Justicia exigua, Cyncium tubulosum, Crotalaria vallicola, C. deserticola, C. incana, Commelina reptans, Kalanchoe lauceolata, Leonotis nepetifolia, Rhynchosia minima, R. elegans and Ocimum suave. The second group of lacustrine plain grasslands include those

grasslands to the north of the Park occurring on lacustrine sediments overlain with volcanic deposits. The group is made up of three grassland communities: Cynodon nlemfuensis - Digitaria abyssinica community (C1), characterized by short heavily grazed grasses, sparsely scattered trees of Acacia xanthophloea, A. hockii and A. gerrardii, and furrowed ground, evidence of recent abandoned cultivation. Cynodon nlemfuensis and Digitaria abyssinica form the main vegetation cover associated with other species such as Chloris gayana, Hyparrhenia hirta, H. anamesa, Themeda triandra, Aristida adoensis, A. kenyensis, Sporobolus pyramidalis, S. africanus. Herbs include Justicia exigua, Gutenbergia cordifolia, Crotalaria incana, C. vallicola, Fuerstia africana, Indigofera brevicalyx, Tagetes minuta, Solanum incanum, Satureja biflora, Melhania ovata, Craterostigma hirsutum and Lippia ukambensis; Chloris gayana - Digitaria abyssinica community, D. abyssinica variant (C2) characterized by bushes of Lippia ukambensis, L. javanica, and L. trifolia, trees of Acacia xanthophloea, A. hockii and A. gerrardii, and tall grasses dominated by Chloris gayana, and Themeda triandra with associations of Aristida adoensis, A. kenyensis, Sporobolus pyramidalis, S. coninis, S. africanus, Cynodon nlemfuensis, Digitaria abyssinica, Hyparrhenia hirta and H. anamesa. Herbs with frequent occurrence included Tagetes minuta, Gutenbergia cordifolia, Achyranthes aspera, Crinum papillosum, Commelina reptans, C. africana, C.

benghalensis, Indigofera brevicalyx, I. bogdanii, Priva curtissae, Crotalaria incana, C. vallicola, C. deserticola, Cyncium tubulosum, Pentanisia ouranogyne, Monechma debile, Hypoestes verticillaris, Aloe graminicola, Senecio disci-folius, Satureja biflora, Heliotropium undulatifolium, Blumea sp., Melhania ovata, Oldenlandia scopulosum, O. corymbosa, Plectranthus assurgens, Fuerstia africana, Ocimum suave and Solanum incanum.

The complex of Chloris gayana and Cynodon nlemfuensis grasslands with Acacia gerrardii, Acacia seyal (C3) are characterized by a belt of small to medium sized trees along the fence and tall grasses on a gentle sloping ground. The dominant tree species include Acacia seyal, A. hockii and A. gerrardii. Other tree species include A. xantho-phloea, A. albida and Nuxia congesta. The tall grasses include Themeda triandra, Chloris gayana, Hyparrhenia hirta and H. anamesa. Other notable grasses include Eragrostis superba, Cynodon nlemfuensis, Sporobolus pyramidalis, Aristida adoensis, A. kenyensis. Other characteristic plant species are the same as those listed for the above plant community (C2).

The grasslands on superficial volcanic deposits over diatomaceous sediments are mainly found on the southern and eastern parts of the Park and were grouped together to form Complex of: Cynodon nlemfuensis and Chloris gayana grasslands (D1). seen on the Map, these grasslands have a widely range of distribution that results to a high degree of variation in species composition and combination with Cynodon nlemfu-

ensis being the predominant species in all the areas this group embraces. However, other common grasses include Chloris gayana, C. pycnothrix, Themeda triandra, Aristida adoensis, A. kenyensis, Sporobolus pyramidalis, S. confinis, S. africanus, Harphachne schimperi, Digitaria abyssinica, Pennisetum mezianum, Hyparrhenia hirta, H. anamesa and Eragrostis superba. The characteristic shrubs include Maerua triphylla, Cordia ovalis and Maytenus heterophylla. Other notable species are Solanum incanum, Lippia ukambensis, L. javanica, L. trifolia, Ocimum suave, Withania somnifera, Hibiscus micranthus, Commelina africana, C. reptans, Priva curtissae, Tagetes minuta, Gutenbergia cordifolia, Hypoestes verticillaris, Pentas zanzibarica, Pentanisia ouranogyne, Monechma debile, Aerva lanata, Heliotropium undulatifolium, Indigofera bogdanii, Crotalaria vallicola, C. incana, C. deserticola, Melhania ovata, Felicia muricata, Leucas martinicensis, Achyranthes aspera and Justicia exigua.

IIa Plain Wooded Grasslands

This group of grasslands consists of one plant community namely, Cynodon nlemfuensis and Acacia xanthophloea community (D2) and occurs on the southern region particularly around Naish Sub/Headquarters. The grassland community

is characterized by a well organized stand of trees of Acacia xanthophloea, scattered high shrubs of Maerua triphylla, Teclea simplicifolia, Cordia ovalis, Tarchonanthus camphoratus, Maytenus heterophylla and Rhus natalensis. The latter form no significant canopy. Cynodon nlemfuensis is the predominant grass contributing more than 95 % ground cover. Other characteristic species include Erythrococca bongensis, Psiadia punctulata, Abutilon longicuspe, Ocimum suave, Lippia ukambensis, Solanum incanum, Hibiscus micranthus, Themeda triandra, Setaria verticillata, Achyranthes aspera, Chenopodium sp., Gutenbergia cordifolia, Aerva lanata, Hypoestes verticillaris and Grewia similis.

III Bushlands

Bushlands were found to contribute the largest vegetation cover in the Park being widely distributed on the hills, ridges, valleys and footslopes to the east; escarpment, plateau and ridges to the west and to the sedimentary plains in the south. Vegetation classification differentiated the bushlands into four plant communities as follows: Tarchonanthus camphoratus - Acacia gerrardii community, Tarchonanthus camphoratus - Acacia xanthophloea community, Tarchonanthus camphoratus - Pluchea bequertii community and Tarchonanthus camphoratus - Euphorbia candelabrum community.

Tarchonanthus camphoratus - Acacia gerrardii community (F1) forms a conspicuous dense Tarchonanthus camphoratus bushland that spreads in the north to south direction along the ridges and slopes of the Lion Hill. The bushland becomes a bush thicket in the valleys that bisect the Euphorbia forest in the south. The predominant vegetation is Tarchonanthus camphoratus associated with Acacia gerrardii and Cussonia holstii that form emergents within the bushland. Other characteristic plant species in this community include Rhus natalensis, Maerua triphylla, Maytenus heterophylla, Grewia similis, Psiadia punctulata, Lippia ukambensis, Aspilia mossambicensis and Tinnea aethiopica (shrubs); Hypoestes verticillaris, Commelina reptans, Chlorophytum bakeri, Pentanisia ouranogyne and Asparagus africanus (herbs), Themeda triandra, Cynodon nlemfuensis and Digitaria abyssinica (grasses).

Tarchonanthus camphoratus - Acacia xanthophloea community dominates the plateau, ridges and gentle slopes of the western escarpment (K2), a portion of the southern plains (D3) and the footslopes of the Lion Hill to the east (G5). The community is formed by a dense vegetation stand of Tarchonanthus camphoratus bushland associated with Acacia xanthophloea. To the west of the lake the bushland is interrupted by openings of wooded grasslands whereas to the east it is interrupted by depression-like lowlands

of Aspilia mossambicensis - Psiadia punctulata bushlands. The plant species that characterize this community include Acacia xanthophloea, A. gerrardii, Cussonia holstii (trees), Tarchonanthus camphoratus, Maytenus heterophylla, Rhus natalensis, Grewia bicolor, G. similis, Maerua triphylla, Senecio petitianus, Cordia ovalis, Tinnea aethiopica, Psiadia punctulata, Aspilia mossambicensis, Lippia ukambensis, Ocimum suave and Solanum incanum (shrubs); Commelina reptans, Tagetes minuta, Aerva lanata, Leucas martinicensis and Hypoestes verticillaris (herbs) and Chloris gayana, Themeda triandra, Cynodon nlemfuensis and Digitaria abyssinica.

Tarchonanthus camphoratus - Pluchea bequertii community (B3) fills the gap left within the 'Colubus forest' (Acacia xanthophloea forest) at the south-western shoreline commonly known as Pelican Corner region. This plant community is characterized by a dense bushland dominated by Teclea simplicifolia, Rhus natalensis, Tarchonanthus camphoratus and Pluchea bequertii, Other characteristic plant species include Acacia xanthophloea, Cussonia holstii (trees); Solanum incanum, Ocimum suave, Lippia ukambensis, Aspilia mossambicensis, Psiadia punctulata, Grewia bicolor, G. similis, Maytenus heterophylla, Maerua triphylla, Senecio petitianus, Cordia ovalis, Olea africana, Erythrococca bongensis, Hibiscus aponeurus and Abutilon longicuspe (shrubs); Chlorophytum bakeri, Melhania ovata, Commelina reptans, Tagetes

minuta, Hypoestes verticillaris and Achyranthes aspera (herbs) and Chloris gayana, Themeda triandra, Cynodon nlemfuensis, Digitaria abyssinica and Setaria pumilla (Grasses).

Tarchonanthus camphoratus - Euphorbia candelabrum community is mainly found on the sothern plains, an area commonly known as Roysambu region (D4) and also covers a small section at the southern end of the western Mau plateau, at the Nganyoi Rangers substation (K3). The vegetation at the Roysambu region is a wooded bushland of Tarchonanthus camphoratus and Euphorbia candelabrum as predominant shrubs and tree species respectively. Near the southern fence the bushland is characterized by lack of Tarchonanthus camphoratus bushes and the presence of dense young Euphorbia trees. Old stumps of Tarchonanthus camphoratus were noted in many places, an indication of'Tree poaching' activities that existed in the region before electrification of the fence that forms the Park boundary. The vegetation at Nganyoi Section is a dense wooded bushland with Tarchonanthus camphoratus as the predominant species in the shrub layer and Acacia xanthophloea and Euphorbia candelabrum species form the major tree canopy. The characteristic plant species in this community include Euphorbia candelabrum, Acacia xanthophloea (trees); Tarchonanthus camphoratus, Ocimum suave, Lippia ukambensis, Psiadia punctulata, Tinnea

aethiopica, Grewia bicolor, G. similis, Maytenus heterophylla, Maerua triphylla, Cordia ovalis, Rhus natalensis, Senecio petitianus and Teclea simplicifolia (shrubs); Hypoestes verticillaris, Commelina reptans, Tagetes minuta, Solanum incanum and Pentanisia ouranogyne (herbs) and Themeda triandra, Cynodon nlemfuensis, Setaria pumilla and Digitaria abyssinica (grasses).

IV. Euphorbia forest : Euphorbia candelabrum - Teclea simplicifolia Community

This plant community is a dense forest predominantly Euphorbia candelabrum that covers the southern ridges and steep slopes of the Lion Hill (F3). Each individual Euphorbia candelabrum trees forms an umbrella-shaped canopy with forked branching and an average height of about 20 m. The branches of one tree interlace with those of another tree and this kind of pattern repeats and continues to form a closed tree canopy that is interrupted in some places by open spaces inside the forest. The other characteristic tree species is Cussonia nolstii. The shrub layer is not conspicuous inside the forest unlike its appearance at the forest margins. The dominant shrub species is Teclea simplicifolia that occurs in combination with other species such as Maerua triphylla, Maytenus heterophylla, Cordia ovalis, Tarchonanthus camphoratus,

Grewia bicolor, Dombeya burgessiae, Rhus natalensis, Erythrococca bongensis and Psiadia punctulata. The herbaceous cover is interrupted by occurrence of bare rock boulders on the steep slopes. The ground cover is mainly that of Hypoestes verticillaris and Achyranthes aspera.

V. Olea forest : Olea africana - Teclea simplicifolia Community.

This forms a narrow forest vegetation belt along the south-west Park boundary on the volcanic soils of the western Mau plateau (K1). The tree layer is formed mainly by three tree species namely, Olea africana, Teclea simplicifolia and Cussonia holstii. Other characteristic tree species include Tarenna graveolens and Euclea divinorum. The trees form a closed canopy interlaced with climbers, twiners and lianes such as Senecio petitianus, Peponium vogelii, Cyphostemma nodiglandulosum, Pterolobium stellatum, Vigna membracea, Rhus natalensis and Sarcostemma viminale. Shrubs form a dense shrub layer dominated by Teclea simplicifolia, Maerua triphylla, Grewia similis, Tinnea aethiopica and Helinus integrifolius. Other characteristic shrub species include Maytenus heterophylla, Cordia ovalis, Gnidia subcordata, Erythrococca bongensis, Dombeya burgessiae, Abutilon longicusne, Aspilia mossambicensis and Tarchonanthus camphoratus. The forest lacks a dense undergrowth but the meager ground cover is contributed by Hypoestes verticillaris and Sansevieria parva.

VI. Acacia xanthophloea forest

The Acacia xanthophloea forest was classified into communities, i.e., Acacia xanthophloea - Ficus sur community and Acacia xanthophloea - Urtica massaica community. Acacia xanthophloea - Ficus sur community is simply the riverine vegetation formation covering the river banks with alluvial soils along the river systems (E2). The vegetation is dense vegetation thicket of trees, shrubs and lianes, sometimes with closed tree canopies formed over the shrub layer. The characteristic plant species include Acacia xanthophloea, Ficus sur, Cussonia holstii and Warburgia ugandensis (trees); Rhus natalensis, Grewia similis, Maerua triphylla, Teclea simplicifolia, Cordia ovalis, Dombeya burgessiae and Erythrococca bongensis (shrubs) and Hypoestes verticillaris and Achyranthes aspera (herbs).

Acacia xanthophloea - Urtica massaica community was further distinguished into two sections that include the section of forest that occurs on the high lacustrine plains with lacustrine sediments (B2) and the section of the forest that occurs on the flood plains with alluvial deposition over diatomaceous sediments (E1). The Acacia xanthophloea forest on the lacustrine plains forms a closed canopy of Acacia xanthophloea trees with an average height of 30 m. tall, lacks shrub layer except at the Pelican Corner (Colobus

forest-south-west) and Kambi ya Nyuki - north-east) regions of the shoreline, and consists of a dense undergrowth. The Acacia xanthophloea forest on the flood plains has a semi-closed canopy, poor shrub layer and also a dense undergrowth. In both cases, the forest is characterized by clumps of lianes, twiners and climbers such as Cynanchum altiscandens, C. hastifolium, Pergularia daemia, Periploca linearifolia, Dregea schimperi, Senecio petitianus, Capparis tomentosa, Achyranthes aspera, Maerua triphylla, Rhus natalensis, Grewia similis, Commicarpus plumbagineus, Toddalia asiatica, Phytolacca dodecandra and Pterolobium stellatum hanging on Acacia trees. Characteristic shrubs include Maytenus heterophylla, Rhus natalensis, Maerua triphylla, Grewia similis, Dombeya burgessiae, Erythrococca bongensis, Abutilon longicuspe, Ricinus communis, Cassia bicapsularis, Ocimum suave, Pluchea bequertii and Solanum incanum. The undergrowth is dominated by Hypoestes verticillaris, Achyranthes aspera, Tagetes minuta and Urtica massaica. In some areas particularly in the south, the undergrowth is entangled with lianes, climbers and twinners. The common grasses include Setaria pumilla, Pennisetum clandestinum and Cynodon nlemfuensis.

The full names of the abbreviated symbols of plant species in figures 10, 11 and 12 are as follows:

AL = Abutilon longicuspe
AG = Acacia gerrardii
AX = Acacia xanthophloea
AM = Aspilia mossambicensis
CS = Canthium schimperiana
CT = Capparis tomentosa
CA = Celosia anthelmintica
CM = Clerodendron myricoides
CP = Commicarpus plumbagineus
CO = Cordia ovalis
CM = Crassocephalum mannii
CD = Croton dichogamus
CH = Cussonia holstii
CN = Cyphostemma nodiglandulosum
DB = Dombeya burgessiae
DS = Dregea schimperi
EB = Erythrococca bongensis
ED = Euclea divinorum
EC = Euphorbia candelabrum
GS = Grewia similis
GSs = Gnidia subcordata
HI = Helinus integrifolia
HT = Heteronorpha trifoliata
HC = Hibiscus calyphyllus
HF = Hibiscus fuscus
HM = Hibiscus micranthus
IM = Iboza multiflora
LU = Lippia ukambensis
LE = Lycium europaeum
MT = Maerua triphylla
Mh = Maytenus heterophylla
OP = Obetia pinnatifida
OC = Ocimum suave
OA = Olea africana

OS = Osyris abyssinica
PP = Pavonia patens
PV = Peponium vogelii
PD = Phytolacca dodecandra
PB = Plectranthus barbatus
PS = Psiadia punctulata
PT = Pterolobium stellatum
Rn = Rhus natalensis
RC = Ricinus communis
SV = Sarcostemma viminale
SA = Schrebera alata
SP = Senecio petitianus
SI = Solanum incanum
ST = Steganotaenia araliacea
CY = Cynanchum altiscandens
TC = Tarchonanthus camphoratus
TG = Tarenna graveolens
TS = Teclea simplicifolia
Ta = Tinnea aethiopica
TO = Toddalia asiatica
VB = Vernonia brachycalyx
VG = Vernonia galamensis
WU = Warburgia ugandensis
WS = Withania somnifera
ZM = Zizyphus mucronata

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

The terrestrial habitats surrounding Lake Nakuru from the shoreline to the escarpments and ridges exhibit a wide ecological diversity that explains why many plant and animal species have been recorded in the Park. All vascular plants encountered in the course of this study were collected, identified and submitted to the East African Herbarium. The plant specimens will be sorted out into duplicates which will be sent out to other Botanical Institutions (as herbarium specimens) including Botany Department, University of Nairobi and Educational Centre at Lake Nakuru National Park. The original specimens will be retained at the East African Herbarium. A plant checklist of the Park was compiled consisting of 556 species, 305 genera and 85 families.

Vegetation classification, based on aerial photographic interpretations and ground floristic inventories differentiated the vegetation into 19 plant communities that were bound in 6 groups of plant communities using Braun Blanquet Tabulation Method. The practicability of the plant communities as mapping units with particular reference to their recognition on aerial photographs and Landsat images and prints has been discussed. The distribution of plant communities in relation to landscape features was plotted on a baseline map and Landscape Ecological Vegetation Map was thus produced.

Floristic distribution was described using Reciprocal Averaging Ordination Method. Quantification of the vegetational attributes such as species density, dominance and height measurements of woody species is of great ecological value particularly in scientific studies such as biomass estimations in the bushland and forest communities. The ecological importance of each woody species was evaluated using line transects (P.C.Q. Method) and the data showed low relative importance values for most of the woody species, an important ecological parameter in the formulation of conservation and management planning programmes. However Acacia xanthophloea and Tarchonanthus camphoratus attained relative importance values much higher than any other species, the criterion on which the vegetation of the woody plant communities was defined as the Acacia - Tarchonanthus bushland.

To quantify the vegetation zonation patterns on an environmental basis, vegetation and soil samples were taken along a catenary sequence from the shoreline to the escarpments and ridges. Analysis of the samples indicated that the pattern variation described phytosociologically coincide with pattern variation in soil characteristics, simulating a vegetation zonation around the Lake as depicted in the profile diagrams.

In view of various derived observations and inferences made in this study, a number of recommendations and valuable suggestions were generated with special considerations. Fire has probably always been a normal part of the environment in the rangelands but in most cases its demerits outweigh the merits in the sense that fire destroys the vegetation climax, thus altering the floristic succession process, floristic composition and physiognomic structural properties of the plant communities in the areas where it occurs. Lake Nakuru National Park, a relatively small area with a powerful Solar electric fence all round and with the highest animal biomass in the country, per unit area, burning in the wooded plant communities does more harm than good and should be discouraged and controlled at all costs for the maintanance of the ecological balance that exists between animals and plants. In this wise, construction of numerous roads through various vegetation stands as has been witnessed in the last two years, especially with the arrival of rhinoceros in the Park, should also be discouranged. Sometimes animals and plants require some privacy and many of such roads or tracks in some habitats cause unnecessary vegetation and animal disturbances let alone soils.

The Park, for the last ten years, has received full Government honours as an Animal Sanctuary for endangered

and threatened animal species. Many animals including giraffes and rhinoceros have been translocated into the Park and their numbers have tremendously increased; for instance, Rothschild giraffes have now increased from the original number of about 20 to 85. At the same time the mortality rates of the residential animals particulary Waterbuck , Impalas, Warthogs and Buffalos are now at threshold value. However, assessment studies are needed on the amount of vegetation biomass available in the Park for both grazers and browsers to establish whether and when the populations of the residential animals will undergo direct competition for the available food supplies with the immigrant animals, in which case the allowance of immigrants should be reconsidered. Unless such studies be carried out and recommendations formulated whether or not to add more animals into the Park, the translocation operations should be halted with immediate effect.

Another environmental process noted with much interest is the vegetation dynamism. There is a recognisable path of succession from grasslands and bushlands into woodlands; hence the marked variation in floristic composition and the rate at which structural complexity increases in these plant communities. It is therefore important that a Vegetation Monitoring Programme should be established in the Park to check the vegetation changes through various environmental mechanisms such as succession, grazing and

browsing pressure and rates of disappearance of certain plant species due to fire, salinity and age factors. In this respect more attention should be on the death of Acacia xanthophloea trees on the shoreline and that of Euphorbia candelabrum on the southern slopes of Lion Hill.

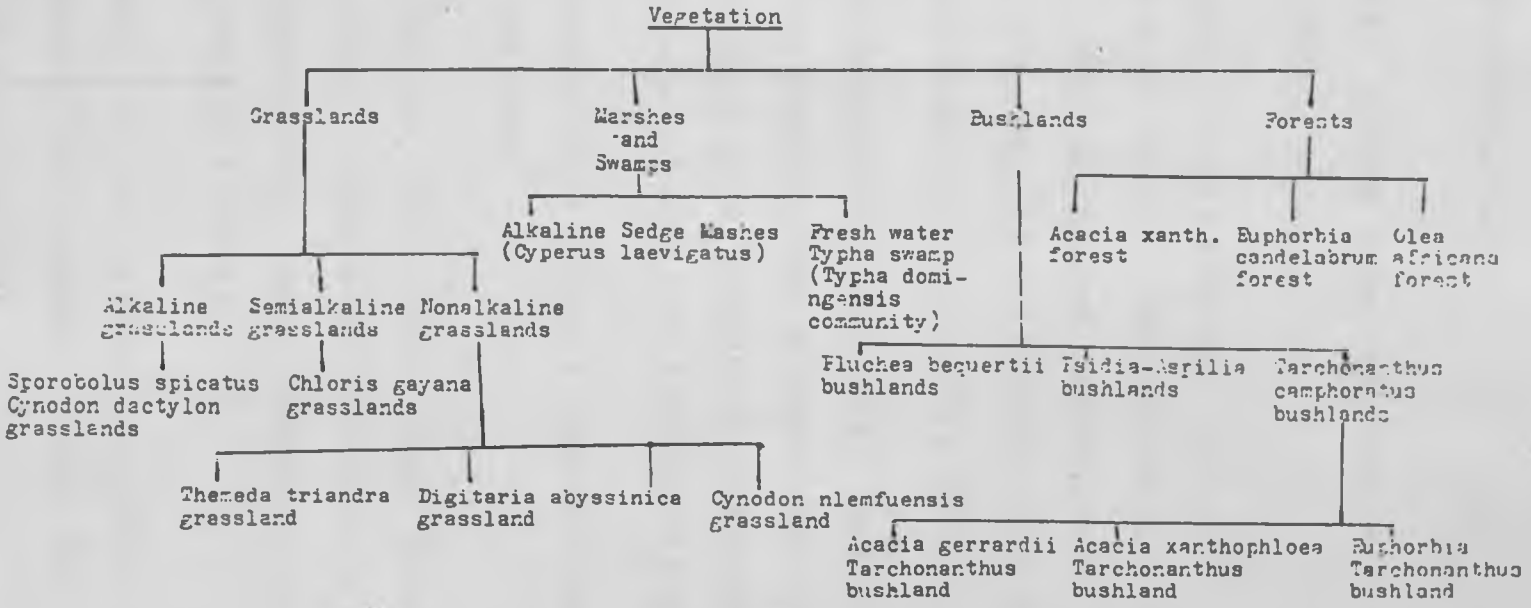
Lastly, the future biological value of the Park depends on socio-ecological status of its catchment zone. Presently the area has been denuded of its natural vegetation to give way to intensive cultivation and ranching. This affects the Park ecosystem directly in terms of soil erosion, rainfall distribution and pollution through agricultural chemicals. To restore the environmental situation of the catchment area back to the original state, **reafforestation** programmes must be established in these areas that include the Bahati highlands, the Lake basin and the Mau escarpments (Njoro and Mau areas). Within this framework a vegetation study of the plant communities along the river systems that drain the catchment area into Lake Nakuru should be carried out to establish their infrastructure and composition as this will help to understand the original vegetation of the catchment zone for **reafforestation** More than being the source of information on the past vegetation in which case they act as 'vegetation indicators' the natural habitats along the river systems also act as floristic genebanks of the regional vegetation whereby plant species are conserved and protected in situ. The vegetation cover along these rivers sustain the river flow by reduction of evaporation rates through the

vegetation canopy cover and also protect against soil erosion. Therefore, such a study will be of highly ecological value to the life of Lake Nakuru.

This study has come up with many new factual findings and it is hoped that the scientific findings obtained from this project will provide baseline information on the vegetation status in the Park. Such information is expected to contribute greatly to future research and ecological monitoring programmes as well as to the conservation strategies and planning programmes that form the management structures of the Park.

Table 11. Vegetation classification summary of Lake Nakuru National Park.

The vegetation classification of Lake Nakuru National Park could be summarized diagrammatically as follows:



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APPENDIX I

A CHECK-LIST OF PLANT SPECIES RECORDED IN LAKE NAKURU NATIONAL PARK

PTERIDOPHYTES

SELAGINELLACEAE

Selaginella caffrorum (Milne) Hieron.

ADIANTACEAE

Actiniopteris semiflabellata Pic. Ser.

Adiantum thalictroides Schlechtend.

Doryopteris concolor(Langsd & Fisch.) Kuhn var. kirkii (Hook.) C. Chr.

Pellaea adiantoides (Willd.) J.S.M.

P. involuta (Swartz) Bak.

P. viridis (Forssk.)Prantt

ASPLENIACEAE

Asplenium aethiopicum (Burm. f.) Benth.

DICOTYLEDONS

15. RANUNCULACEAE

Clematis brachiata Thunb.

C. hirsuta Guill. & Perr.

23. MENISPERMACEAE

Stephania abyssinica (Dill. & Rich.) Walp. var. abyssinica

S. abyssinica (Dill. & Rich.) Walp. var. tomentella (Oliv.) Diels

28. PIPERACEAE

Peperonia stuhlmannii DC.

32. PAPAVERACEAE

Argemone mexicana L.

36. CAPPARIDACEAE

Capparis fascicularis DC. var. elaeagnoides (Gilg.) De Wolf.

C. tomentosa Lam.

Gynandropsis gynandra (L.) Briq.

Maerua triphylla A. Rich. var. johannis De Wolf.

39. CRUCIFERAE

Crambe abyssinica R.E. Fries.

C. hispanica L.

Erucastrum arabicum Fisch. & Mey.

Farsetia stenophera Hochst. ssp. stenoptera

F. undulicarpa Johnsell

Lepidium bonariensis L.

Ferula communis L.

41. RESEDACEAE

Caylusea abyssinica (Fresen.) Fisch. & Mey.

42. POLYGALACEAE

Polygala abyssinica A. Rich.

P. petitiana A. Rich.

P. sphenoptera Fresen. var. sphenoptera

P. sphenoptera Fres. var. minor (Chod.) Chiov.

45. CRASSULACEAE

Crassula volkensii Engl. ssp. coleae (Bak.) Wickens & Bywater

Kalanchoe densiflora Rolfe var. densiflora

K. lanceolata (Forssk.) Pers.

K. laciniata (L.) DC.

53. CARYOPHYLLACEAE

Drymaria cordata (L.) Roem. & Schultes

Pollichia campestris Ait

Polycarpaea eriantha A. Rich. var. eriantha

Silene macroselen A. Rich.

54. AIZOACEAE

Delosperma nakurense (Engl.) Herre

Gisekia pharnoceoides L. var. pharnoceoides

Zaleya pentandra (L.) Jeffrey

56. PORTULACACEAE

Portulaca foliosa Ker

P. kermesina N.E. Br.

P. oleracea L.

P. quadrifida L.

57. POLYGONACEAE

Oxygonum sinuatum (Meisn.) Dammer

Polygonum senegalensis Meisn.

Rumex usambarensis (Dammer) Dammer

59. PHYTOLACCACEAE

Phytolacca dodecandra L'Herit

61. CHENOPODIACEAE

Atriplex semibaccata R. Br.

Chenopodium fasciculosum Aellen var. fasciculosum

C. opulifolium Koch. & Ziz.

C. procerum Moq.

C. schraderanum Schult.

63. AMARANTHACEAE

Achyranthes aspera L.

Aerva lanata L. Juss.

Alternanthera pungens H.B.K.

Amaranthus spinosa L.

A. hybridus L.

Celosia anthelmintica Aschers.

Cyathula cylindrica Moq.

C. unicinulata (Schrad.) Schinz

C. sp.

Pupalia lappacea (L.) A. Juss.

64. BASELLACEAE

Basella alba L.

66. ZYGOPHYLLACEAE

Tribulus terrestris Linn.

67. GERANIACEAE

Geranium ocellatum Cambess

Monsonia angustifolia A. Rich.

Pelargonium quinquelobatum A. Rich.

69. OXALIDACEAE

Oxalis corniculata L. var. corniculata

81. THYMELAEACEAE

Gnidia subcordata Meisn

83. NYCTAGINACEAE

Commicarpus pedunculosus (A. Rich.) Cuf.

C. plumbagineus (Cav.) Standley

84. PROTEACEAE

Grevillea robusta A. Cunn.

93. FLACOURTIACEAE

Dovyalis abyssinica L.

D. caffra (Hook. f. & Harv.) Warb.

Scolopia theifolia Gilg.

95. CANELLACEAE

Warbugia ugandensis Sprague

W. ugandensis ssp. ugandensis

103. CUCURBITACEAE

Coccinia adoensis (A. Rich.) Cogn.

C. trilobata (Cogn.) C. Jeffrey

Cucumella engleri (Gilg.) C. Jeffrey

Cucumis aculeatus Cogn.

C. ficifolius A. Rich.

Gerrardanthus lobatus (Cogn.) C. Jeff.

Kedrostis foetidissima (Jacq.) Cogn.

K. hirtella (Nand.) Cogn.

Lagenaria siceraria (Molina) Standley

Momordica foetida Schumach.

Peponium vogelii (Hook. f.) Engl.

Zehneria minutiflora (Cogn.) C. Jeff.

Z. scabra (L. f.) Sond

107. CACTACEAE

Opuntia sp.

118. MYRTACEAE

Callistemon speciosus (Sims) DC.

Eucalyptus citriodora Hook.

121. COMBRETACEAE

Combretum illairii Engl.

123. HYPERICACEAE

Hypericum roeparanum A. Rich.

128. TILIACEAE

Grewia bicolor Juss.

G. similis K. Schum.

G. trichocarpa A. Rich.

Triumfetta rhomboidea Jacq.

130. STERCULIACEAE

Dombeya burgessiae Gerrard

D. rotundifolia (Hochst.) Planch.

Melhania ovata (Cav.) Spreng

M. velutina Forssk.

132. MALVACEAE

Abutilon engleranum

A. fruticosum Guill. & Perr.

A. holstii Guerke

A. longicuspe A. Rich.

A. mauritianum (Jacq.) Medic.

A. rehmannii Bak. f.

Gossypium somalensis (Guerke) Hutch.

Hibiscus aethiopica L.

H. aponeurus Sprague & Hutch.

H. calyphyllus Cav.

H. cannabinus L.

H. diversifolius Jacq.

H. flavifolius Ulbr.

H. fuscus Garcke

H. micranthus L. f.

H. vitifolius L.

132. MALVACEAE contd.

Kosteletzkya begoniifolia (Ulbr.) Ulbr.

Malva parviflora L.

M. verticillata L.

Pavonia patens (Andr.) Chiov.

P. urens Cav. var. tomentosa Brenan

Sida cuneifolia Roxb.

S. ovata Forssk.

S. rhombifolia L.

S. schimperiana A. Rich.

S. tenuicarpa Vollesen sp. nov.

135/D. LINACEAE

Linum volkensii Engl.

136. EUPHORBIACEAE

Clutia abyssinica Jaub. & Spach

Croton dichogamus Pax

C. macrostachyus Del.

C. megalocarpus Hutch.

Erythrococca bongensis Pax

Euphorbia candelabrum Kotschy

E. crotonoides Boiss

E. gossypina Pax var. coccinea Pax

E. inaequilatera Sond.

E. nyikae Pax

E. schimperiana Scheele

136. EUPHORBIACEAE contd.

Phyllanthus maderaspatensis L.

Ricinus communis L.

Tragia brevipes Pax

T. insuavis Prain

143. ROSACEAE

Alchemilla sp.

Rubus niveus Thunb.

146. CAESALPINIACEAE

Cassia bicapsularis L.

C. didymobotrya Fres.

C. mimosoides L.

Pterolobium stellatum (Forssk.) Brenan

147. MIMOSACEAE

Acacia abyssinica Benth. ssp. calophylla Brenan

A. albida Del.

A. brevispica Harms

A. gerrardii Benth. var. gerrardii

A. hockii De Willd.

A. senegal (L.) Willd.

A. seyal Del. var. seyal

A. xanthophloea Benth.

Albizia gummifera (Gmel.) C.A. Sm.

Entada abyssinica A. Rich.

148. PAPILIONACEAE

Alysicarpus rugosus (Willd) DC.

A. zeyheri Harv.

Astragalus atropilosulus (Hochst.) Bunge
ssp. burkeanus (Harv.) Gillett

Calpurnea subdecandra (L. Herit) Schweickerdt

Crotalaria agatiflora Schweinf.

C. agatiflora Schweinf. ssp. imperialis (Taub.) Polhill

C. apiculata Polhill

C. deserticola Bak. f. var. deserticola

C. incana L. ssp. purpurasceus (L.) Milne-Redh.

C. pycnostachys Benth.

C. spinosa Benth.

Desmodium intortum (Mill.) Urb.

Eriosema richardii Bak.

Erythrina lysistemon Hutch.

Glycine wightii (W. & A.) Verdc.

Indigofera arrecta A. Rich.

I. costata Guill. & Perr. ssp. gonoides (Bak.) Gillett

I. bogdanii Gillett var. bogdanii

I. bogdanii Gillett var. peteri Gillett

I. brevicalyx Bak. f.

I. hochstetteri Bak.

I. tinctoria L.

I. spicata Forssk.

148. PAPILIONACEAE contd.

Lotononis platycarpus (Viv.) Pic-Serm.

Medicago laciniata (L.) Mill.

Neonotonia wightii (Wight. & Arn.) Verdc.

ssp. petitiana (A. Rich.) Verdc. var. meamsii (De Wild.) Verdc.

N. wightii (W. & A.) Verdc. var. longicanda (Schweinf.) Verdc.

Rhynchosia elegans A. Rich.

Rhynchosia minima (L.) DC. var. nuda (DC.) O. Kuntze

R. minima (L.) DC. var. prostata (Harv.) Merkle

Sesbania goetzei Harms

S. sesban (L.) Merr. var. nubica Chiov.

Tephrosia athiensis Bak. f.

T. emeroides A. Rich.

Trifolium rueppellianum Fres. var. rueppellianum

T. semipilosum Fres. var. glabrescens Gillett

Vigna membracea A. Rich.

V. oblongifolia A. Rich. var. parviflora Verdc.

154. BUXACEAE

Notobuxus obtusifolius Hildbr.

156. SALICACEAE

Salix subserrata Willd.

167. MORACEAE

Ficus sur Forssk.

F. cordata Thunb.

167. MORACEAE contd.

Ficus craterostoma Warb.

F. cordata Thunb.

F. sur Forssk.

F. thonningii Blume

F. wakefieldii Hutch.

169. URTICACEAE

Droguetia debilis Rendle

Girardinia condensata Wedd.

G. diversifolia (Link.) Friis

Fleurya aestuans (L.) Miq.

Obetia pinnatifida Baker

Urtica massaica Mildbr.

173. CELASTRACEAE

Hippocratea africana (Willd.) Loes

Loeseneriella africana (Willd.) Wilczek & Halle

Maytenus heterophylla (Eckl. & Zeyh.) N. Robson

185. LORANTHACEAE

Danserella fischeri (Engl.) Balle

Odontella fischeri (Engl.) S. Balle

O. ugogensis (Engl.) Balle

Phragmanthera rufescens (DC.) S. Balle var. usuiensis (Oliv.) Balle

Tapinanthus zizyphifolius (Engl.) Danser

186. SANTALACEAE

Osyris abyssinica A. Rich.

190. RHAMNACEAE

Helinus integrifolius (Lam.) Kuntze

H. mystacinus (Ait.) Steud.

Rhamnus staddo A. Rich.

Scutia myrtina (Burm. f.) Kurz.

Ziziphus mucronata Willd.

193. VITACEAE

Cyphostemma adenocaulis (Gilg. & Brandt.) Desc.

C. bambuseti (Gilg. & Brandt.) Willd. & Drum.

C. cyphopetalum (Fresn.) DC.

C. nierense (Th. Fr.) Descoings

C. nodiglandulosum (Th. Fr. jr.) Desc.

C. orondo (Gilg. & Brandt.) Desc.

Rhoicissus tridentata (L. f.) Willd. & Drummond.

194. RUTACEAE

Teclea simplicifolia (Engl.) Verdoorn

Toddalia asiatica (L.) Lam.

197. MELIACEAE

Ekebergia capensis Sparrm.

198. SAPINDACEAE

Dodonaea angustifolia L. f.

205. ANACARDIACEAE

Rhus natalensis Krause

Schinus molle L.

212. ARALIACEAE

Cussonia holstii Engl. var. holstii

213. UMBELLIFERAE

Ferula communis L.

Heteromorpha trifoliata (Wendl.) Eckl. & Zeyh.

Hydrocotyle ranunculoides L. f.

Steganotaemia araliacea Hochst.

221. EBENACEAE

Euclea divinorum Hiern.

228. LOGANIACEAE

Buddleja polystachya Fresen.

Nuxia congesta Fresen.

229. OLEACEAE

Olea africana (Mill.) P.S. Green

Schrebera alata (Hochst.) Welw.

230. APOCYNACEAE

Landolphia kirkii Dyer.

231. ASCLEPIADACEAE

Caralluma dummeri (N.E. Br.) Bruce

Cynanchum tetrapterum (Turz.) R.A. Dyer

C. altiscandens K. Schum.

C. hastifolium N.E. Br.

Dregea schimperi (Decne) Bullock

Gomphocarpus fruticosus L. Ait. f.

G. integer (N.E. Br.) Bullock

G. semilunatus A. Rich.

G. stenophyllus Oliv.

Periploca linearifolia Dill. & Rich.

Pergularia daemia (Forssk.) Chiov.

Sarcostemma viminale R. Br.

232. RUBIACEAE

Canthium lactescens Hiern

C. schimperianum A. Rich.

Galium simense Fress

G. spurium L. ssp. africana Verdc.

Kohautia coccinea Royle

Oldenlandia corymbosa L. var. linearis

O. corymbosa L. var. caespitosa Verdc.

O. scopulorum Bullock

O. wiedlemannii K. Schum.

Pentanisia ouranogyne S. Moore

232. RUBIACEAE contd.

Pentas longiflora Oliv.

P. pubiflora S. Moore

P. zanzibarica (Kl.) Vatke

Psydrax parviflora (Afz.) Bridson ssp. rubrocostata (Robyns) Bridson

P. schimperiana (A. Rich.) Bridson ssp. schimperiana

Pterocephalus frutescens A. Rich. ?

Tarenna graveolens S. Moore

Vangueria apiculata K. Schum.

236. DIPSACACEAE

Pterocephalus frutescens A. Rich.

238. COMPOSITAE

Ageratum conyzoides L.

Artemisia afra Willd.

Aspilia mossambicensis (Oliv.) Willd.

Bidens pilosa L.

Blumea crispata

B. sp. aff. B. alata Sch. Bip.

Carduus sp.

Cirsium vulgare (Savi) Ten

Conyza bonariensis L.

C. floribunda H.B. & K.

C. pedunculata (Oliv.) Willd.

238. COMPOSITAE contd.

Conyza schimperi A. Rich.

C. steudelii A. Rich.

C. stricta Willd. ssp. pinnatifida (D. Don.) Kitam.

C. tigrensis Oliv. & Hiern

C. volkensii O. Hoffm.

Crassocephalum crepidioides (Benth.) S. Moore

C. mannii (Hook. f.) Milne-Redh.

C. montuosum (S. Moore) Milne-Redh.

C. picridifolium (DC.) S. Moore

C. vitellinum (Benth.) S. Moore

C. rubens (Jacq.) S. Moore

Dichrocephala integrifolia O. Ktze

Erigeron floribundus (H.B.K.) Sch. Bip-

Gutenbergia cordifolia (Benth.) S. Moore

G. fischeri R.E. Fr.

G. rueppellii Sch. Bip.

Felicia abyssinica A. Rich. ssp. neghellensis (Cuf.) Gran.

F. hyssopifolius Less.

F. muricata (Thunb.) Nees

Galinsoga ciliata (Raf.) Blake

G. parvifolia Cav.

Gnaphalium undulatum L.

G. luteo-album L.

Gulzotia scabra (Vis.) Chiov.

Gynura scandens O. Hoffm.

238. COMPOSITAE contd.

Helichrysum glumaceum DC.

H. odoratissimum (L.) Less.

Hirpicium diffusum (O. Hoffm.) Roess

Lactuca capensis Thunb.

Melanthera scandens (Schumach. & Thonn.) Roberts

Microglossa angolensis Oliv. & Hiern

Nicolasia nitens (O. Hoffm.) Eyles.

Notonia petraea R.E. Fries

N. sp. near N. hildebrandtii Vatke

Osteospermum vaillantii (Decne) T. Norl

Pluchea bequaertii Robyns

P. nitans O. Hoffm.

P. ovalis DC.

Psiadia punctulata (DC.) Vatke

Reinchardia tingitana (L.) Roth.

Schkuhria pinnata (Lam.) O. Kuntze

Senecio discifolius Oliv.

S. lyratipartitus A. Rich.

S. mesograumoides O. Hoffm.

S. petitianus A. Rich.

S. ruwenzoriensis S. Moore

Spilanthes mauritianus (Pers) Pax

Tagetes minuta L.

T. patala L.

Tarchonanthus camphoratus L.

238. COMPOSITAE cont.

Vernonia auriculifera Hiern.

V. brachycalyx O. Hoffm.

V. cinerea (L.) Less.

V. galamensis (Cass.) Less.

V. holstii O. Hoffm.

V. karanguensis Oliv. & Hiern

V. lasiopus O. Hoffm.

240. PRIMULACEAE

Anagallis arvensis L.

241. PLUMBAGINACEAE

Plumbago zeylanica L.

243. CAMPANULACEAE

Wahlenbergia abyssinica (A. Rich.) Thulin subsp. abyssinica

249. BORAGINACEAE

Cordia ovalis DC.

Cynoglossum coeruleum DC.

C. geometricum (Bak. & Wr.)

Ehretia cymosa Thonn.

Heliotropium undulatifolium Thrril.

250. SOLANACEAE

Datura stramonium L.

Lycium europaeum L.

L. tenuiramosum Dammer

Nicandra physaloides Gaertn.

Nicotiana glauca R. Grah.

Physalis ixocarpa Brot.

P. peruviana L.

Solanum aculeastrum Dunal

S. incanum L.

S. nigrum L.

S. mauense Bitter

S. sesselistellatum Bitter

S. nakurense C.H. Wright

Withania somnifera (L.) Dunal

251. CONVOLVULACEAE

Astripomoea grantii (Redle) Verdc.

Cuscuta australis R. Br.

C. campestris Yuncker.

C. kilimanjari Oliv.

Convolvulus siculus L. ssp. agrestis (Schweinf.) Verdc.

Ipomoea cairica (L.) Sweet

I. kituiensis Vatke

I. wightii (Wall) Choisy var. kilimandschari (Dammer) Verdc.

I. sp. nr. I. sinesis (Desv.) Choisy

252. SCROPHULARIACEAE

Craterostigma hirsutum S. Moore

C. plantagineum Hochst.

Cycnium tubulosum (L. f.) Engl. ssp. montanum (N.E. Br.) O.J.Hansen

C. volkensii Engl.

Hebenstretia dentata L.

Limosella aquatica L.

Rhamphicarpa henghinii Schweinf.

R. montana N.E. Br.

Scopubia eminii Engl.

S. ramosa (Hochst.) Schweinf.

Striga gesnerioides (Willd.) Engl.

253. OROBANCHACEAE

Orobanche minor Smith.

259. ACANTHACEAE

Asystasia schimperi T. Anders.

Barleria micrantha C.B. Cl.

B. stuhlmannii Lindau

B. submollis Lindau

B. ventricosa Nees.

Dyschoriste perrottetii S. Moore

D. radicans Nees

Dicliptera colorata C.B. Cl.

Hypoestes verticillaris (Linn. f.) Roem. & Schult.

259. ACANTHACEAE contd.

Justicia exigua S. Moore

J. flava Vahl.

J. heterocarpa T. Anders

J heterophylla (Eckl. & Zeyh.) N. Robyson

J. striata Bullock

Monechma debile (Forssk.) Nees

Monothecium glandulosum Hochst.

Phaulopsis imbricata (Forssk.) Sweet

Thunbergia alata Sims

262. VERBENACEAE

Clerodendron discolor (Kl.) Vatke

C. myricoides (Hochst.) Vatke

Lantana camara L.

L. rhodesiensis Moldenke

L. trifolia L.

Lippia javanica (Burm. f.) Spreng

L. ukambensis Vatke

L. wilmsii H.M.W. Pears

Priva curtisiae Kabask

Verbena bonariensis L.

264. LABIATAE

Becium obovatum (E. Mey.) N.E. Br.

Fuerstia africana T.C.E. Fr.

Leonotis nepetifolia (L.) Ait. f.

264. LABIATAE contd.

Leucas martinicensis R. Br.

L. glabrata (Vahl) R. Br.

L. grandis Vatke

L. nakurensis Guerke

L. neuflizeana Court

L. pratensis Vatke

Ocimum basilicum L.

O. suave Willd.

Plectranthus barbatus Benth.

P. caninus (Roth.) Vatke

P. assurgens Bak.

P. cylindraceus Benth.

P. marrubioides Benth.

P. kivuensis Leb & Touss.

Pycnostachys deflexifolia Bak.

P. umbrosa (Vatke) Perkins

Satureia biflora (D. Don.) Benth.

Satureja punctata (Benth.) Briq.

Tetradenia riparia (Hochst.) Codd

Tinnea aethiopica Hook. f.

MONOCOTYLEDONS

280. COMMELINACEAE

Commelina africana L.

C. benghalensis L.

280. COMMELINACEAE contd.

Commelina forskalaei Vahl.

C. reptans Brenan

C. sp. "A" of UKWF (Upland Kenya Wild Flowers).

Cyanotis arachnoide C.B. Cl.

293. LILIACEAE

Aloe graminicola Rehn.

A. kedongensis Reyn.

A. rabaiensis Rendle

A. secundiflora Engl.

Asparagus aethiopicus L. var. angusticladus Jessop.

A. africanus Lam.

A. buchananii Bak.

A. falcatus L. var. ternifolius Jessop.

A. asparagoides (L.) Wight

Bulbine abyssinica A. Rich.

Chlorophytum bakeri Podl.

C. comosum (Thunb.) Jacq.

Gloriosa superba L.

305. TYPHACEAE

Typha domingensis L.

306. AMARYLLIDACEAE

Crinum macowanii Bak.

C. papillosum Nordal

Scadoxus multiflorus (Martyn) Raf.

307. IRIDACEAE

Gladiolus psitacium Hook. f.

313. AGAVACEAE

Sansevieria parva N.E. Br.

S. suffruticosa N.E. Br. var. suffruticosa

S. volkensii Guerke

314. PALMAE

Phoenix reclinata Jacq.

326. ORCHIDACEAE

Cyrtorchis arcuata (Lindl.) Schltr.

Habenaria sp.

Polystachya stricta Rolfe

331. CYPERACEAE

Bulbostylis boeckeleriana (Schweinf.) Beetle

Cyperus immensus C.B. Cl.

C. laevigatus L.

C. obtusiflorus Vahl

C. rigidifolius Steud.

C. stuhlmannii C.B. Cl.

C. teneriffae Poir

C. usitatus Burch. (C. sp. "D")

C. dichrostachys A. Rich.

Fimbristylis humilis A. Peter

Mariscus amauropus (Steud.) Cuff.

M. aristatus (Rottb.) Charm.

M. impubes (Steud.) Napper

M. mollipes C.B. Cl.

M. macropus (Boeck.) C.B. Cl.

Mariscus sp.

332. GRAMINEAE

Andropogon chinensis (Nees) Merr.

Aristida adoensis Hochst.

A. kenyensis Henr.

Brachiaria brizantha (A. Rich.) Stapf

B. semiundulata (A. Rich.) Stapf

Cenchrus ciliaris L.

Chloris gayana Kunth

C. pycnothrix Trin

C. virgata Sw.

Cymbopogon nardus

C. caesius (Hook. & Arn.) Stapf

C. pospischilii (K. Schum.) C.E. Hubbard

Cynodon dactylon (L.) Pers.

C. nlemfuensis Vanderyst

Dactyloctenium aegypticum (L.) Beauv.

Digitaria abyssinica (A. Rich.) Stapf

D. scalarum (Schweinf.) Chiov.

D. velutina (Forssk.) Beauv.

Ehrharta erecta Lam. var. abyssinica (Hochst.) Pilg.

Eleusine indica (L.) Gaertn.

E. jaegeri Pilg.

E. multiflora A. Rich.

Enneapogon schimperanus (A. Rich.) Henr.

Eragrostis braunii Schweinf.

E. cilianensis (All.) Lut.

E. racemosa (Thunb.) Steud.

E. superba Peyr.

332. GRAMINEAE contd.

Eragrostis tenuifolia (A. Rich.) Steud.

E. volkensii Pilg.

Harpachne schimperi A. Rich.

Hyparrhenia anamesa W.D. Clayton

H. hirta (L.) Stapf

Loudetia kagerensis (K. Schum.) Hutch.

Microchloa kunthii Desv.

Oplismenus hirtellus (L.) Beauv.

Panicum atrosanguineum A. Rich.

P. maximum Jacq.

Pennisetum clandestinum Chiov.

P. mezianum Leeke

P. procerum (Stapf) W.D. Clayton

P. purpureum Schum.

P. sphacelatum (Nees) Th. Dur. & Schinz

P. squamulatum Fresen.

P. trachyphyllum Pilg.

Rhynchelytrum repens (Willd.) C.E. Hubbard

Setaria orthosticha Herrm.

S. pumila (Poir.) Roem. & Schult.

S. sphacelata (Schumach.) Moss

S. verticillata (L.) Beauv.

Sporobolus africanus (Poir.) Robyns & Tournay

S. agrostoides Chiov.

S. confinis (Steud.) Chiov.

332. GRAMINEAE contd.

Sporobolus consimilis Fresen.

S. festivus A. Rich.

S. fimbriatus (Trin.) Nees

S. ioclados (Trin.) Nees

S. pyramidalis Beauv.

S. spicatus (Vahl) Kunth.

S. stapfianus Gand.

Stipa dregeana Steud.

Themeda triandra Forssk.

Tragus berteronianus Schult.

Trichoneura teneriffae (L. f.) Link.

APPENDIX II

SOIL TEXTURAL ANALYSIS BY HYDROMETER METHOD

Table 12a: Soil textural analysis along Profile Transect 1 established from the southern lakeshore running through the mudflats, alkaline grasslands, the Pluchea bushlands, Chloris gayana grasslands, Acacia xanthophloea forest, open and wooded Cynodon nlemfuensis grasslands and all the way to the Euphorbia candelabrum - Tarchonanthus camphoratus bushlands in the Southern Central Plains (fig 8a).

Table 12b: Soil textural analysis along Profile Transect 2 established on the south eastern lakeshore passing through the mudflats, alkaline sedge marshes (Cyperus laevigatus) alkaline grasslands (Sporobolus spicatus and Cynodon dactylon), Pluchea bequaertii bushland, Acacia xanthophloea woodland bushed Chloris gayana - Cynodon nlemfuensis grasslands and up to the Euphorbia candelabrum forest and Tarchonanthus camphoratus bushlands on Lion Hill (fig 8b).

Table 12c: Soil textural analysis along Profile Transect 3 situated on the north-western lakeshore and cut through the mudflats, alkaline grasslands (Sporobolus spicatus), Pluchea bequaertii bushland, Chloris gayana grasslands, Acacia xanthophloea

woodland, Digitaria abyssinica grassland and then Acacia xanthophloea forest next to Njoro River (fig 8c).

Table 12d: Soil textural analysis along Profile Transect 4, that crossed the western Mau escarpment from the Lakeshore through the mudflats, alkaline grasslands, Pluchea bequaertii bushland, Acacia forest (Colubus forest), Psiadia punctulata bushland, Tarchonanthus camphoratus bushland on the slopes and Acacia xanthophloea - Tarchonanthus camphoratus bushland on the plateau (fig 8d).

Table 12a. Soil Textural Analysis: Profile Transect 1

SOIL SAMPLE NO.	SAMPLE LAYER (U=Upper) (L=Lower)	HYDROMETER READINGS I (4 Min.) Weight (g)	Temp. (°C)	Corrected Hydrometer Reading	II (2 Hrs.) Weight (g)	Temp. (°C)	Corrected Hydrometer Reading	SOIL SEPARATES Percentages %Sand	%Silt	%Clay	TEXTURAL CLASS (Soil Type)
1	U	31.0	18.0	30.28	13.0	19.0	12.64	34.0	38.4	27.6	CLAY LOAM
	L	35.0	18.0	34.28	21.0	19.0	22.64	25.3	25.3	49.4	CLAY
2	U	21.0	17	21.02	12.0	17.0	12.02	56.16	22.0	21.84	SANDY CLAY LOAM
	L	17.0	17	28.02	15.0	18.0	14.28	42.16	29.28	28.56	CLAY LOAM
3	U	5.0	19.0	7.64	6.0	19.5	5.52	94.72	5.64	11.64	LOAMY SAND
	L	10.0	19.0	9.64	6.0	20.0	6.0	85.72	7.28	12.00	SANDY LOAM
4	U	27.0	19.0	26.64	20.0	19.0	19.4	46.72	38.28	14.56	SANDY SILT LOAM
	L	33.5	19.0	33.14	26.0	20.0	26.0	33.72	14.28	52.00	CLAY
5	U	36.0	17.0	34.92	23.0	19.0	22.28	30.16	25.28	44.56	CLAY
	L	39.0	17.0	37.92	26.0	19.0	25.28	24.16	25.28	50.56	CLAY
6	U	30.0	19.0	29.64	19.0	20.0	19.0	40.72	21.28	38.00	CLAY
	L	31.0	19.0	30.64	19.0	20.0	19.0	38.72	21.28	40.00	CLAY
7	U	26.0	19.0	25.64	25.0	20.0	26.0	28.72	19.28	52.00	CLAY
	L	27.0	19.0	26.64	25.0	20.0	26.0	26.72	21.28	52.00	CLAY
8	U	40.0	19.5	39.32	23.0	19.0	22.64	21.36	33.36	45.28	CLAY
	L	40.0	17.5	39.1	25.0	19.5	24.64	21.50	29.22	49.28	CLAY
9	U	32.0	17.5	31.1	20.0	19.5	19.64	37.30	22.92	39.78	CLAY
	L	34.0	17.5	33.1	22.0	19.5	21.64	33.20	22.92	43.28	CLAY
10	U	36.0	18.0	35.28	18.0	19.0	17.64	20.44	31.28	48.28	CLAY
	L	37.0	18.0	36.28	19.0	19.0	18.64	27.44	34.28	37.28	CLAY
11	U	13.0	17.0	11.92	13.0	19.0	9.64	76.16	4.56	19.28	SANDY CLAY LOAM
	L	14.0	17.0	12.92	11.0	19.0	10.64	74.16	4.56	21.28	SANDY CLAY LOAM
12	U	35.0	18.0	34.28	20.0	19.0	19.28	31.16	50.0	18.56	CLAY LOAM
	L	45.0	18.0	44.28	32.0	19.0	31.28	11.44	22.0	66.56	CLAY
13	U	34.0	18.0	33.28	19.0	19.0	18.28	33.44	30.0	36.56	CLAY
	L	33.0	18.0	32.28	18.0	19.0	17.28	35.44	30.0	34.56	CLAY LOAM
14	U	32.0	17.0	30.92	16.0	19.0	15.64	38.16	30.56	31.28	CLAY LOAM
	L	33.0	17.0	31.92	14.0	19.0	13.64	36.16	36.56	27.28	CLAY LOAM
15	U	32.0	17.0	30.92	18.0	19.0	17.64	38.16	26.56	35.28	CLAY LOAM
	L	28.0	17.0	26.92	14.0	19.0	13.64	46.16	26.56	27.28	CLAY LOAM
16	U	31.0	18.0	30.28	13.0	19.0	12.64	39.44	35.28	25.28	CLAY LOAM
	L	33.0	18.0	32.28	17.0	19.0	16.64	35.44	31.28	33.28	CLAY LOAM
17	U	42.0	20.0	42.0	26.0	21.0	26.16	18.00	31.28	52.72	CLAY
	L	38.0	20.0	38.0	22.0	21.0	22.16	24.00	31.28	44.72	CLAY
18	U	40.0	20.0	40.0	26.0	21.0	26.16	20.00	27.28	52.72	CLAY
	L	41.0	20.0	41.0	26.0	21.0	26.16	18.00	29.28	52.72	CLAY
19	U	31.0	20.0	31.0	20.0	21.0	20.16	38.00	21.28	40.72	CLAY
	L	31.0	20.0	31.0	20.0	21.0	20.16	38.00	21.28	40.72	CLAY
20	U	35.0	16.0	33.56	16.0	17.0	14.92	26.16	41.28	32.56	CLAY LOAM
	L	18.0	16.0	16.56	28.0	17.0	26.92	26.84	19.28	53.84	CLAY
21	U	28.0	16.0	27.56	17.0	17.0	15.92	44.16	21.28	33.56	CLAY LOAM
	L	29.0	16.0	27.56	11.0	17.0	11.92	44.16	31.28	23.56	CLAY LOAM
22	U	21.0	17.0	19.92	13.0	17.0	12.28	60.16	15.28	24.56	SANDY CLAY LOAM
	L	30.0	17.0	28.92	17.0	17.0	15.28	42.16	25.28	32.56	CLAY LOAM

Table 12:b. Soil Textural Analysis: Profile Transect 2

SOIL SAMPLE NO.	SAMPLE LAYER (U=Upper) (L=Lower)	HYDROMETER READINGS I (4 Min.) Weight (g)	Temp. (°C)	Corrected Hydrometer Reading	II (2 Hrs.) Weight (g)	Temp. (°C)	Corrected Hydrometer Reading	SOIL SEPARATES Percentages %Sand	%Silt	%Clay	TEXTURAL CLASS (Soil Type)
1	U	42	15	40·2	30	16	28·56	19·6	23·28	57·12	CLAY
	L	45	15	43·2	34	16	32·56	13·6	21·28	65·12	CLAY
2	U	39	15	37·2	28	16	26·56	25·6	21·28	53·12	CLAY
	L	46	15	44·2	35	16	33·56	11·6	21·28	67·12	CLAY
3	U	9	17	7·92	7	18	6·28	84·16	3·28	12·56	LOAMY SAND
	L	23	17	21·92	18	18	17·28	56·16	9·28	34·56	SANDY CLAY
4	U	28	17	26·92	20	18	19·28	46·16	15·28	38·56	SANDY CLAY
	L	35	17	33·92	17	18	16·28	32·16	35·28	32·56	CLAY LOAM
5	U	23	17	21·92	17	18	16·28	56·16	11·28	32·56	SANDY CLAY
	L	25	17	23·92	18	18	17·28	52·16	13·28	32·56	SANDY CLAY
6	U	22	17	20·92	10	18	9·28	58·16	23·28	18·56	SANDY CLAY LOAM
	L	23	17	21·92	11	18	10·28	56·16	23·28	20·56	SANDY CLAY LOAM
7	U	24	17	22·92	13	18	12·28	54·16	21·28	24·56	SANDY CLAY LOAM
	L	30	17	28·92	15	18	14·28	42·16	29·28	28·56	CLAY LOAM

Table 12:C. Soil Textural Analysis: Profile Transect 1

SOIL SAMPLE NO.	SAMPLE LAYER (U=Upper) (L=Lower)	HYDROMETER READINGS I (4 Min.) Weight (g)	Temp. (°C)	Corrected Hydrometer Reading	II (2 Hrs.) Weight (g)	Temp. (°C)	Corrected Hydrometer Reading	SOIL SEPARATES Percentages %Send	%Silt	%Clay	TEXTURAL CLASS (Soil Type)
1	U	25	30	28·60	15	25	16·80	42·8	23·60	33·60	CLAY LOAM
	L	30	30	33·60	24	26	26·16	32·8	14·88	52·32	CLAY
2	U	39	28	41·88	16	24	17·44	16·24	48·88	34·88	SILTY CLAY LOAM
	L	23	26	25·16	12	23	13·08	49·68	24·16	26·16	CLAY LOAM
3	U	10	26	12·16	7	23	8·08	75·68	8·16	16·16	SANDY LOAM
	L	22	26	24·16	14	23	15·08	51·68	18·16	30·16	SANDY CLAY
4	U	10	28	12·88	6	25	7·80	74·24	10·16	15·60	SANDY LOAM
	L	22	28	24·88	13	25	14·80	50·24	20·16	29·60	SANDY CLAY
5	U	14	24	15·44	9	22	9·72	69·12	11·44	19·44	SANDY CLAY LOAM
	L	16	24	17·44	10	24	11·44	65·12	12·00	22·88	SANDY CLAY LOAM
6	U	27	23	28·08	15	20	15·00	21·92	48·08	30·00	CLAY LOAM
	L	17	26	19·16	12	23	13·08	30·84	43·00	26·16	CLAY LOAM
7	U	33	24	34·16	15	24	16·44	15·84	51·28	32·88	SILTY CLAY LOAM
	L	33	24	35·16	15	23	16·08	14·84	53·00	32·16	SILTY CLAY LOAM

Table 12: d. Soil Textural Analysis: Profile Transect 4

SOIL SAMPLE NO.	SAMPLE LAYER (U=Upper) (L=Lower)	HYDROMETER READINGS I (4 Min.) Weight (g)	Temp. (°C)	Corrected Hydrometer Reading	HYDROMETER READINGS II (2 Hrs.) Weight (g)	Temp. (°C)	Corrected Hydrometer Reading	SOIL SEPARATES Percentages %Sand	%Silt	%Clay	TEXTURAL CLASS (Soil Type)
1	U	36	15	34·2	29	16	27·56	31·6	13·28	55·12	CLAY
	L	29	15	27·2	20	16	18·56	45·6	17·28	37·12	SANDY CLAY
2	U	12	17	10·92	9	18	8·28	78·16	5·28	16·56	SANDY LOAM
	L	38	17	36·92	31	18	30·28	26·16	13·28	60·56	CLAY
3	U	10	18	9·28	6	19	5·64	81·44	7·28	11·28	SANDY LOAM
	L	21	18	20·28	14	19	13·64	59·44	13·28	27·28	SANDY CLAY LOAM
4	U	22	18	21·28	14	19	13·64	57·44	15·28	27·28	SANDY CLAY LOAM
	L	21	18	20·28	13	19	12·64	59·44	15·28	25·28	SANDY CLAY LOAM
5	U	18	18	17·28	12	19	11·64	65·44	11·28	23·28	SANDY CLAY LOAM
	L	29	18	28·28	14	19	13·64	43·44	29·28	27·28	CLAY LOAM
6	U	20	20	20·00	15	21	15·36	60·00	9·28	30·72	SANDY CLAY
	L	20	20	20·00	14	21	14·36	60·00	11·28	28.72	SANDY CLAY LOAM
7	U	29	20	29·00	14	21	14·36	42·00	29·28	28·72	CLAY LOAM
	L	29	20	29·00	18	21	18·36	42·00	21·28	36·72	CLAY