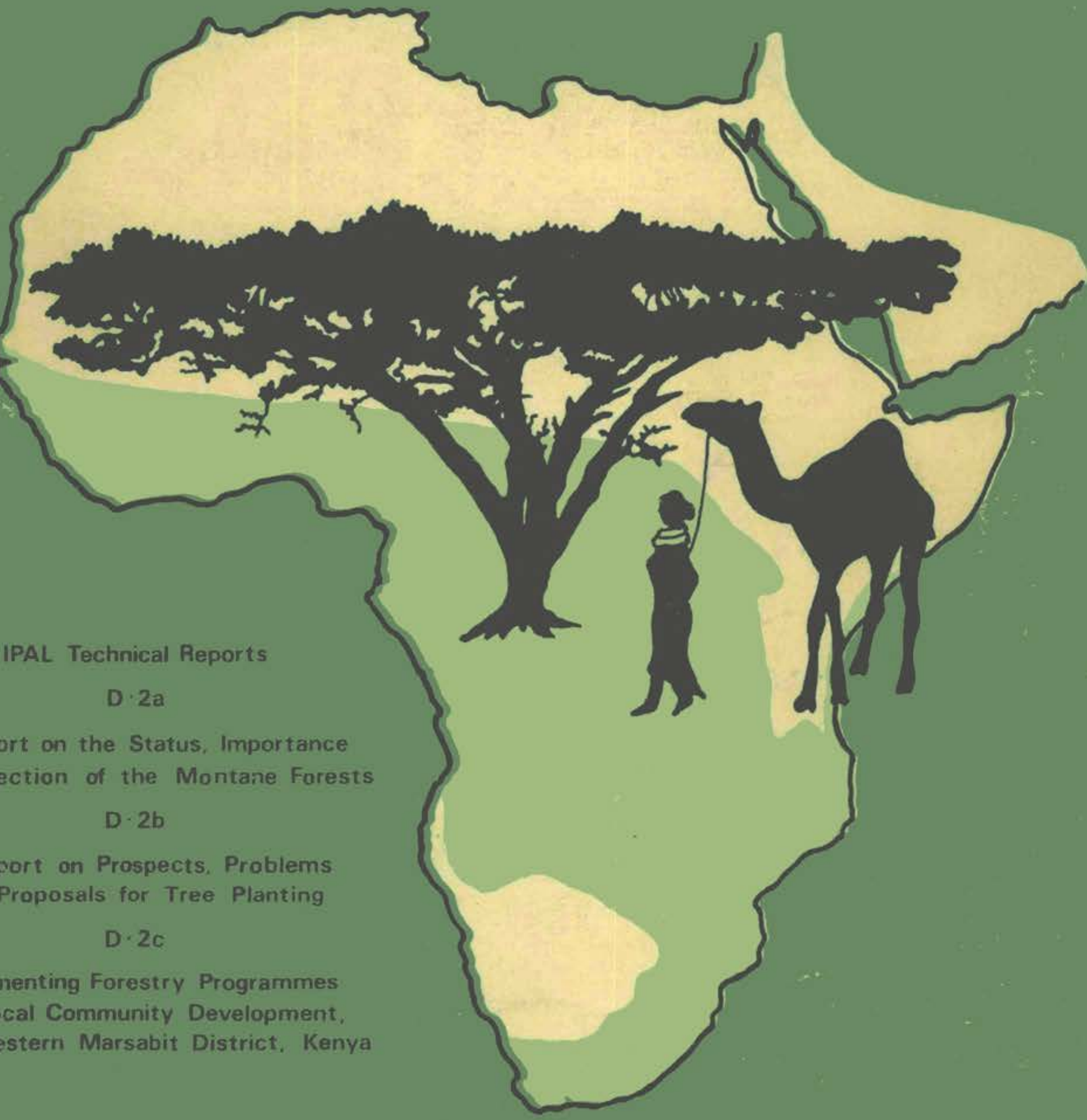
Unesco Programme on Man and the Biosphere (MAB)

United Nations Environment Programme (UNEP)

Integrated Project in Arid Lands (IPAL)



IPAL Technical Reports

D·2a

A Report on the Status, Importance and Protection of the Montane Forests

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Implementing Forestry Programmes for Local Community Development, South-western Marsabit District, Kenya

MAN AND THE BIOSPHERE PROGRAMME

Project 3: Impact of Human Activities and Land Use Practices on Grazing Lands

IPAL Technical Report Number D - 2a

A REPORT ON THE STATUS, IMPORTANCE AND PROTECTION OF THE MONTANE FORESTS

by
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May 1979

UNEP - MAB Integrated Project in Arid Lands

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Appendices

Summary Introduction to IPAL and the Technical Report Series

The Integrated Project in Arid Lands (IPAL) was established joinly by UNEP and UNESCO in 1976 with the aim of finding direct solutions to the most urgent environmental problems associated with desert encroachment and ecological degradation of arid lands. It forms part of the operations under MAB Project 3, the Secretariat of which is jointly held by UNESCO and FAO, and also those of UNEP's Desertification Unit, established in response to the plan of Action adopted by the United Nations Conference on Desertification. It is an example of the type of pilot activity that UNEP and UNESCO, together with other organisations and a number of governments, are trying to promote to provide the scientific basis for the rehabilitation and rational development ofarid and semi-arid zone ecosystems, through integrated programmes of research (including survey, observation and experimentation), training and demonstration.

During the early operation work of IPAL, a co-ordination unit was established in Nairobi and the initial field-work started in the arid zone of northern Kenya, where a field station has been constructed on the lower slopes of Mount Kulal and a working area demarcated between Lake Turkana and Marsabit Mountain. Work was started on several aspects of the ecology and experimental management, centred upon the interaction of pastoralists and their livestock with the soils and vegetation of the environment.

During the next two or three years (1979 - 1982), the investigations in progress will be extended and intensified. Initially, new activities within the IPAL project will be started in Tunisia, to be followed by other areas in the arid zone of Africa and the Near and Middle East.

This report is one of a series published by IPAL describing technical findings of the project and where appropriate, giving management recommendations relating to the central problems of ecological and sociological degradation in the arid zone. The reports are divided into the following categories distinguished by the base colours of their covers:

A. general, introductory and historical: white.

B. climate and hydrology: blue.

C. geology, geomorphology and soils: brown.

D. vegetation: green.

E. livestock and other animal life: red.

F. social and anthropological: yellow.

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1. INTRODUCTION

The terms of reference for this study of the montane forests were for "an ecological study of the isolated mountain rain forests within the project working area. It will include preliminary ecological surveys to provide an account of the botanical composition of the forests. The major part of the work will be to describe the successional trends taking place and the interactions of the forests with the human populations. An attempt will be made to answer the questions: What is the role of the forests in the ecology of the region? What is the impact on the forests of human activity? What are the probable results of this impact? A report will be produced which will emphasize the importance of the forests and provide additional arguments for their conservation, and recommendations for their management."

I have interpreted the term 'mountain rain forests' in a wide sense to include all closed tree and shrub communities on the higher ground (in practice almost entirely above 900 m, and mostly above about 1200 m) in which shade-intolerant grasses, and the species characteristic of more open vegetation, and the influence of fire are almost absent. Thus, various evergreen bushland and gulley-thicket communities have been studied (but not the whole of the evergreen and semi-deciduous bushland mapped by D. Herlocker).

The mountain forests of NFD have been among the least studied of the East African forests, and I have found no full published descriptions of the forest communities or their composition. However, many of the leading botanists in Kenya have collected briefly on Marsabit and Kulal, and their combined collections present a surprisingly complete picture of the species composition. Marsabit is the least typical, perhaps because of its unusual combination of size, isolation and high rainfall, while the forest communities on Kulal and other mountains, and their ecological status, are similar to those in several other highland forest areas in East Africa, including the mountains at similar latitudes in E. & N. Uganda.

Thus, while it has not been possible to arrange extensive foot safari in the less accessible mountain areas, this has also not been entirely necessary. Sufficient information has been available from written and verbal reports, and from my own observations, for a preliminary assessment of the status and ecological relationships of the vegetation communities; this has been supplemented by several hundred botanical collections from the forests by myself and other IPAL staff, and by inspection of the records and specimens from other collectors, mostly in the Herbarium in Nairobi.

No attempt is made here to describe the background to the project or the project area, or the general vegetation, soils or climate, since these subjects will be fully described elsewhere.

This study could not have been carried out in isolation, and I am particularly grateful for logistical help and environmental information from Dr. C.R. Field, Dr. D. Herlocker, and Mr. Paul Teasdale at Gatab, Dr. and Mrs. Schwartz and Mr. Charlie Barnett at Ngurunit and Mr. & Mrs. Anderson at Kalacha. Their help in studies of the montane areas, and the domestic support of my family, by Dr. Herlocker and his family while living on Mt. Kulal, are gratefully acknowledged.

2. THE EXISTING MONTANE FORESTS AND THEIR LEGAL STATUS.

The field headquarters of the IPAL study area are on Mount Kulal, (Figures 1 and 2) which carries a substantial are of closed montane forest. The Hurri Hills and about half of the forest on Marsabit Mountain are also within the IPAL area. However, other mountain ranges, particulary Nyiru, Ol Doinyo Mara and Ndoto, with their vegetation, exert such an important influence on the lowlands of the IPAL area, and are so important as dry-season grazing areas for the inhabitants of the area, that they must also be considered here.

The following table summarises some of the basic information about the mountainsconsidered.

Name	District	Total area demarcated ha	Total area of forest ha	Maximum altitude m	Long. E	Lat. N
Hurri Hills	Marsabit	(30,000)*	(100) !	1539	37°50'	3°35'
Kulal	Marsabit	45729	3500-4400	2295	36°50'	2°40'
Marsabit	Marsabit	14917	14000	1836	38°	2°20'
Ndoto	Samburu	96040	4500	2637	37°10'	1°45'
Nyiru	Samburu	45400	8000-9500	2752	36°45'	2°15'
Ol Doinyo Mara	Marsabit	(5000)*	(100) !	2067	36°55'	2°15'

* Proposals, not demarcated
! Guesses, not measured.

Most of the figures given above are approximations. There is wide variation in published estimates of mountain heights, and only on Marsabit has a detailed attempt been made to measure forest areas. Note also that the Leroghi Forest was reserved by Proclamation No. 2 of 1936 with an area of c. 90880 ha, and the Mathews Range Forest by Proclamation No. 454 of 1956 with an area of 92680 ha.

The following notes describe the history of the protection and reservation of these forests. It has not been possible to prepare a detailed chronology of the human use of the forests, or of the advances and retreats of the forests in response to grazing, fire and climatic fluctuations, but further information is available in the Background History of the Mount Kulal Region of Kenya, by N.W. Sobania (1979).

The present legal status of these forests is founded on The Forests Act, Chapter 385, including the consolidated regazetting of forest reserves, Legal Notice No. 174, Declaration of Central Forests, effective 1 June 1963.

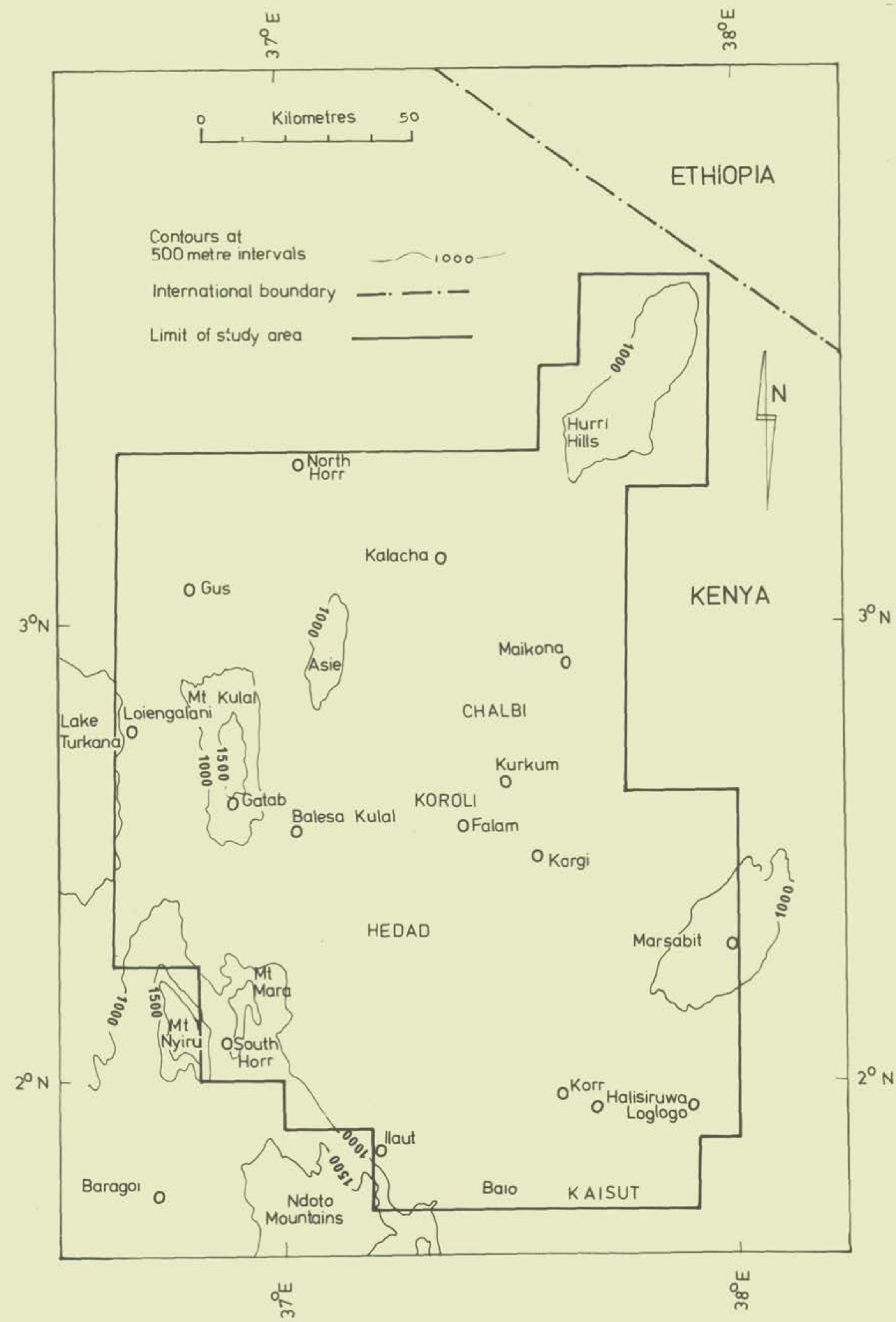

FIGURE I THE IPAL STUDY AREA

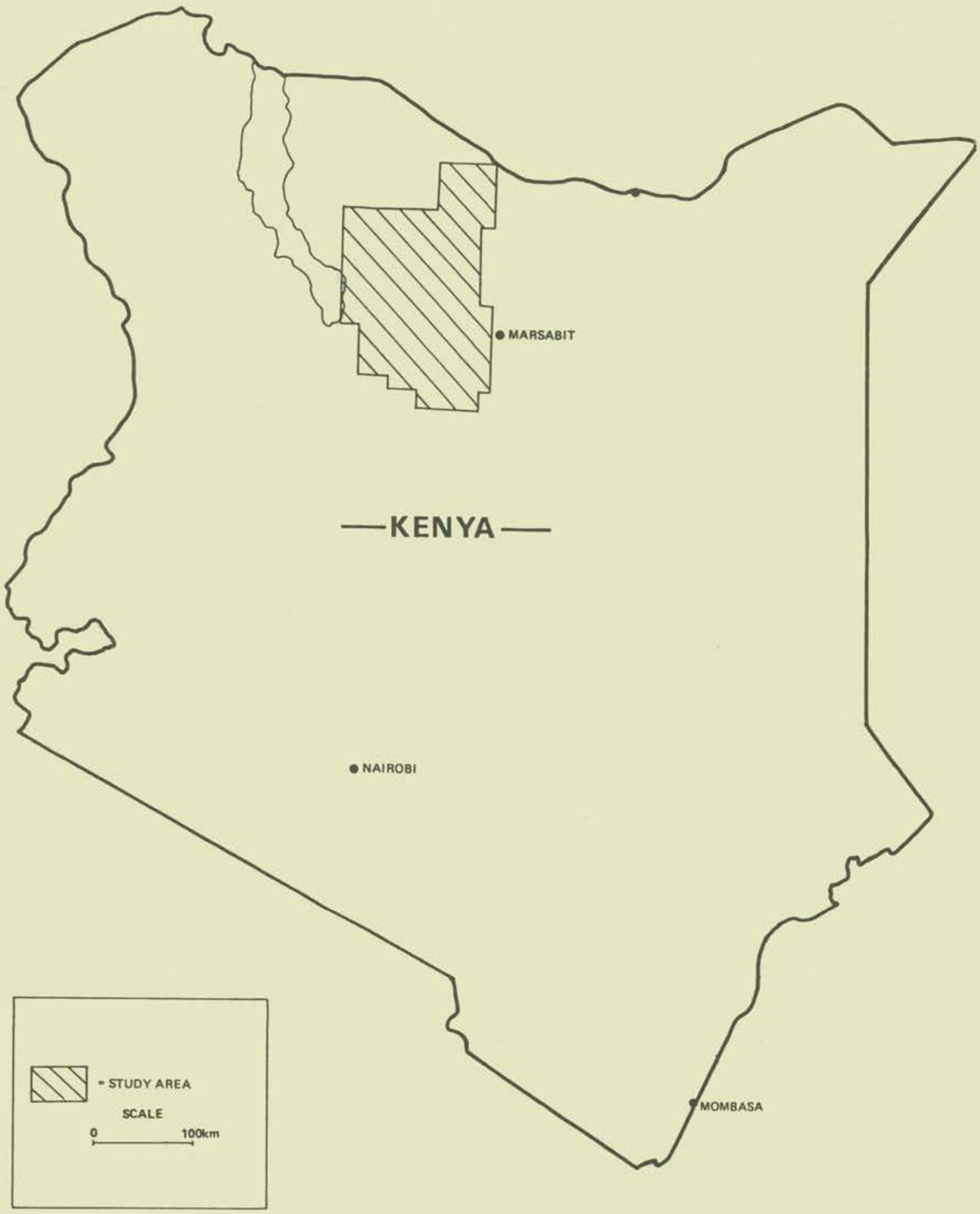

FIGURE 2 LOCATION OF STUDY AREA

2.1 Marsabit

The first intervention in land use control occurred in 1902 with the establishment of the Northern Game Reserve, which included Marsabit. The upper slopes of the mountain were gazetted as a forest area by Proclamation No. 44 of 1932 with an area of 37760 acres after the administration had become increasingly worried about the effects of burning and grazing in the forest. At that time the forest was largely used by Gabbra who had moved in from Ethiopia since the early years of the century, but Sobania confirms that many people had used the forest as dry season grazing in previous centuries. The boundary of the Forest Reserve was demarcated in 1947, embracing c. 15000 ha, substantially the same as now.

The Marsabit National Reserve was established by Govt. Notice 936 in 1948, extending eastwards from the southern end of L. Rudolf (Turkana) down to Isiolo and including Marsabit and the Mathews Range. The National Reserve was reduced to its present size of 780 sq. miles (c. 202,000 ha) on 22 Dec. 1960.

There has been considerable planting activity in Marsabit Town, particularly since 1927. However, the planting was largely experimental, and for shade, shelter and decoration; it had little effect on the total forest area, or on providing for the fuel and pole requirements of the people, and hence little effect on maintaining water supplies or on controlling environmental degradation.

The efforts of the Forest Dept. from c. 1951 were largely concentrated on fighting and preventing fires, and preventing excessive or unauthorised grazing by means of regular foot patrols, and on early burning a broad belt round the forest at least once a year. (Early burning is a well established technique which usually prevents uncontrolled and devastating fires later in the dry season, and frequently enables bush and forest to expand outwards, gradually increasing the forest area). Several reports and letters refer to the extensive damage caused by fires, but it is probable that the areas burned were largely the more inflammable bushland surrounding the closed forest communities, with the fires sometimes penetrating and destroying areas near the forest margins.

The forest boundary was surveyed in 1951. In 1959, the Chief Conservator of Forests (in a letter to the Provincial Commissioner dated 3 September 1959) explained Forest Dept. policy for Marsabit: "the highest priority is to protect water supplies, by preventing destruction or damage of the forest by fire or animals, by firelines and controlled burning." Some grazing, cutting of poles and collection of dead wood for fuel has been authorized, and on the whole the policy has been successfully implemented; the forest vegetation within the Reserve has been well protected, while trees and shrubs outside the Reserve have had little or no protection.

The Council in Marsabit has had a similar policy, as explained in the District Development Plan, 1976: "The water catchment and storage functions of the forest areas are of the utmost importance for life in the district, and these functions must not be interfered with adversely. The large scale forest areas on Marsabit Mountain, and to a smaller extent other areas, also have considerable direct economic value if properly utilized. The water conservation aspects should, however, over-ride any other aspects, and economic utilization should be carried out in a way that does not impair the main functions namely, water catchment and [storage]."

Neither the District Development Plan nor the early Forest Department plans envisaged measures specifically designed to satisfy the wood needs of the people, although they were clearly concerned about desert encroachment and control. The Forest Dept. has made several attempts to plant up gaps and grassy areas within the Forest Reserve, with the aim of reducing the fire risk, increasing the total forest area and improving water conservation. The earlier attempts, frequently with indigenous species, largely failed because of deaths from drought and termites. A renewed attempt since 1971 has achieved a total of 45 ha, largely with Cassia siamea in grassy areas, with a planned annual program of 12 ha. The objective has, as before, been largely for conservation, and increasing the forest area, rather than maximising wood production.

2.2 Kulal

Mount Kulal has been much less visited by forestry and administration officers than Marsabit. Sobania quotes a report of 1927 and 1928 which refers to devastating fires which burnt much Juniper; his report also shows that both years were severe drought years. Sobania also reports that Kulal was largely depopulated during the first c. 40 years of this century. There were probably ndorobo elements in the mountain forests at this time, and occasional hunters from the lowlands, so the net effect was probably regular but largely haphazard grass burning in dry seasons, keeping the forest edges in check; occasional serious fires in the Juniper communities during drought years (but probably not seriously affecting the mixed hardwood communities which are less flammable and less vulnerable); and a more or less compensatory recovery and slight expansion during wet years.

During the 1950's, various foresters including J. Smart and other officials visited the forest and observed the impact of grazing and browsing. The forest was considered for reservation, and the N.F.D. forester W.W. Beer organized the demarcation and survey of a boundary line, completed in August 1956. The result was Boundary Plan No. 180/1970, enclosing a total of 45 729 ha. However, the Forest Dept. decided that since they did not have adequate resources to ensure the full protection of the proposed reserve, they should not undertake the responsibility; in a letter to the Provincial Commissioner, Isiolo, on 3 September 1959, the CCF wrote: "... owing to shortage of funds and staff .... decided not to go forward with the gazettement."

From c. 1960, grazing inside the forest was forbidden or limited. The mountain came under the administrative control of the District Council, like most of the rest of the District, as Trust Land. For several years the Council employed some forest guards to protect the forest. However the guards had no professional supervision, and little local encouragement. During the 1970's the Gatab mission employed a guard, largely to persuade local people not to burn the forest, and the mission was actively involved in fire fighting particularly towards the end of the 1968-76 drought. From 1976, IPAL also employed a guard, to assist in enforcing the Council's decision that grazing in the forest should be controlled.

During the long drought, the grassy areas in the forest zone (above about 1600 m) were heavily grazed, and cattle also browsed through the closed forest areas. With the increasing rains from 1977, the intensity of grazing, browsing and burning decreased markedly.

At the time of writing, almost no grazing is taking place within the forest zone, because of the abundance of pasture elsewhere; the D.C. has confirmed his determination to enforce the Council's earlier decision to limit grazing in the forest; and the Council has decided to approve the gazettement of the forest as a Forest Reserve.

2.3 Hurri Hills

These hills have had a long and complex history of human use as valuable grazing land, but have had no special conservation status. At one time the Forest Dept. considered the possibility of reserving c. 30 000 ha, and still includes the hills among those considered for hill-top plantations, designed to improve water supplies and to increase the national forest estate.

2.4 Nyiru Forest

The Nyiru Range and the neighbouring Ol Doinyo Mara surrounding the S. Horr valley have been used as dry season grazing by Samburu and other groups, and have been inhabited by ndorobo elements for generations. Government officers observed the impact of fire and grazing, and the forest was closed to grazing at various times. Demarcation of c. 45 400 ha of Nyiru as a Forest Reserve was apparently completed in 1951, and the area was gazetted by Proclamation 454 of 1956.

There is a forest station in S. Horr, which has been strengthened in early 1979. It has been largely concerned with small-scale tree planting and with protecting the Forest Reserve. It is probably safe to assume that the forest zone is affected by little more than the customary seasonal cattle movements, relatively slight during the current heavy rains.

Ol Doinyo Mara has never been reserved or protected by the Forest Dept., presumably because it carries very little closed forest.

2.5 Ndotos Range

During the 1940s, Government officers apparently considered that the Ndotos were much more severely affected by grazing and fires then Nyiru or the Mathews Range. This impression is consistent with the fact that the mountain area finally reserved was more than double that on Nyiru, whereas the area of closed forest now surviving is estimated to be about half of that on Nyiru.

The demarcation of a Forest Reserve boundary line was completed in 1950, and the area was gazetted by Proclamation 454 of 1956.

Initially, the reserve was regularly patrolled and the boundary maintained. During the 1960s, the continued determined opposition of local pastoralists to attempts to exclude them from the Reserve (an area about 20 times the area of the true closed forests), and increasing security risks during the shifta emergency, resulted in the withdrawal of continuous patrols. Boundaries were maintained by occasional (more or less annual) operations involving several workers moving together around the whole boundary. This had little effect on the customary use of dry season grazing areas in the forest. However, it is reported that the Samburu did not make intensive use of the Reserve during shifta times, because of security risks (from c. 1963).

At the end of the emergency, before the end of the long drought, very large numbers of livestock belonging to Samburu and other people were moved up beyond the foothills into the reserve and the forest. Very intensive grazing, browsing and lopping for fodder is reported to have occurred for some years, about 1972-6. At that time, there were no effective protective measures, at least in the S and E Ndotos.

When the rains improved from 1977, livestock largely moved out of the forest zone and out of the Reserve, and the vegetation recovered greatly. During early 1979, during exceptionally wet weather, even ndorobo manyattas were removed from the Reserve for the first time since 1972. The Forest Dept. now intends to intensify its protection of this Reserve, with a strengthened Forest Station at Wamba.

3. FOREST TYPES : composition, status, stability and succession.

3.1 <u>The state of collecting and ecological knowledge</u>

There are no published reports or substantial unpublished reports describing in detail the mountain forests of the IPAL area, but from numerous collection-notes, safari reports (Verdcourt 1958) and other verbal and written communications, as well as personal observations, some general conclusions can be drawn.

A few observations were made by explorers during the 19th Century and by early Government officers but biological collecting started relatively late on these mountains. The following collectors (mostly botanists and foresters) have contributed to our knowledge of the forest composition:

W.H.R. Martin, 1934, Kulal

J. Adamson, 1942-4, 1957, Kulal & Marsabit

J. Leakey, 1945, Marsabit

J. Williams, 1947, 1956, Kulal and Marsabit

P.R.O. Bally, 1947, 1963, Kulal, Marsabit, Hurri Hills

J.B. Gillett, 1953, Marsabit

T. Adamson, 1956-1959, Marsabit, Kulal

B. Verdcourt, 1958, Kulal, Marsabit

O. Kerfoot, 1960, Ndotos, Nyiru

J. Oteke, 1960, Kulal, Marsabit

R. Polhill, 1961, Marsabit

F. Woodhouse, 1963, Marsabit

M. Faden, 1968, Marsabit

D. Herlocker, 1976 - Kulal, Marsabit, Hurri Hills

M. Ichikawa, 1977, Mathews Range

M. Gilbert, 1978-9, Ndotos

N. Hepper and P. Jaeger, 1978, Kulal, Marsabit, Nyiru, Ndotos

F. White, 1979, Kulal

Appendix 1, based on these and my own collections and observations, gives a list of all the forest trees and shrubs known to occur in the mountains of this area. Appendix 2 gives a list of Boran-Gabbra, Rendille and Samburu names, for all species for which I have been able to find a local name. Both these lists are inevitably incomplete; our knowledge of the Hurri Hills, Ndotos and Nyiru are such that almost any full day of collecting could be expected to add woody plants to the list; there are certainly tree and shrub species still uncollected on Kulal and Marsabit. Our knowledge of the herbs, climbers and epiphytes is even less complete. N. Hepper is intending to compile and publish a full flora for Kulal.

It is hoped that the lay-out of Appendices 1 and 2, and the needs of the project, will encourage additions to be collected and recorded, and that more complete information will be published after a few years. The vernacular names are expected to be particularly useful for human-ecologists, and should aid a fuller understanding of the use made by humans and animals of their environment.

In the following sections, the ecology and status of each of the forest areas is described separately. This is followed by a section in which the forests are compared to one another, and the main differences pointed out and if possible explained.

In the time available, it has not been possible to identify different mature forest communities occurring within each mountain area, In time, such communities may be shown to exist, related to local differences in soil quality or depth, topography or moisture availability. Thus, in Kulal some species such as Ocotea appear to occur mainly in wetter, sheltered valleys in the southwest, but far too little is known about the distribution of this and other species over the mountain, or even over the southern block of forest, to allow any generalisations about different mature forest types or "climax" communities. In the Ndoto and Nyiru ranges, it is not even certain that all the most common tree species have been recorded. Therefore, descriptions of the forests and other communities and of differences between them, are based mainly on the presence or absence of characteristic or ecologically significant species, and not on differences between associations or on any quantitative measures of stocking or volume.

However, the species occurring in particular stands, and various structural indicators (such as the presence of very large, wide-spreading trees in a matrix of more uniformly small, straight-stemmed trees) enables certain conclusions to be made about the successional status and history of these stands and about larger areas of the better known forests such as S. Mt. Kulal and Marsabit.

3.2 Marsabit

Marsabit mountain rises to a height of c. 1836 m, substantially lower than the other forest-bearing mountains; nevertheless, the area of closed forest is larger than that of any of the other mountains, and closed forest descends to a lower altitude than elsewhere. Indeed elsewhere, an altitude of c. 1700 m is close to the lower limit of closed, mixed forest.

It appears that at any given altitude Marsabit receives substantially more rain, mist and cloud cover than the other mountains, because of the large bulk of the mountain and its position as the first substantial high ground in the line of the monsoon winds from the east; this is confirmed by the altitudinal limit of the forest on the SE of the mountain, down to 900-1000 m, substantially lower than that on the NW side, 1300-1400 m. The present character of the forest is doubtless also partly due to the relatively effective protection the Reserve has had since 1932.

Marsabit forest differs from the others in both structure and composition. The structural difference is difficult to define, but the forest gives the impression of approaching closer to the multi-storied arrangement typical of tropical moist forests at lower elevations, with an intimate mixture of trees, shrubs and climbers of all sizes. Strong winds do not appear to be a dominant feature of the mountain, and the topography is steep but not violently disected, so the forest presents a relatively uniform appearance.

The commonest large trees on Marsabit are Casearia, Croton megalocarpus, Strombosia, Diospyros abyssinica, Olea africana, Olea capensis, Cassipourea and Apodytes. Among the commoner shrubs and small understorey trees are Canthium spp., Ochna spp., Teclea nobilis, Ritchiea, Rinorea. The two Croton and Olea species are among the most conspicuous components, with Croton macrostachyus particularly prominent in young forest around the margins. Triumfetta spp. are very active colonisers of bushland and grassland, in addition to other common colonising and bushland shrubs such as Rhamnus spp., Bauhinia tomentosa, Clausena, Harrisonia and Rhus spp.

Neither Juniperus nor Podocarpus have been seen on Marsabit. Juniperus could probably grow well at higher elevations, but Marsabit does not have the open grassy glades and small thickets with unstable margins, advancing and retreating with the effects of fire and climatic fluctuations, which seem typical of many Juniperus habitats. The upper levels of Marsabit are perhaps so favourable for stable mixed broad-leaved species that a relatively shade-intolerant species like Juniperus is unable to thrive. The lower edges of the forest, around the Forest Reserve boundary, may be too low (i.e. too dry, hot or affected by fire) to allow Juniperus to compete with broad-leaved shrubs and colonisers.

During 1970, the Inventory Section of the Forest Dept. reported on a vegetation-type survey of Marsabit Forest Reserve, with the following results:

Stocked forest:	10 499 ha
Dwarf forest:	485
Brush with grass; grass with brush; grass:	3 225
Brush with scattered trees:	671
Water:	37
Total area of Forest Reserve:	14 917 ha

Some closed forest occurs outside the Reserve in gulleys, and around the SE of the mountain, with substantial tree cover in and around the town; in addition, with continued protection from excessive burning and grazing, the forest edge has continued to expand slowly in recent years. The total area of forest is therefore assumed to be of the order of 14 000 ha, which is the area plotted on Herlocker's vegetation map.

No comprehensive vegetation studies have been made on Marsabit (or in the other forests) although numerous botanists have collected in the forest. Probably Terence Leakey inspected more parts of the forest than any other collector. He and others have compiled species lists, now in the Marsabit forest office file, which included a few comments on the distribution of some of the less common species but in the absence of specimens some of the observations must remain inconclusive. Several of the less common trees and shrubs are usually found in wetter or lower forests in East Africa; notable occurrences include *Ocotea kenyensis* (rare), *Erythroxylum* (understorey), *Drypetes* (large), *Prunus* (rare), *Albizia gummifera* (rare, riverine), *Celtis* spp (rare), *Catha edulis*, *Strombosia* (large, not uncommon in wetter areas), *Ekebergia* (very large), *Trichilia emetica* (in E Parts, uncommon), *Aningeria* (recorded, unconfirmed), *Strychnos* spp., *Linociera* (in wet forest), *Coffea arabica*, *Cordia africana*, and *Premna maxima* (recorded as the largest in the forest). There are many uncertainties, even in this easily accessible forest. A more thorough and detailed collecting-survey would be of great scientific interest.

In general, the forest appears to be stable, well developed and of considerable antiquity, although not particularly rich in species even by East African standards. The vigorous development of the colonising forest edge suggests that it could continue to expand if completely protected, while it appears in some areas to be developing a stable forest margin, able to withstand occasional light fires. Official correspondence has often stressed the great dangers of fire, but it is probable that fires which succeed in penetrating the closed forest during a drought will be largely confined to leaf litter and dead ground herbs; this will not necessarily cause much mortality among larger trees and shrubs, and need cause no long term harm if grazing and other disturbances are excluded from the burned areas until the vegetation has recovered.

In the past, large mammals such as elephants and buffalo as well as livestock probably contributed considerably to keeping some parts of the vegetation relatively open and to increased erosion along water courses and around water holes. The piping of the water out of the forest to Marsabit town and other watering points, and the more recent decline in wildlife populations, may be assumed to have substantially increased soil and water conservation abilities of the forest.

3.3 Kulal

The vegetation of the Kulal forests has become better collected than that of the other forests, largely because of the location of IPAL station near the forest edge at Gatab. In previous years, several collectors had been in the forests, notably Bally and Verdcourt, assisted by the roads built up the north and south ends of the mountain for the piped water supply. More species of trees and shrubs have been collected on Kulal than on the other mountains; nevertheless, four new records have been collected in early 1979 (*Celtis*, *Dracaena*, *Ilex* and *Rapanea*) and several more reported but unconfirmed. Almost all the forest collecting has been in the southern half of Kulal; the block of forest north of the main dividing gorge has scarcely been explored above the important grassland areas at Arabel (although frequently inspected from aeroplanes).

The forest areas of S. Kulal have been frequently inspected and are of a type familiar on other mountains, so it is possible to describe both the composition and the successional status of the different communities with some confidence. The main vegetation types are:

1. Mature, mixed, hardwood forest
2. Juniper communities: Patches and stands with irregular ages and structures with an important proportion of Juniperus
3. Colonising forest edges
4. Bushland, more or less evergreen, of shrub species or colonising forest species
5. Open grassland with few woody species

These types are presented for descriptive purposes, to clarify successional processes and relative stabilities of different communities and are not intended as a form of vegetation classification.

1. Mature mixed hardwood forest

Some of these closed forest stands appear to be very old and stable, with a wide range of size-classes (and presumably age-classes) represented. These stands include large trees which appear (from the branching-patterns) to have grown up in a forest environment, and are now surrounded by trees and shrubs of all sizes. Such stands appear to be more common in sheltered, damp valleys, particularly in the S.E., at higher elevations, and include several tree species of relatively limited distribution. The tree and shrub species typical of these more mature communities in favourable situations are *Xymalos*, *Ocotea*, *Casearia*, *Clausena*, large *Ficus*, *Brucea*, *Lepidotrichilia* and *Oxyanthus*, in addition to many of those found in drier areas.

Other hardwood communities, sometimes with a few scattered *Juniperus*, and more or less lacking large individuals of the above species, also occur. Their relative spatial and site distribution is uncertain, but it is noticeable that many of the stands include a few conspicuously large individuals, often with low or spreading branches which suggest that they may have developed under more open conditions, but now surrounded by tall, straight-stemmed trees with a relatively restricted size distribution. These signs suggest somewhat younger or less stable communities which were at some time (perhaps over a century ago) much more open but which subsequently regenerated into closed forest over relatively few years; it is quite possible that cycles of closure and relative opening may have occurred many times, and over larger or smaller areas, under the influence of drought, fire or destruction by landslide or trampling. Characteristic tree and shrub species include Nuxia, Olinia, Ochna spp., Prunus, Apodytes, Teclea spp., Diospyros abyssinica, Strychnos, and Olea spp.,

At the highest levels, the forest is kept more open in some localities on the edges or steep slopes of gorges by the action of wind or landslips. Here, stable communities include Dombeya goetzenii and Phoenix.

2. Juniperus communities.

Young regeneration of Juniperus is almost never seen inside mature, closed, hardwood forest, while it is often abundant around the edges of these stands, in colonising forest fringes, in small thickets and in bushland, sometimes only a few yards away from the heavy shade of the closed forest. Juniperus is thus a pioneer species, typically intolerant of shade, but more susceptible to fire damage than many other colonisers. It may therefore be assumed that all stands of mature Juniperus were at one time relatively open or broken regenerating or colonising communities (as distinct from the stable, self-perpetuating old hardwood stands). We can now see Juniperus in a wide variety of communities, (many of them in and around Gatab);

——very young individuals in bushland, small thickets and on forest edges, with shrubs and small trees of Dovyalis, Maytenus, Rhamnus, Turraea, Allophylus, Rhus, Cussonia, Heteromorpha, Euclea, Myrsine, Olea africana, Schrebera, Pavetta, Psychotria, Vangueria etc., gradually developing into a closed forest community if conditions continue to be favourable, or else gradually broken up into bushland with scattered trees if too much affected by drought or large mammals.

——tree stands with an upper layer almost entirely of Juniperus, with an understorey of the species listed above and a proportion of forest tree species such as Diospyros and Teclea spp. The broad-leaved trees may gradually take over as the Juniperus die, or the community may revert to a thicket or bushland community.

——large, old individuals (sometimes dead or dying) standing in minute thickets, or isolated in grassland; these are presumed to result from the decline or destruction of more closed stands which grew in more favourable conditions after good regeneration, but now largely destroyed by fire, drought or animals.

——large old trees, scattered in a more or less mature broadleaved forest stand, indicating the late stages of a succession from colonising bush to mixed hardwood forest. In lower, drier areas this succession is checked. The junipers are not always succeeded by hardwood forest and the stand breaks up to form open bushland, including young junipers.

3. Colonising forest edges

This community is particularly prominent now, after two exceptionally wet years. Many of the thickets and main forest edges are surrounded by a strip up to 10 m wide, consisting of woody species invading the grassland and consolidating the bushland, as the first stage in a developing forest. The species involved include all those associated with young Juniperus communities, with Aspilia conspicuous on Kulal. Acanthus spp. are typical colonisers in rainforest at medium altitudes in much of tropical Africa, and found on Kulal in a few wetter, higher glades. By replacing grasses and other herbs with perennial woody plants, the colonising fringe is more resistant to fire and grazing; it will continue to expand when conditions are favourable, and may remain stable (with an almost static and very sudden forest-grassland boundary) when conditions reach an equilibrium; it may be destroyed by particularly fierce fires or very heavy browsing by livestock or elephants, followed by invasion of grasses and retreat of the forest edge. On Kulal, the colonising forest edges are similar in composition over a wide range of altitudes from Gatab, c. 1600 m, to the edges of glades around 2200 m.

4. Bushland

These communities also include many of the shrubs typical of the colonising forest, but usually at lower elevations and in drier situations than the closed forest areas. In some situations the bushland probably has the capability of developing into forest, and it may do so now that elephants, buffalo, rhinos and giraffe have declined and if grazing restrictions are enforced. However, in some situations the bushland appears to be in equilibrium with the effects of rainfall, altitude and soil depth. Several other species, less characteristic of forests, are included such as some *Grewia* spp., *Cadia*, *Erythrina*, *Osyris*, *Pappea*, *Ruttya* and an increasing admixture of succulent plants such as *Aloe*, *Euphorbia*, and (below Gatab airstrip) *Dracaena ellenbeckiana*. The small shrubs and subshrubs which are common in bushland and many colonising forest fringes include *Lippia*, *Clerodendrum*, *Ocimum* and several composites. Larger shrubs include *Carissa*, *Euclea*, *Rhus* and some *Olea africana*.

5. Grassland

The origin of the open grassy glades, partly or completely surrounded by forest, is uncertain. On Kulal, they were probably initiated by fires (started by lightning or by hunters, pastoralists or honey-gatherers) and do not appear to be edaphically controlled. At elevations below about 1500 m, grassland on Kulal usually includes many bushy plants, but above about 1700 m many of the glades contain mostly grasses, with fewer broad-leaved herbs and few woody plants. It is probable that the resident populations of wildlife, particularly buffaloes and various antelopes such as greater kudu have had an important effect on maintaining these grasslands, by maintaining some grazing pressure all year round. However, the main influence has been the periodic grazing of livestock, which may be extremely heavy during times of drought, plus occasional fires in the grassy glades, in the bushland and even in some closed forest areas, acting over many generations. It may be confidently stated that if the influence of fires and grazing is withdrawn, many of the grassy glades would develop into closed forest, some very quickly, although some areas of bushland on steep eroded slopes and of swampy herbaceous vegetation near springs might remain. This conclusion is based on the vigour of the woody colonising vegetation now developing, which has already taken over significant areas of grassland, filling up narrow bays, during the past two years, and on observations of the effects of fire and grazing control and early burning on Marsabit and in many other East African forest areas.

At the time of writing, the influence of large wild mammals on Kulal is much reduced, and the Council shows an intention of restricting grazing in the forest, while the locally employed patrolmen over the past 3-5 years have succeeded in persuading people to reduce the incidence of burning. It may be predicted that if these trends continue, the grassy glades will be steadily reduced in area.

It should be stressed that some of the grassy areas are probably very old, while some parts of the grassland may have developed only recently. The complete elimination of all the grassland areas above 1600 or 1700 m would perhaps produce some modest improvement in water catchment and conservation (particularly because grazing activities result in locally increased erosion and soil compaction), but also inevitably constituting a loss of biological and habitat diversity, of scientifically interesting communities, and of valuable drought-emergency grazing resources of great importance to sustaining the local pastoral economy.

Habitat stability

Verdcourt (1958) and Dale, during their visit to Kulal with the Governor, Sir Evelyn Baring, came to the following conclusion about local vegetation changes, based on Dale's particular study of East African forest history (Dale, 1954):

c. 1750 : The old mist forest extended lower down the mountain than at present

c. 1750-1850 : The climate was desiccating and the mist forest was destroyed by grass fires with the exception of the summit areas at 7-8000 ft.

c. 1850-1900 : The climate became wetter and a young mist forest regenerated down to the 6000 ft contour with a fringe of cedar extending below 6000 ft

c. 1900-1950 : The cedar fringe was largely destroyed by grass fires.

Dawkins (1954) has considered the history of some similar mountains, in slightly more northern latitudes in Uganda. His ideas were based on the minimum of dogma and extrapolation, but on careful observation of features of vegetation, human land-use and erosion. Like Verdcourt and Dale, he thought that the climate now and for some generations past was favourable to forests, although much forest destruction (and resultant erosion) had occurred as a result of fire and cultivation. He found evidence of much more arid conditions, with little vegetation cover, but concluded that the change to more humid conditions may have occurred some centuries ago.

Much research has been carried out in recent years on climatic and vegetation change in eastern Africa. The most convenient summary is given by Hamilton in Lind and Morrison (1974). It is clear from all lines of evidence that the forest vegetation on this and other mountains has occupied significantly larger and smaller areas than at present during the last few thousand years, but a more detailed assessment of local vegetation history on Kulal will have to be based on local evidence as well as regional climatic changes.

It is highly probable that variations in the intensity of land use by humans are as important as variations in rainfall and climate, as determining factors in the advance and retreat of forests. During dry periods occupying many decades, with little grass growth, fires may be reduced for lack of fuel, and closed forest has a remarkable ability to maintain its own internal climate and persist in depressions, valleys and other favoured areas even at low altitudes. The grass fires which can occur during the dry season between wet seasons with abundant grass growth may be much more damaging. It was observed during the severe 1968-1976 drought that many large and well established cedars died, but this did not necessarily result in forest destruction and retreat; many of the trees were surrounded by relatively non-flammable bushland, with broad-leaved mainly evergreen trees, and the forest is now regenerating itself, usually with some young cedars developing. A more damaging factor during that drought was the extremely intensive grazing, browsing and trampling, with some lopping, which, if sustained, could have gradually destroyed the ability of the forest to maintain itself. During previous climatic fluctuations, the transhument pastoralists, the itinerant hunters and the resident ndorobo would all have had different effects on the vegetation at different times, and it is not at present possible to interpret the vegetation history in detail.

In general, the equilibrium between forest, climate and human influences is highly dynamic, with both long and short term local advance, retreats and changes in species composition. Events may also vary dramatically from place to place: during a long wet phase, with net expansion of forest, a localised dry season fire may destroy the forest in one locality; on the other hand, during a long dry phase when the forest is particularly vulnerable, the death and grazing of grasses and other herbs may allow woody vegetation to consolidate its hold in favoured localities.

3.4 Nyiru, with Ol Doinyo Mara, and Ndotos.

Much less is known of the forests of these ranges than of Kulal and Marsabit. The mountains are substantially taller, and of a quite different geological formation, and these factors affect the composition and the status or vulnerability of the forests. Botanical collecting has not been very thorough, and the apparent differences shown in Appendix 1.1 are probably largely a reflection of under-collecting.

Both ranges have substantial (but not accurately measured) forest areas. The main forest tree and shrub species which are certainly (or probably) common to both ranges are *Juniperus*, *Podocarpus milanjianus*, *Croton megalocarpus*, *Sapium*, *Prunus*, *Rhamnus* spp., *Teclea* spp., *Brucea*, *Trichilia*, *Cussonia holstii*, *Diospyros*, *Maesa*, *Nuxia*, and *Olea* spp. It is noteworthy that the cycad *Encephalartos tegulaneus* has been seen only on the Ndoto range, while Afro-alpine vegetation including *Hypericum* and Ericaceae have been observed only on Nyiru (presumably above c. 2500 m). There are small patches of forest on Ol Doinyo Mara, reportedly including *Juniperus*. Since the ridge is relatively small and narrow, and the soils vulnerable, the forests have probably suffered particularly severely from the effects of grazing. They could probably recover substantially if protected, and the denuded state of the vegetation on Ol Doinyo Mara certainly has a damaging effect on local erosion.

The rocks forming these ranges are not of volcanic origin and are rich in quartz; the sandy subdesert soils of the Hedad and other lowland areas are derived largely from these formations. They are relatively infertile, and there are strong indications that the mountain soils are more easily eroded by water and more damaged by trampling than the volcanic soils of Kulal, Marsabit and many other mountains. The smooth, steep, bare rock faces, with tussock grasses and small shrubs, are a conspicuous feature of the Ndotos, and deep soils are apparently uncommon except in valley bottoms filled with alluvial soils at lower elevations; Kulal and Marsabit have substantial areas of relatively gently sloping ground with deep red soils. The deep, almost vertical-sided gorges of Kulal are not a feature of the Ndoto or Nyiru ranges. Thus the topography of the mountains, as well as the appearance of surface erosion under the influence of soil exposure and trampling, indicate that differences in erodibility are related to the rock substrate, and therefore that great care in avoiding vegetation destruction and livestock impact is needed in some areas. More information is needed about these differences, but my impression is that under the present climatic regime the crystalline mountains are more easily eroded than the volcanics.

3.5 Hurri Hills

There are no extensive areas of closed forest on these hills, but many valleys, gulleys and steep hillsides at higher elevations carry dense thickets and in some areas small trees form a closed canopy, resulting in a low forest. Among the tree and large shrub species growing in such forest communities are *Croton macrostachyus*, *Euphorbia candelabrum* (or a similar species), *Bauhinia tomentosa*, *Pistacia*, *Olea africana*, *Ruttya fruticosa* and many other shrub species which are also found in small thickets such as *Croton dichogamus*, *Osyris*, and *Rhus* spp., with several Rubiaceae, Labiatae and Verbenaceae.

These communities have much in common with the evergreen bushland found on Kulal and elsewhere, with the notable absence of *Juniperus*. The vigour of the colonising edge of many of these valley and gulley forests, often including *Croton macrostachyus*, strongly suggests that closed forest and bushland could significantly extend its range, and could probably maintain itself over larger areas even during dry periods. The present distribution of the closed woody stands is almost certainly limited by fire, which is a regular occurrence in dry weather but which is generally unable to penetrate the deeper valleys and gulleys; the forested areas probably also have more favourable water supplies and wind protection.

The open hills and gentle slopes of the Hurri Hills also carry open woodland or savanna of two types: one, in the wetter western slopes, includes *Combretum molle*, *Lannea* and *Ozoroa* (*Heeria*), while in most of the accessible areas the most conspicuous tree is *Erythrina burttii* (often very large) with *Acacia* spp, *Fagara chalybea*, *Pappea*, *Cordia sinensis*, *Dichrostachys*, *Ormocarpum*, *Zizyphus* and *Ficus*. Many shrubs such as various *Grewia* spp. can be found in almost all communities.

Much of the Hurri Hills is grass-covered. Some of these areas are probably edaphically controlled, with heavy clay soils, impeded drainage and frequently flooded; these areas can often be easily identified on the ground. However, many of the grassy areas appear to be derived from woodland, as indicated by the scattered large old Erythrina and other species (some recently dead and partially burned). Almost certainly the woodland was denser and more widespread at various times in the past, and has been thinned out by occasional fires (which can burn fiercely in the perennial grassland under suitable conditions). Wooded grassland communities with similar composition but greater density can be found on the neighbouring mountains, but the frequent mists which favour the small forest patches and large woodland trees also favour the dense growth of grass which becomes highly flammable during dry seasons. There is no indication that large parts of the open woodland or grassland in the Hurri Hills have recently (within the lifetime of existing large trees) been covered by montane forests of the type now found on neighbouring mountains and now poorly represented in some valleys and gulleys. Not only are there no known relict patches of closed forest of typical montane forest species (such as Casearia, Cassipourea, Brucea, Diospyros abyssinica, Prunus, Olea capensis), but also none of these species occur as isolated relict trees such as are so often found in grassland areas formed by the destruction of forest; on the contrary, the grasslands and woodlands include tree species which are characteristic of such environments (notably Acacia spp., Erythrina burttii) and of thickets and forest edges (such as Croton dichogamus and C. macrostachyus) and not of closed forest. Even the treeless areas, which cover wide areas, are rich in herbs other than grasses, and semi-woody plants such as Echinops, and give the impression of being old and stable communities.

3.6 Comparisons and contrasts

It is difficult to make confident comparisons between these forests when there is no single kind of information which is known accurately or fully for all the forests. The forest areas, altitudinal ranges, ecological and human histories, and species lists are incompletely known, and even for the best known forests there is virtually no information about community associations, nor are there any inventories of numbers and sizes.

However, there are some interesting differences in species records. To a large extent these are a reflection of the lack of collected specimens and reliable records, and it is certain that many species will be found to occur on more of the mountains than is shown in Appendix 1. Indeed it is probable that all the species listed would be capable of surviving and growing (if not of maintaining viable independent populations) on all the mountains (though not all on the Hurri Hills) if introduced into suitable situations. Thus the species distributions reflect the reaction between each species' ecological characteristics and seed-dispersal ability and the climate and soils on each mountain now and more especially during the past few thousand years. The absence of one species from one mountain may mean that the species never succeeded in establishing itself there, because of unsuitable climate or soil, or else that previous populations were eliminated, perhaps by a period of unfavourable climate. Dispersal of montane forest tree seeds across large distances of dry country has successfully colonised many isolated mountains, but a study of species distribution may suggest that certain barriers to dispersal may have operated. All such indications are of value and interest in interpreting the history and current status of the mountain communities. It might be expected, for example, that the Balessa Kulal would provide an effective dispersal route between Nyiru and Kulal during periods of wet climate, but there appear to be many species-differences between the two mountains. The absence of Juniperus, with its easily dispersed seeds, from Marsabit is initially surprising, but in fact there is little suitable habitat for it: much of Marsabit is a solid block of mature closed forest with few of the glades, open areas and young communities which are typical of Juniperus stands on Kulal, whereas the lower forest edge of Marsabit is lower and hence probably warmer than typical Juniperus areas. The apparently isolated areas of Encephalartos and Dracaena in the Ndotos may be the result of much more ancient climatic events.

These few examples are given to show the potential importance of species distributions, but in most cases no explanation can be made and perhaps none should be attempted until the species distributions are more clearly known. The following list shows certain apparent localisations including mainly the species of economic or ecological significance:

Encephalartos	:	Ndotos only
Juniperus	:	not Marsabit or Hurri Hills
Podocarpus	:	Ndoto, Nyiru; reported on Kulal?
Ocotea	:	Kulal, Marsabit; not elsewhere
Pittosporum	:	Kulal
Casearia	:	Kulal, Marsabit, not elsewhere
Syzigium	:	Kulal
Sapium	:	Ndotos only
Cassipourea	:	Kulal and Marsabit
Albizia spp.	:	Marsabit only
Croton megalocarpus	:	Not Kulal ?
Celtis spp.	:	Marsabit and Kulal only
Ilex	:	Kulal
Catha	:	Marsabit
Strombosia	:	Marsabit
Harrisonia	:	Marsabit
Ekebergia	:	Marsabit
Lepidotrichilia	:	Kulal
Trichilia	:	not Kulal
Calodendron	:	? Kulal, ? Nyiru
Rapanea	:	Kulal
Schrebera	:	Kulal
Coffea arabica	:	Marsabit
Cordia africana	:	Marsabit
Ehretia cymosa	:	Kulal
Premna maxima	:	Marsabit
Acanthus	:	Kulal
Hypericum and Ericaceae	:	Nyiru
Dracaena spp.	:	Kulal
Phoenix	:	Kulal and Ndotos

It would be helpful if further collecting and ecological studies could include checking the occurrence of these species, as well as attempting to fill in some of the other gaps in the distribution list, Appendix 1, Many of the apparent discrepancies will probably then disappear, but other records of rarities will doubtless be discovered, and some species, so far uncollected in these mountains, may be found locally abundant in some areas. Some real differences will doubtless remain between each of the forests.

Marsabit forest can be expected to differ from the others because it is substantially larger (thus perhaps allowing some species to maintain themselves when they could not do so in a smaller area), and lower, and wetter at any given elevation; its proximity to Ethiopia may explain the occurrence of Coffea arabica. Kulal is smaller in forest area but higher than Marsabit, with generous rain at higher altitudes, so it is reasonable that species of higher, moist montane forests such as Rapanea and Ilex should occur there and not on Marsabit. Both Kulal and Marsabit forests occur on deep red volcanic soils; their soils and topography are clearly different from those of Ndotos and Nyiru, and there is some indication that the crystalline mountains have lower rainfall as well as different soil-moisture characteristics, so it may be expected that real differences in species and relative abundances occur between the volcanic and the crystalline mountains because of these physical, environmental differences. Nyiru is substantially the highest range, and some of the high-montane forest flora as well as the afro-alpine flora may be expected to occur there and not elsewhere. The Hurri Hills, having a lower elevation and total rainfall than the other ranges, have a poorer forest flora, but the relative abundance of Croton macrostachyus (collected on Marsabit but not Kulal) and of Erythrina burttii are notable features; the perennial grasslands, rich in herbs, and the woodland with Combretum and Ozoroa are better developed here than elsewhere.

4. IMPORTANCE OF THE MONTANE FORESTS AND SOILS

The conclusion of this study is that the main importance of the montane forests is for water conservation, in particular for maintaining the supplies of water for use by people and livestock in the lowlands. This has been stressed many times by the Forest Dept. and other organizations, but it is worth elaborating on this important aspect and also mentioning the many other useful roles of the forest.

The forest exerts its main role by protecting, and helping to develop, the soil cover and litter layer and by softening the impact of heavy rain on the soil surface so that rain is enabled to percolate into the soil and into the subsoil aquifer. Soil erosion, and the rapid flow of the rainwater into gullies and streams, often by surface flow, and its rapid removal from the system (in our case, its loss into L. Turkana or the Chalbi Desert) are all reduced. In addition, the forest trees and shrubs with attendant epiphytes are effective at intercepting and condensing water from the clouds which supply an important part of all plant water requirements in the higher areas; other objects such as grass, posts, netting and rocks also condense water vapour, but condensation is partly determined by the surface area exposed so a forest is particularly effective.

This is not to suggest that the forest has a demonstrable effect on the total rainfall or cloudiness. These are largely determined by the altitude and bulk of the mountain itself, and there is no evidence that the bulk of the forest, or its effect on local radiation, or temperature regimes have a significant local effect; total rainfall and its seasonal distribution would presumably be little different under any other form of vegetation or land use. Further, the forest itself uses and transpires much of the water that arrives as rain or fog-drip; much of the rain and fog which wets the trees is also evaporated into the air without ever reaching the ground. Total water loss from transpiration and evaporation may be (and often is) greater from forest than from grassland or agricultural areas; hence the total water yields from a catchment area may be less when under forest than when under shallow-rooting herbaceous plants, and total streamflow is even more likely to be reduced.

However, in the IPAL area and other arid areas, perennial streams are few and the people and livestock obtain most of their water from occasional floods in rivers and gulleys and from springs and wells, and from ponds and rock pools in very wet weather. The vegetation cover in water catchment areas can affect these supplies. If the infiltration of rain on a mountain catchment into the subterranean aquifer is promoted by a suitable vegetation cover, a larger proportion of the total rain is then available for supplying springs and perennial streams where the water table reaches the soil surface. This is achieved with less of the soil erosion that occurs with rapid surface flow and flash floods into and along drainage lines. This more reliable water supply is more valuable to people and livestock and more suitable for potential development schemes. In our area, almost permanent rivers occur at Marsabit, South Horr and Ngurunit but there are none from Kulal or the Hurri Hills. On the other hand, if the vegetative cover of the catchment is destroyed, there is less infiltration into aquifers, and larger quantities of water are quickly shed into short but often violent floods. These floods may be far larger than the flows from perennial streams in the same situation, and they may reach and benefit places far down the drainage line which might otherwise receive no water or only a small (if more constant) flow. Indeed many agricultural systems in the Middle East rely on very large, occasional floods from mountain watersheds, for watering large areas in a short space of time; however, such systems are unpredictable, often uncontrollable, and are associated with great erosion and flood damage. Far more productive and also fairer use of soil and water resources may be obtained by protecting soils and maintaining regular water supplies.

Most of the permanent or semi-permanent water supplies in the IPAL area are springs and wells associated with moving aquifers over impermeable layers or along drainage lines. The flow from these sources is determined by the quantities of water infiltrating into the aquifer, and if infiltration is reduced and if surface flow into gullies and out of the system is increased, there is a risk that regular water supplies will be reduced. The Loiengalani springs are a conspicuous example of a perennial supply of fresh water, reaching the surface very near the shores of the salty Lake Turkana, but presumably originating from rainfall at higher levels of Mt. Kulal. Certain ultimate 'sinks' of water, such as L. Turkana and the reservoirs under the Chalbe desert may be expected to maintain themselves whether the water arrives as subsurface flow or as flash floods, but in general water supplies in springs and wells will be strongly affected by anything that affects the rate of infiltration of rainfall into the aquifer.

The forests also provide many other benefits, although none which are as important for the whole mountain and desert system as their effect on perennial water supplies and erosion.

The forests provide many materials needed by people living on and near the mountains, including timber, poles, sticks, plant and animal foods of many kinds, medicines, firewood and charcoal. These materials will become increasingly important if supplies of trees and shrubs elsewhere are diminished. Many forests elsewhere in Kenya are utilised more heavily, yielding products with a much higher total value; the forests of the IPAL area, if managed carefully, could yield sustained supplies of useful materials in far greater quantities than at present without reducing protective and other benefits. The main limitations must be to ensure that products are not removed at a rate faster than the forest can produce them, and that the action involved in removing products does not promote erosion or fire-damage.

The grassland areas which occur in patches in and around the forests are, in normal dry seasons, more valuable grazing for livestock than are the closed forests and thickets. There are strong arguments in favour of permitting local people to continue to use the patches of grassland during regular dry seasons, as they have for centuries past, even though it will be necessary to ensure that these areas are not overused and that forest is not converted into grassland by fire and browsing, in order to maintain the water conservation value of the high altitude vegetation. During unusually severe dry seasons and long droughts large numbers of cattle and other stock move into the closed forests in search of food. During the mid-1970s, trees and shrubs were heavily browsed and even lopped for fodder, as in the Ndoto Range above Ngurunit. The forests can supply a reserve of acceptable drought-fodder even when grasslands have died back and been entirely consumed. The forests certainly appear to suffer from this treatment in the short run, but they are well able to recover and to continue with a slow expansion when the climate improves. This browsing resource is not only of great value during a drought; it may be of vital importance in maintaining local herds, and the livelihood of local people, and it need not be excluded from the overall land use systems.

The forests are also important for purposes of scientific study, gene resource conservation (including all forms of wildlife), instruction and training and as representatives of the afro-montane flora and fauna. This applies at the level of the communities and associations, and of individuals, and some of these forests have the great advantage that they are not under any immediate threat of destruction, as similar forests are in agricultural areas. They might be endangered if present trends continued uncontrolled, but their conservation can be justified in terms of direct benefits to local populations without having to base the case on general scientific and ideological considerations.

Natural and semi-natural forest communities have great value for investigations into basic processes of ecology, particularly interactions of plants, animals, soils, and cycling of water and nutrients. The information obtained can be of direct value for improved management of man-made vegetation for human use. These studies include all that is covered by the MAB program, section 1, "ecological effects of increasing human activities on tropical and subtropical forest ecosystems", and also very extensive phytogeographical and phytosociological studies. For these purposes, forest conservation must include not only rare or relict communities, outlying populations, and endangered species, but also typical stands of widespread communities. At any time, species may unexpectedly become important for human welfare and economies, for breeding programs or for harvesting. This is well illustrated by the recent demand, and potentially large export orders, for <u>Brucea</u> seeds

Thus the conservation of these montane forests for the sake of potential future scientific and material benefits, in addition to the more immediate benefits of soil and water conservation and the provision of human livestock demands, is likely to be well worth while.

With the benefits of these forests for training, education and research, we may include their attractions for recreation and wildlife viewing in the broadest sense. However, the cash-equivalent value for tourism is likely to remain small for a long time.

5. DESTRUCTIVE INFLUENCES ON THE FORESTS

In this section, we need to consider how the forests have survived and responded to the human and environmental influences in the past; how the current level of human and livestock impact is affecting the forests; and what may happen to the forests if various alternative developments in human and livestock populations, land use and climatic fluctuations occur in future.

PAST

We can confidently assume that forests have existed on these as on other mountains in eastern Africa for some thousands of years. From the conclusions of studies elsewhere in East Africa, we can also be certain that the species composition and possibly the whole structure of the forests as well as their areas, have fluctuated within wide ranges during the last 10 000 years. At certain times some of the forest areas were probably substantially larger than at present, possibly permitting direct contact between the Nyiru, Ndoto and Mathews Ranges, although there is no reason to believe that forest cover ever extended across the desert areas to Kulal & Marsabit (seed-dispersal by animals and wind can effectively account for the distribution of montane forest plants). At other times, particularly during long cooler or wetter epochs, the forest areas were presumably greatly reduced.

While these changes were largely determined by the climate, an important role was probably played by fire and livestock particularly within the last few centuries. Some communities such as wooded grasslands, colonising forest edges and relatively vulnerable <u>Juniperus</u> stands may have been greatly affected by occasional fires. It is possible that these fires may have been partly responsible for eliminating <u>Juniperus</u> from Marsabit and Hurri hills and for limiting some of the potential expansion of all forest areas by keeping the colonising edge in check. However, experience here and elsewhere suggests that fires alone, without much browsing and cutting, will not usually lead to the destruction of mixed hardwood forests.

For many centuries, the forests have maintained a dynamic equilibrium with the effects of climate, fire and livestock. It seems likely that if the human and livestock populations of past generations and the old land use practices continued to prevail with all their periodic fluctuations (induced by war, disease, famine and social practices) the forests would continue to maintain themselves, with no imminent danger of disappearance, affected largely by occasional local catastrophes and climatic fluctuations.

PRESENT

The principal feature of the present decade which distinguishes it from past situations is the larger population of humans and livestock and the apparently irreversible trend towards still larger numbers. The introduction of human and livestock health measures has already reached a significant portion of the population, although isolated nomads are still often beyond the reach of medical and veterinary aid, and has ensured a steady rise in populations. The severe drought of the early 1970s did not result in the massive human starvation that many other droughts had caused, and it is unlikely that wars and starvation will again exert their old control on population numbers. The current improved communications, purchasing power and veterinary services have perhaps ensured that livestock numbers have been able to recover from the effects of the drought faster than in earlier generations, and these services are likely to extend further in future.

Another significant modern development has been the removal of the old restrictions which limited grazing to certain times and certain peoples, enforced by government during colonial times and arranged by strength and by negotiation during earlier times. The removal of these restrictions has ensured that good grazing land may be utilised by many herds, some travelling from far away, even from Marsabit or S. Horr to Kulal. These influences primarily affect the rangeland but during times of severe drought they have exposed the forests (perhaps previously limited more to the local Samburu) to more intensive use.

To some extent, the decisions of the Forest Dept. and the District Council have limited grazing in the forests by law, but this influence has largely been confined to Marsabit. The more remote forest areas have not been intensively managed, and many local pastoralists have probably had no contact with Forest Dept. staff over intervals of several years at a time, in spite of occasional patrols. The Marsabit forest has been well protected from grazing and from uncontrolled exploitation for some decades, which has certainly helped substantially to maintain water supplies, but it has also had the effect of concentrating livestock grazing and browsing, and also fuel and pole cutting, outside the reserve.

Whenever human uses of the forest and its products are restricted, other areas of land are likely to be used and perhaps overused with correspondingly greater intensity, if no attempt is made to provide for local human requirements. In Marsabit and some other Districts, fuel and pole cutting, grazing and browsing in Central Forests has been limited, although not completely forbidden, while little and often no attempt has been made to maintain or improve rangeland elsewhere or to plant trees for local needs. The affect has often been to accelerate environmental deterioration outside the forests, which in the long run exposes the forests to greater pressure and demands for more intensive utilisation. In the past, when the Forest Dept. was one of very few institutions with an infrastructure in the field for large scale land management and protection, there were many advantages in placing large areas of vulnerable land under their care. However, in some places the success of their protection, and the deterioration of land elsewhere has itself created new threats, which can be tackled only by a more integrated approach to land management.

At present, the forests of this area do not face serious threats from farmers, or from commercially oriented sawmillers, stock raisers or charcoal burners. All these activities have in other areas been capable of valuable contributions to local welfare and economy as well of major destruction of vegetation and soils. The small amount of wood collection, charcoal burning and pole cutting which now occurs in and around the forests,plus some tree destruction by honey gatherers, doubtless causes some small increase of erosion and nutrient losses from the system, but this is easily outweighed by its value to the community.

A final significant cause of damage to the forests is caused by the entry of livestock for access to water holes, particularly in the dry season when streams dry up and water is available only near their sources. The damage is caused by soil compaction, vegetation trampling, increased erosion and associated browsing. This form of damage is particularly serious in areas perennially short of water, since certain areas are affected increasingly, with no chance of recovery, unlike the dry-season grazing areas which can regrow in wet weather. In addition, the long distances which livestock must walk in dry weather up to the stream-heads is certainly a cause of reduced livestock growth and yields. Fortunately, much has already been done on Marsabit and Kulal to reduce both the vegetation damage and the pastoralists' problems by piping water out to more convenient watering places. Piping water has the added advantage of reducing losses from evaporation or seepage in the river, and much more valuable work of this kind could be done.

FUTURE

It is necessary to consider what may happen to these and similar isolated forest areas in the future if present trends continue, if experiences in other regions are repeated here, or if various alternative land use developments take place.

Although forests have maintained themselves in equilibrium with human activities in many parts of Africa for thousands of years, and although many governments have a good record for forest conservation and protection, the fact remains that indigenous closed forest is being destroyed in Africa at a rate between 2 and 4 million ha p.a.. This destruction involves conversion to some other form of vegetation cover such as cultivation, savanna or grassland, in the face of steadily increasing numbers of people and livestock.

In this and other arid areas, modern influences are tending to lead to or encourage settlement, crop-raising and population increases. It is safe to predict that if these influences continue to grow, and present trends continue, the montane forests will be in severe danger of diminution or disappearance as has been the case in many other regions of the tropics under all rainfall regimes.

If unprotected, the forests will be exposed to the risk of slow but steady destruction in the face of an intensification of all the past influences of grazing, browsing and burning. There are also possible dangers of much more sudden destruction by poorly executed logging or fuel exploitation, or by consolidated livestock or farming operations, whether by private initiative or a Government agency.

Forests in Kenya and elsewhere have been, and are being, destroyed in countless different ways. Forest Reserve status is clearly no guarantee that an individual forest area will survive indefinitely.

However, the dominant objective should be not simply the maintenance of a particularly piece of forest, nor even maximising the human benefits obtained from that piece of forest, but rather the maintenance or improvement of the benefits obtained from the land use system as a whole. Therefore the future management of the forest areas should be decided in the light of integrated land use policies and programmes for the region.

6. RECOMMENDATIONS

In the existing arrangement of legislation and government infrastructure, forest reserve status is probably an essential prerequisite for ensuring the protection of forest vegetation in the interests of soil, water and biological conservation. It is recommended that all substantial areas of closed forest, especially on vulnerable sites, should be protected as forest reserves, including Kulal and the upper reaches of Ol Doinyo Mara. For maximum benefit and convenience, the reserves may include very steep and erodible slopes, even if only lightly wooded, and also patches of included or partially included grassland as on Kulal, It is not necessary to reserve all small, isolated forest patches.

Since the forests are reserved in the interests of the human population, a substantial amount of utilisation of the forest resources should be permitted so long as it does not significantly diminish the conservation values of the forest. It is appropriate that local residents should be permitted to remove fuel wood (perhaps only dead wood) and perhaps poles free of charge for their private domestic consumption. This is an important principal. If such domestic extractions are likely to be so large as to damage the forest, it is essential to note that the problem is not solved by forbidding such extractions or even by charging for them; such measures merely export the environmental degradation to the unreserved areas. Large local needs should be provided for by positive measures such as tree-planting.

Decisions about grazing in these and other mountains should not be decided only by reference to the Forests Act. Many of the hillsides are traditional grazing grounds; some may be currently overused and others could safely support more animals. The controlling decisions about the most suitable vegetation cover and the seasons and intensities of livestock use should be made jointly by representatives of the land-users and the forestry, livestock, rangeland and local authorities. When an authority exists with the power and ability to organize and control grazing activities, with full environmental and conservation safeguards, it may no longer be necessary for the woodland and bushland grazing areas to remain as forest reserves unless there is a particular local justification (such as the requirements of a forestation program). There is an urgent need for measures to protect the vegetation and soils throughout the arid lands, not just on the wooded catchments. Sound land use planning, with properly controlled implementation, is required to take over many of the old objectives of forest reserve status on a larger scale.

It is recommended that many of the wooded hillsides below the closed forests should be open for regular dry season grazing by identified groups of pastoralists in controlled, agreed and variable numbers. It will be necessary to ensure that most livestock leave the dry-season areas during wet seasons in order to ensure that they retain their function.

I do not recommend that such areas on Kulal (e.g. the areas currently utilised below and around Gatab) should be declared forest reserves, or that such areas on the base of the Ndotos range should necessarily remain forest reserve indefinitely.

It is recommended that the utilisation of the montane forests during periods of extreme drought should be permitted not as a privilege but as an accepted part of the land use plan, by agreement between all the interested parties. The local and government authorities will need the power to open the forests for grazing, and also to close them strictly when grazing conditions improve again elsewhere.

As already mentioned, the piping of water out of the forests and away from steep slopes from springs and stream heads will be a highly effective way of reducing damage. Such investments, started in the 1940s, should be extended to all suitable springs. Appendix 3 includes a list of springs or Kulal, taken from Marsabit files, which should be considered for water-piping. Similar attention should be paid to Nyiru and Ndotos (e.g. above Ngurunit and Ilaut).

The environmental importance of these and similar forests is so great that the collection of basic information about them deserves special attention. An unobserved contraction of the forests could have serious consequences, and a project such as IPAL should determine the areas, and significant changes with time, of each forest, and should take the opportunity of making continued biological observations, including arrangements for more thorough ground checks and botanical collection. These require a program of aerial photography and analysis at a much more detailed level than the surrounding rangeland.

It is recommended that new aerial photography should be carried out, perhaps only over a small sample of the IPAL area, combined with a detailed comparison with the old photographs of c. 1958 and c. 1962-3, with two particular aims: 1) a quantitative study of changes in areas of all the main identifiable vegetation types during the 20 years covered by photographs, and 2) the definition of the areas of closed forest now existing, together with the location of the boundaries and forest edges on detailed maps. In addition, it is recommended that some double-edge-enhanced imagery based on LANDSAT photographs should be commissioned from the Earth Satellite Corporation, preferably for two different seasons (e.g. during the long drought, and at present), covering the whole IPAL area, for purposes of land use planning.

A study of the stocking and productivity of these forests would be of considerable scientific interest, but it would be a major time-consuming and long term undertaking. I cannot recommend such studies for the IPAL program, but they should certainly be included in any MAB studies. Suitable techniques for design, fieldwork, assessment and interpretation of plot-based studies in forests are given by Dawkins and Field (1978) and Synnott (1979).

Summary of recommendations

1. Forest Reserve status for the forested areas and some steep gullies on Kulal, c. 5000 ha.

2. Forest Reserve status for the upper levels of Ol Doinyo Mara, c. 1000 ha.

3. Continued Forest Reserve status for other forest areas, with a review of the status of the partially wooded lower slopes in due course.

4. Regular patrolling, with the patrolman-guard-ranger system, combined with maintenance of permanent boundaries, to enforce the local land-use decisions.

5. The encouragement of diverse uses of the forest, including honey gathering, timber-cutting of the largest trees, and some fuel gathering and charcoal burning, with careful environmental safeguards.

6. The practice of dry-season grazing, and the use of forests as "drought-emergency grazing areas", integrated with the proposals for managed "grazing blocks".

7. Continued botanical collection and other basic, but not elaborate, biological observations.

8. New aerial photography and satellite imagery to define vegetation changes and forested areas.

9. The maintenance of water-piping systems, and the extension of water piping to many more springs and streams in all catchment areas.

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"The woody flora is therefore quite unextraordinary and exceedingly similar to that occurring in the central highlands of Kenya and the higlands of Ethiopia and clearly derived from them. The molluscs, however, appear to have evolved more quickly since some are apparently endemic."

Appendix 1

An annotated distribution list of the montane forest trees and shrubs of the project area.

This list is certainly incomplete, because of the incompleteness of botanical explorations and collections in and around the IPAL project area. However, it aims at completeness in its records of the trees and larger shrubs of the closed montane forests. It also includes some records of the trees and shrubs of forest edges, evergreen bushland and woodland at higher altitudes, particularly of those species which are prominent, abundant or well-collected. A few species are included purely for the botanical or phytogeographical interest, starting with Encephalartos.

I have records of very large numbers of other plants, including forest herbs, climbers and epiphytes, and non-forest plants, but these records are inevitably much less complete than those of the forest trees and shrubs.

The list here is based on many collections, and includes checks carried out in the herbaria at Nairobi, Kew and Gatab. It is probably an almost complete reflection of the current status of information. It would be helpful if local collectors and researchers could annotate this list in the light of their own observations.

Arrangement:

Families: The sequence of families follows that used by Gillett and McDonald (1970, A numbered checklist of trees, shrubs and noteworthy lianes indigenous to Kenya) and Agnew (1974, Upland Kenya Wild Flowers). This is a phylogenetic sequence, reflecting the relatedness of families, and within the main groups it leads from the more primitive to the advanced families.

Genera and Species: listed alphabetically within families.

Key:

X = observations supported by botanical collections in herbaria.
(X) = observations, probably reliable, but no collections
? = reported but uncertain, unconfirmed.
K = Mount Kulal.
Nd = Ndotos Range.
Ny = Nyiru Range, including Ol Doinyo Mara.
HH = Hurri Hills.
M = Marsabit Mountain.

Collections:

The botanical specimens supporting these lists are mostly in Nairobi, Kew, Oxford and Gatab. I have the numbers and records of these specimens, although they are not listed here.

Species	K	Nd	Ny	HH	M
CYCADACAE					
Encephalartos tegulaneus Melville Observed in Ndotos, including above Ngurunit, on rocky and steep grassy slopes. Occurs also on Mt. Lolokwe, Mathews Range, in forest or bushland.		(X)			
CUPRESSACEAE					
Juniperus procera Endl. Abundant in and around lower margin of forest on Kulal, especially at southern and northern ends, but apparently less prominent on Nyiru and Ndotos. Able to act as a coloniser, establishing itself in grassland and open areas, when it may form closed Juniper forest or may be succeeded by mixed broadleaved trees.	X	X	X		
PODOCARPACEAE					
Podocarpus gracilior Pilger Collected on Mathews Range and Leroghi Plateau, common around Mararal, but not collected here.					
Podocarpus milanjianus Rendle Grows to very large sizes in wet montane forests, in wetter areas than Juniper.	?	X	X		
MONIMIACEAE					
Xymalos monospora Baill. Frequent in wetter areas of Kulal forests as understorey tree or in canopy. Collected in open mountain side on Nyiru.	X		X		
LAURACEAE					
Ocotea kenyensis (Chiov.) Robyns & Wilczek Frequent in wetter areas of Kulal forests, sometimes very large. Rare on Marsabit.	X				X
CAPPARACEAE					
Ritchiea albersii Gilg Frequent small tree in closed forest.					X
VIOLACEAE					
Rinorea convallarioides (Bak. f.) Eyles Frequent small understorey tree in wet forest.					X
OLINIACEAE					
Olinia usambarensis Gilg Reported in forest and bushland as shrub or small tree.	(X)				(X)
THYMELAEACEAE					
Peddiea volkensii Gilg Reported as small tree in forest with Ocotea					(X)

	K	Nd	Ny	HH	M
PROTEACEAE					
Faurea saligna Harv. Usually a savanna, woodland or forest edge tree.			X		(X)
Protea kilimandscharica Engl. Shrub in open areas at high altitudes.			X		
PITTOSPORACEAE					
Pittosporum viridiflorum Sims Small tree in open forest and evergreen bushland.	X				
FLACOURTIACEAE					
Casearia battiscombei R.E. Fries Frequent large tree in wetter, old mixed forest.	X				X
Dovyalis abyssinica (A. Rich.) Warb. Frequent shrub or tree, sometimes large, in bushland and in old closed forest.	X		X		X
Scolopia theifolia Gilg In mixed forest, recorded with Olea, Teclea, Cassipourea.	X				
OCHNACEAE					
Ochna insculpta Sleumer Frequent small tree or shrub in forest, forest edges and thickets, reaching up to the highest areas of Kulal and Ndotos in forest, and as low as 1000 m in gulley thickets on Hurri Hills.	X	X	?	X	X
Ochna ovata F. Hoffm. Shrub or small tree in bushland and scrub, sometimes forest, collected at lower altitudes and usually occurring in more open sunny places than O. insculpta.	X	X			
MYRTACEAE					
Syzigium guineense (Willd.) DC. Occurs elsewhere, including Mathews Range, in riverine forest and protected relict patches at moderate altitudes.	(X)				
RHIZOPHORACEAE					
Cassipourea malosana (Bak.) Alston Large tree in mixed forest, including some drier types, frequent on Kulal, from just above Gatab, and on Marsabit.	X				X
GUTTIFERAE					
Garcinia sp.					?
TILIACEAE					
Grewia similis K. Schum. Shrub in thickets, bushland, Juniper stands and in closed mixed forest, less prominent in higher wetter areas.	X	X			X

	K	Nd	Ny	HH	M
STERCULIACEAE					
Dombeya goetzenii K. Schum. Straggling tree found on ridge and edge of main gorge near top of Kulal, over 2000 m.	X				
ERYTHROXYLACEAE					
Erythroxylum emarginatum Thonn. Small understorey tree in mixed forest, collected in lower parts of Marsabit forest.					X
EUPHORBIACEAE					
Croton dichogamus Pax Shrub in thickets, scrub and grassy areas, not a species of closed forest, usually in mid-mountain altitudes.	(X)	X	X	X	X
Croton macrostachyus Hochst. ex Del. Spreading tree in grassland, thickets and forest edges, an effective coloniser in some situations.				X	X
Croton megalocarpus Hutch. Tall tree in forest edges and sometimes in well-developed mixed forest, with some characteristics of a coloniser.		(X)	X		X
Drypetes gerrardii Hutch. Moderate-sized tree in closed mixed forest.	(X)				X
Erythrococca bongensis Pax Shrub or small tree in bushland, forest edges and in closed forest.	X				X
Euphorbia candelabrum Kotschy Spreading tree in bushland, open forest and steep valley sides.	X			(X)	(X)
Euphorbia engleri Pax Shrub in closed mixed forest.	X				
Sapium ellipticum (Krauss) Pax Tree in riverine forest above Ngurunit, c. 1000 m.		X			
ROSACEAE					
Prunus africana (Hook. f.) Kalkm. Typical tree of mountain forests, not uncommon in Kulal forests and forest edges, reported rare on Marsabit.	X	(X)	X		(X)
LEGUM.: CAESALPINIOIDEAE					
Bauhinia tomentosa L. Shrub or small straggling tree, common on Marsabit, also in low dry forest in gullies, and in bushland, thickets and riverine scrub.	?	X		X	X

	K	Nd	Ny	HH	M
LEGUM.: MIMOSOIDEAE					
Albizia gummifera (Gmel.) C.A. Smith Recorded as rare and riverine, tall tree.					(X)
LEGUM.: PAPILIONOIDEAE					
Cadia purpurea (Picc.) Ait. Shrub in understorey of irregular Junperus-Olea forest, at high altitudes, and in bushland, ravines and rocky ground (e.g. around Gatab, 1750 m), down to as low as c. 1000 m (base of El Kajata gorge)	X	X	X		
Erythrina burttii Bak. f. Spreading tree in wooded grassland and thickets, prominent in Hurri Hills, locally common Kulal, observed (this species?) in Ngurunit Valley.	X	(X)		X	
HAMAMELIDACEAE					
Trichocladus ellipticus Eckl. & Zeyh. Usually a shrub or small tree in thickets.	(X)				(X)
ULMACEAE					
Celtis africana Burm. f. Only seedlings have been found, in old mixed forest.	X				X
Celtis durandii Engl. Only seedlings found.					X
Chaetacme aristata Planch. Usually a straggling bush or tree in forest edges.	(X)				
Trema orientalis (L.) Blume Small tree in riverine forest above Ngurunit, c. 1000 m. Usually a coloniser.		X			
MORACEAE					
Ficus capensis Thunb. Variable tree, sometimes a large strangler, in forest and riverine forest.	X				X
Ficus dekdekena (Miq.) A. Rich. Small tree, sometimes in forest.					X
Ficus glumosa Del. Spreading trees, not in closed forest, in dry rocky sites, prominent around Luai, below Gatab.	X				
Ficus thonningii Blume Tree, sometimes extremely large, inside forest and in bushy grassland.	X				
AQUIFOLIACEAE					
Ilex mitis (L.) Radlk. A single record as a shrub on forest edge, c. 2100 m, but elsewhere often a substantial mountain forest tree.	X				

Species	K	Nd	Ny	HH	M
CELASTRACEAE					
Catha edulis (Vahl) Endl. A typical mountain forest shrub and small tree.	(X)				
Maytenus heterophylla (Eckl. & Zeyh.) N. Robson Shrub or small tree in forest edges or bushland.	X	X			X
Maytenus senegalensis (Lam.) Exell Shrub or small tree in forest or bushland.	X				
Maytenus undata (Thunb.) Blakelock Shrub or small tree in closed Juniper or mixed forest.	X				
Mystroxylon aethiopicum (Thunb.) Loes. Shrub or small tree in forest, forest edge and grassy areas.	X				X
ICACINACEAE					
Apodytes dimidiata Arn. Shrub or tree near lower margins of forest area, in forest, forest edges and bushland.	X				X
OLACACEAE					
Strombosia scheffleri Engl. Occasional in wetter areas of Marsabit as a large tree.					X
SANTALACEAE					
Osyridicarpus schimperianus (Hochst. ex A. Rich.) A.DC. Straggling shrub in forest edges or in irregular Juniper-Olea forest.	X				
Osyris abyssinica A. Rich. Frequent shrub or small tree in irregular forest, forest edges, bushland and grassy areas.	X	X	X	X	X
RHAMNACEAE					
Rhamnus prinoides L'Herit. Usually a shrub, common in forest edges and bushland, sometimes under forest.	X	X	X		X
Rhamnus staddo A. Rich. Shrub or small tree, in forest, forest edges or bushland.	X	X	X		X
Scutia myrtina (Burm. f.) Kurz Shrub or scrambler in forest edges or bushland.	X				(X)
RUTACEAE					
Calodendrum capense (L.f.) Thunb. Forest tree observed only from the air, presumably this species.	(X)		(X)		
Clausena anisata (Willd.) Benth. Small tree or understorey shrub in forest or forest edge, frequent in higher and wetter areas of Kulal forests.	X		X		X

	K	Nd	Ny	HH	M
Teclea nobilis Del. Tall tree, frequent in mixed hardwood forest.	X		X		X
Teclea simplicifolia (Engl.) Verdoorn Forest tree, sometimes a bushland shrub, frequent.	X	X	X		X
Vepris samburuensis Kokwaro Tree in riverine forest above Ngurunit, c. 1000 m.		X			
SIMAROUBACEAE					
Brucea antidysenterica Mill. Shrub or understorey tree, also conspicuous in forest edges, locally frequent in wetter or higher parts of Kulal forests but not apparently common on the other mountains.	X	X	X		X
Harrisonia abyssinica Oliv. Shrub or small tree in bushland.					X
MELIACEAE					
Ekebergia capensis Sparrm. A montane forest tree, recorded as very large.					X
Lepidotrichilia volkensii (Guerke) Leroy Understorey tree in closed mixed forest.	X				
Trichilia emetica Vahl (or perhaps T. dregeana Sond.) Collected in South Horr and in closed riverine forest, c. 1000 m, above Ngurunit, and recorded for east parts of Marsabit.		X	X		(X)
Turraea mombassana Hiern ex C.DC. Abundant shrub in evergreen bushland and forest edges.	X				
SAPINDACEAE					
Allophylus abyssinicus (Hochst.) Radlk. Occasional tree in higher, wetter parts of forest.	X				
Allophylus rubifolius (A. Rich.) Engl. Shrub in forest edge and bushland.	X				
Pappea capensis Eckl. & Zeyh. Shrub or tree in thickets and bushland.	X	X		(X)	
ANACARDIACEAE					
Pistacia aethiopica Kokwaro Shrub or straggling tree in patches of forest, forest edges and bushland, common on Kulal. Collected above Ngurunit.	X	X		(X)	

	K	Nd	Ny	HH	M
Rhus natalensis Krauss Frequent shrub in forest edges, thickets, bushland and grassy areas.	X		X	(X)	X
Rhus ruspoli Engl. Shrub in bushland.			X		
Rhus vulgaris Meikle Frequent shrub in forest edges, thickets and bushland.	X			(X)	X
ARALIACEAE					
Cussonia holstii Harms ex Engl. Frequent tree in forest, thickets and forest edge.	X		X		
UMBELLIFERAE					
Heteromorpha trifoliata (Wendl.) Eckl. & Zeyh. Frequent shrub in forest edges and thickets.	X		X	(X)	
ERICACEAE					
Erica arborea L. Shrubby tree forming thickets, above 2100 m.			X		
EBENACEAE					
Diospyros abyssinica (Hiern) F. White Forest tree, frequent in less wet parts of Kulal forests above Gatab; descending to c. 1100 m in valley above Ngurunit.	X	X			X
Euclea divinorum Hiern Shrub in dry gulley forest				X	
Euclea schimperi (A.DC.) Dandy Frequent shrub in forest edges and bushland.	X				
SAPOTACEAE					
Aningeria adolfi-friederici (Engl.) Robyns & Gilb.					(X)
MYRSINACEAE					
Maesa lanceolata Forssk. Shrub or tree, typically in wetter areas, valleys or forest edges, often as a coloniser.	X		X		X
Myrsine africana L. Frequent understorey shrub in closed forest or Juniper thickets, and in forest edges and bushland.	X	X	X		
Rapanea melanophloeos (L.) Mez. Shrub in low, closed forest at top edge of main gorge, Kulal, c. 2100 m.	X				
LOGANIACEAE					
Nuxia congesta Fres. Shrub or tree, sometimes large, in drier closed mixed forest.	X		X		

	K	Nd	Ny	HH	M
Strychnos henningsii Gilg Small tree in drier parts of forest.	X				X
Strychnos mitis S. Moore Forest tree	X				X
OLEACEAE					
Linociera battiscombei Hutch. Tree in wet forest.					X
Olea africana Mill. Frequent tree in closed mixed forest, particularly in drier areas, and in some thickets and bushland as a shrub.	X	X	X	X	X
Olea hochstetteri Bak. (Olea capensis) Occasional or frequent tree in mixed hardwood forest, usually perhaps in wetter or higher parts than O. africana.	X				X
Schrebera alata (Hochst.) Welw. Small tree in drier forests, thickets and bushland.	X				
APOCYNACEAE					
Carissa edulis (Forsk.) Vahl Frequent shrub in thickets and bushland.	X				
RUBIACEAE					
Anthospermum usambarense K. Schum. Shrub at highest altitudes in open areas, collected at 2300 m			X		
Aulacocalyx diervilleoides (K. Schum.) Petit Shrub in mixed forest understorey.	X				
Canthium schimperanum A. Rich. Small tree in thickets and mixed forest understorey.	X	X			X
Coffea arabica L. Frequent understorey shrub in dense forest.					X
Oxyanthus speciosus DC. Understorey tree or shrub in mixed, wetter forest.	X				X
Pavetta abyssinica Fresen Understorey shrub in mixed hardwood forest and forest edges.	X				X
Pavetta aethiopica Brem. Shrub in thicket.				X	
Pavetta gardeniifolia A. Rich. Shrub in forest and thicket.	X		X		

	K	Nd	Ny	HH	M
Psychotria kirkii Hiern varieties Shrub in forest, forest edge, thickets, bushland and grassy hillsides	X	(X)	X	X	X
Psychotria orophila Petit Understorey shrub in old mixed forest, mainly above 2000 m	X		X		
Rytigynia butaguensis (De Wild.) Robyns Understorey shrub in forest.	X				
Rytigynia neglecta (Hiern) Robyns Understorey shrub or small tree in mixed hardwood forest.	X				X
Tarenna graveolens (S. Moore) Bremek varieties Shrub or small tree in montane forest and bushland, extending down to thickets and open woodland at lower altitudes (e.g. to 800 m above Ngurunit)	X	X	X	X	X
Vangueria acutiloba Robyns Spreading tree or shrub in forest edges and riverine forest or scrub, often at lower altitudes.			X		X
Vangueria apiculata K. Schum. Shrub or small tree in forest edges, thickets and bushland.	X	(X)			X
Vangueria linearisepala K. Schum. Frequent in evergreen bushland.	X				
BORAGINACEAE					
Cordia africana Lam. Often a large spreading tree, typically in more open forest.	(X)				X
Cordia ovalis DC. Straggling tree or bush in various types of closed montane forest, in mid-mountain woodland and in gulley thickets and valley scrub at lower altitudes.	X	X	X	X	X
Ehretia cymosa Thonn. Shrub or tree, usually on forest edge, collected around 1800-2000 m.	X				
ACANTHACEAE					
Acanthus eminens C.B.Cl. Occasional in higher wetter areas in forest edges and glades, an effective coloniser.	X				
Ruttya fruticosa Lindau Shrub in closed dry forest at higher altitudes (e.g. with Juniperus, Olea), in thickets and in gulley forest at lower altitudes.	X	(X)		X	X
VERBENACEAE					
Clerodendrum myricoides (Hochst.) Vatke Small shrub in forest edge, bushland and grassy areas.	X	X		X	X

	K	Nd	Ny	HH	M
Clerodendrum johnstonii Oliv. Small tree, shrub or climber in forest.			X		X
Premna maxima T.C.E. Fries Large forest tree, occasional.					X
LABIATAE					
Plectranthus sylvaticus Guerke Small shrub in mixed hardwood forest at higher altitudes.	X				
AGAVACEAE					
Dracaena afromontana Mildbr. Shrub or tree in closed mixed montane forest.	X				
Dracaena ellenbeckiana Engl. Small erect tree, collected on steep gulley wall below Gatab airstrip.	X			?	
Dracaena laxissima Engl. Shrub in mixed forest.					X
PALMAE					
Phoenix reclinata Jacq. Tree in irregular forest and steep gorge walls at high altitudes.	X	X			

Appendix 2.

Vernacular names of plants in project area

This list of scientific and vernacular names is intended to assist those working in the project area in interpreting the uses made by man and animals of the local plants and to help in botanical identifications. The list is obviously incomplete, but, more important, it makes little attempt at linguistic precision or uniformity. I have recorded some names given to me in the field as best I could; otherwise the names are copied from botanical collections in herbaria, from various reports and publications and from books such as Kenya Trees and Shrubs. Among my own notes, I have recorded the origin of each vernacular name listed here.

Some names listed are obviously varying renderings of the same name. I have not attempted to decide which spellings are most appropriate, unless I have myself heard the name pronounced or unless I have had to reduce a list of several different spellings down to two or three examples. There are also doubtless many errors arising from faulty identification or knowledge. Some species have been recorded with several quite different names in a single language, and this may be quite correct, embracing examples of different shapes, sizes and qualities, but including perhaps some misidentifications.

I suggest that any workers who find the list useful should annotate it with revisions and additions, following consistent phonetic guidelines.

It is not possible for me to define the language groups used, since much of the information comes from imprecise secondary sources. Gabbra has been included with Boran because they are relatively closely related languages and because I was informed that many names were used by both peoples.

	SAMBURU	RENDILLE	GABBRA-BORAN
CYCADACEAE			
Encephalartos tegulaneus Melville	ipision		
CUPRESSACEAE			
Juniperus procera Endl.	ndarakwoi	haru	aru
PODOCARPACEAE			
Podocarpus gracilior Pilger	piripirindi, dibilibilit		
Podocarpus milanjianus Rendle	biribiriti, ikenjeesu		
LAURACEAE			
Ocotea kenyensis (Chiov.) Robyns & Wilczek	masiat		
RANUNCULACEAE			
Clematis brachiata Thunb.	ukolekole		
MENISPERMACEAE			
Stephania abyssinica (Dillon & A. Rich.) Walp.	lakitimu		
CAPPARACEAE			
Boscia angustifolia A. Rich.	lororoi		
Boscia coriacea Pax		nyaror, ioror	kalkatch, galgacha-hareh
Cadaba farinosa Forsk.	larasoro	geikuku	khaddi, tutch, haggarinyap
Cadaba glandulosa Forsk.			dugh, dekuku
Cadaba ruspolii Gilg	rasia		
Capparis cartilaginea Decne.			gorra
Capparis fascicularis DC.	lerenday		
Capparis tomentosa Lam.	loturdei		gorrah-gel
Gynandropsis gynandra (L.) Brig.	lasaiet		
Maerua angolensis DC.	luliondo, loitarkini, lamalogi		kalkaj, galgacha
Maerua crassifolia Forsk.	lumi		galgacha, umacho, kalkaj-domaio
Maerua triphylla A. Rich.	mulingula		
Thylachium africanum Lour.	lolmugu, sangaretai		

	S	R	G-B
CRUCIFERAE			
Erucastrum arabicum Fisch. & Mey.	njunge		
MORINGACEAE			
Moringa sp.	imasiligi		safarra
VIOLACEAE			
Rinorea convallarioides (Bak. f.) Eyles			kara, fito
CRASSULACEAE			
Kalanchoe citrina Schweinf.	losisanjo		
AIZOACEAE			
Gisekia pharnaceoides L.	lekulupani loldonyio		
Mollugo cerviana (L.) Ser.	nyoorte-lenkop, siakie		
Trianthema salsoloides	lekuruki		
PORTULACACEAE			
Portulaca foliosa Ker-Gawl.	rarabarob		
CHENOPODIACEAE			
Salsola dendroides Pallas			urrte, durte
Suaeda monoica J.F. Gmel.			durte
AMARANTHACEAE			
Achyranthes aspera L.			gurbi
Aerva lanata (L.) Juss.	masigirai		
Amaranthus graecizans L.	eromram, loirabirabi		
Celosia sp.	icheui-ronkai, letamesii		
Cyathula erinacea Schinz			igadyi
Dasysphaera prostrata (Gilg) Cavaco	lopitara		jilbete
Gomphrena celosioides Mart.	dawa-lenkop		
Pupalia lappacea (L.) A. Juss.	lorepirepi	dadagle	
Sericocomopsis hildebrandtii Schinz			garbitch
Sericocomopsis pallida (S. Moore) Schinz	lturkan		
Volkensinia prostrata (Gilg) Schinz			jilbete

	S	R	G-B
GERANIACEAE			
Pelargonium quinquelobatum A. Rich.	naseisio		
LYTHRACEAE			
Lawsonia inermis L.	ilgiria, lngiriai	halam, ilam	ur'ur
OLINIACEAE			
Olinia usambarensis Gilg.	lgering		
PROTEACEAE			
Faurea saligna Harv.	kikeriai, olbugui		
FLACOURTIACEAE			
Casearia battiscombei R.E. Fries	ge-ebor		
Dovyalis abyssinica (A. Rich.) Warb.	limoro		kurawa
Flacourtia indica (Burm. f.) Merr.	loloroi		
Trimeria tropica Burkill	mdaga		
PASSIFLORACEAE			
Adenia volkensii Harms	iturmaei		
CUCURBITACEAE			
Cucumis sp.	nkalamoi		
Kedrostis gijef (J.F. Gmel.) Jeffrey		sarkhudum	
Peponium vogelii (Hook. f.) Engl.	igusyaeti, raragi		
Zehneria anomala C. Jeffrey	imelapale		
OCHNACEAE			
Ochna insculpta Sleumer	modonkorit, lcipilikua		
Ochna ovata F. Hoffm.	lalamoroi		
MYRTACEAE			
Syzigium guineense (Willd.) DC.	lamulii, lepeloi, lairakai, laupop		
COMBRETACEAE			
Combretum aculeatum Vent.	lemawoi, lemowei	hikho	kaleda
Combretum collinum Fres.	lebarasien		
Crombretum molle G. Don			rukhes
Terminalia brownii Fres.	ilbugoi		
Terminalia orbicularis Engl. & Diels		bisirkh	

	S	R	G-B
RHIZOPHORACEAE			
Cassipourea malosana (Bak.) Alston	mburuli, labbobo		
GUTTIFERAE			
Garcinia livingstonei T. Anders.	ikasiyoi, iyoret		
TILIACEAE			
Grewia bicolor Juss.	siteti, sigteti, lagratenai	dabach	arorera, hororessa
Grewia mollis Juss.	siteti	dabach	
Grewia similis K. Schum.	iri, ngaligoi		
Grewia tembensis Fres.	iri		deka
Grewia tenax (Forsk.) Fiori	lngongomi, beteti	mulehenyu	murie, dekah, irgedud, sarkam
Grewia villosa Willd.	lbuboi, lopopoi fruit = lpupo		ogumti, ogomdi
Triumfetta flavescens A. Rich.			hanch'abbi
STERCULIACEAE			
Dombeya goetzenii K. Sch.	ilporowai		
Hermannia kirkii Mast.		hasura	
Sterculia africana (Lour.) Fiori			gharari
Sterculia stenocarpa H. Winkler	ikalaasia		
MALVACEAE			
Abutilon hirtum (Lam.) Sweet			hatawi
Abutilon pannosum (Forsk.) Schlect.	surubei		
Hibiscus greenwayi Baker	erigen-manjoi		
Hibiscus micranthus L.f.	lokimeki		
Pavonia arabica Boiss.	lyolon		
MALPIGHIACEAE			
Caucanthus auriculatus (Radlk.) Nied.	imanumanu		
ERYTHROXYLACEAE			
Erythroxylum emarginatum Thonn.			karra
EUPHORBIACEAE			
Acalypha fruticosa Forsk.	syeiti		
Croton dichogamus Pax	lakingdirgat, lakirdingai, lageridinai		

	S	R	G-B
Croton macrostachyus Hochst. ex Del.	iborguai, parmaala		mukanisia
Croton megalocarpus Hutch.	marakuet, lemaruguet		nyapo
Erythrococca bongensis Pax	leshapiriki, itulelei		
Euphorbia cuneata Vahl		andikha	
Euphorbia engleri Pax	iguburtu		
Euphorbia polyantha Pax	lekule		
Euphorbia scheffleri Pax	ngoborbit		
Euphorbia systyloides Pax	lekule, naishoontase		
Euphorbia tirucalli L.	lorien, loile		anno
Jatropha dichtar Macbride	laparana		
Sapium ellipticum (Krauss) Pax	ngereni		
Securinega virosa (Willd.) Pax & K. Hoffm.	munyi munyi		
Tragia brevipes Pax	sabai		
ROSACEAE			
Prunus africana (Hook. f.) Kalkm.	maralal, malau		
LEGUM.: CAESALPINIOIDEAE			
Bauhinia tomentosa L.	lechoro		abartabat
Cassia mimosoides L.	masegrai		
Delonix elata (L.) Gamble	lawoi, lawai, laichimi lawai	lupupontoi, bubunto	sukela
Tamarindus indica L.	rogeyi		roka
LEGUM.: MIMOSOIDEAE			
Acacia brevispica Harms	girigiri		amaresa
Acacia bussei Sjoestedt			halo
Acacia drepanolobium Sjoestedt	luai, lmarti		
Acacia etbaica Schweinf.			alakabess
Acacia gerrardii Benth.	rankau		
Acacia goetzei Harms			buru
Acacia hockii De Wild.	lmarti kinii, labai		
Acacia horrida (L.) Willd.	lerai, lo-kees		chachanneh
Acacia mellifera (Vahl) Benth.		bilhil	sabansa-gurach, sabansa
Acacia nilotica (L.) Del. subsp. subalata (Vatke) Brenan	eldekeci, ikiloliki, lkoloriti		burgege, burkekeh
Acacia nubica Benth.	loepe	dahar	wanga, wangai

	S	R	G-B
Acacia paolii Chiov.	lmarti	gomor	chachanneh-ariti, chachane
Acacia reficiens Wawra	lcurai	khassa	sigirsoi
Acacia senegal (L.) Willd.	lngerdedi, eldekeci, ikerdedi, loloruki		sabanso-dima, idado
Acacia seyal Del.	lerai leldonyio	fulai	wachu, wacho-dima
Acacia stuhlmannii Taub.			chachanneh
Acacia tortilis (Forsk.) Hayne	ltepes	dhar	daddetch, dadach
Albizia amara (Roxb.) Boiv.			boria
Albizia anthelmintica Brongn.			hawacho
Albizia gummifera (Gmel.) C.A. Smith	sogore		
Dichrostachys cinerea L.	legili, rangau		jirime, butiyeh
Newtonia hildebrandtii (Vatke) Torre	siysiy, elmuki, loimugi		
LEGUM.: PAPILIONOIDEAE			
Cadia purpurea (Picc.) Ait.	ilkirereai, ikekeliai		
Craibia laurentii (De Wild.) De Wild.	loiley, lelei		
Erythrina burttii Bak. f.			wallena
Erythrina melanacantha Harms	nmorotshi		wolena, wolensu
Indigofera schimperi Jaub. & Spach			agargaro
Indigofera spicata Forsk.	dawadenkop	chorroh	agargaro
Lonchocarpus ? eriocalyx Harms	ilteroi		
Mucuna gigantea (Willd.) DC.	larachi		
Ormocarpum trichocarpum (Taub.) Engl.	idolishoi		butiye
Rhyncosia minima (L.) DC.			agargaro
Tephrosia noctiflora Bak.	lyolai		
Vatovaea pseudolablab (Harms) Gillett	nanyoi		agargaro
Vigna frutescens A. Rich.	nkapanga		
Vigna vexillata (L.) A. Rich.	lmorianchoi		
HAMAMELIDACEAE			
Trichocladus ellipticus Eckl. & Zeyh.	lobalugilugi		
MYROTHAMNACEAE			
Myrothamnus flabellifolius (Sond.) Welw.	lakima		
ULMACEAE			
Chaetacme aristata Planch.	sunungurr		

	S	R	G-B
Trema orientalis (L.) Bl.	lositet		
MORACEAE			
Dorstenia sp.	imaugaritt		
Ficus capensis Thunb.	loponyi, idayasan, ilngaboli		odaa
Ficus dekdekena (Miq.) A. Rich.			dambi, dembi
Ficus glumosa Del.			kilta
Ficus natalensis (Miq.) Hochst.	labuli		
Ficus salicifolia Vahl	sabtei		
Ficus sycomorus L.	lugaboli		od, oda
Ficus thonningii Blume	subtei		
Ficus wakefiȇldii Hutch.	reteti		
CELASTRACEAE			
Catha edulis (Vahl) Forsk. ex Endl.	mamiraa		
Maytenus heterophylla (Eckl. & Zeyh.) N. Robson	ikokorai, sagumie		
Maytenus senegalensis (Lam.) Exell.	laimurunyai, sokoneti		
Maytenus undatus (Thunb.) Blakelock	nakapile, itui ltunganayan, selemonai		
Mystroxylon aethiopicum (Thunb.) Loes.	selemunai		
ICACINACEAE			
Apodytes dimidiata Arn.	eyaoneti, logurguru, njeniarok		
SALVADORACEAE			
Dobera glabra (Forsk.) Poir.			garsa
Salvadora persica L.	sogetey, siakotei	hayayay	addi
OLACACEAE			
Ximenia americana L.	lamai		
LORANTHACEAE			
Plicosepalus curviflorus (Benth.) v. Tiegh		gaigiri	
SANTALACEAE			
Osyris abyssinica A. Rich.	sigeteti, njeni narok		wato

	S	R	G-B
RHAMNACEAE			
Berchemia discolor (Klotzsch) Hemsl.	santaiti		
Helinus mystacinus (Ait.) E. Mey.	lalakete, loitegomi		
Rhamnus prinoides L'Herit.	ikenyeli, makeradi		
Rhamnus staddo A. Rich.	kokilai, ikokorai		gale
Scutia myrtina (Burm. f.) Kurz	sanunguri		
Ziziphus abyssinica A. Rich.	loilailei		
Ziziphus mauritiana Lam.		gupp	ququra
Ziziphus mucronata Willd.	lolale, loilailei, esilang, itelendei		
RUTACEAE			
Calodendrum capense (L.f.) Thunb.	larachi		
Clausena anisata (Willd.) Benth.	lmataasia		siscar
Teclea simplicifolia (Engl.) Verdoorn	elgalai, ngelai, ngilai orok		mike
Vepris samburuensis Kokwaro	nkampariti		
Toddalia asiatica (L.) Lam.	lparamunyo		
Xanthoxylum chalybeum Engl.	loisuki		gada
Xanthoxylum usambarense (Engl.) Kokwaro	loisuki		
SIMAROUBACEAE			
Brucea antidysenterica J.F. Miller	songoroi		
Harrisonia abyssinica Oliv.	lasaramai		
BALANITACEAE			
Balanites aegyptiaca (L.) Del.	sarai	kulum	badan
BURSERACEAE			
Boswellia hildebrandtii Engl.	silalei		dakkara
Boswellia microphylla Chiov.			mokh-lidi, mogole, dabasso
Boswellia rivae Engl.			kurrah, matta-but
Commiphora africana (A. Rich.) Engl. s.l.	loishimi, lerokoc, icheni nzito		
Commiphora boiviniana Engl.	laiamai		dakkidah
Commiphora campestris Engl.			amess-dirrah, sanga-igu
Commiphora candidula Sprague	ltilimani, samanderi, samanderi lokees		

	S	R	G-B
Commiphora madagascariensis Jacq.	lemarasin		jalanga
Commiphora schimperi (Berg) Engl.	lyakola		mesakaiya, kurrah
Commiphora spp.	lailepai, imanbalian	ramo, hagar, geiborbor, dawahadado, galdayan	hamess
MELIACEAE			
Lepidotrichilia volkensii (Guerke) Leroy	lugukutia, ilagas		
Melia volkensii Guerke	maramarui		
Trichilia emetica Vahl	ilberi, ibeeri		anona
Turraea mombassana Hiern ex C.DC.	ejaneoebor		
SAPINDACEAE			
Allophylus abyssinicus (Hochst.) Radlk.	ilkutekute		
Allophylus africanus P. Beauv.	masanabat		gadida
Allophylus rubifolius (A. Rich.) Engl.	lesanavata, ngilai		
Cardiospermum corindum L.	ltongomi, loitekomi, lowesiwesi		
Dodonaea viscosa Jacq.			hidesa
Lepisanthes senegalensis (Poir.) Leenh	iligisiriko		
Pappea capensis Eckl. & Zeyh.	igurungule, loposeten		
ANACARDIACEAE			
Lannea alata (Engl.) Engl.			wa'anreh
Lannea stuhlmannii (Engl.) Engl.			ile, tille
Lannea triphylla (Hochst. ex A. Rich.) Engl.	lambureri		andarak
Ozoroa insignis Del.	lekunono		gari
Pistacia aethiopica Kokwaro	lengoruo		
Rhus natalensis Krauss	lasaramai, iltord musigio, limisigiyioi		dabobiss,
Sclerocarya birrea (A. Rich.) Hochst.			didissa
ARALIACEAE			
Cussonia holstii Harms ex Engl.	loiyapiyapi		abratu
Cussonia spicata Thunb.	borilio		

	S	R	G-B
UMBELLIFERAE			
Heteromorpha trifoliata (Wendl.) Eckl. & Zeh.	lukuyeinei, ilkunyeinini		ali-hanko
Peucedanum linderi Norman	ikewachi		
Steganotaenia aralacea Hochst.	lulei		lugaluke, kubdi shan
EBENACEAE			
Diospyros abyssinica (Hiern) F. White	legurdien, ilchanai orok		roho, logo
Diospyros scabra (Chiov.) Cufod.	lgotoi, lyotto	yakhakhura	locho
Euclea schimperi (DC.) Dandy	ngingei, lchingei, ilikinjai		miesa
MYRSINACEAE			
Myrsine africana L.	seketeta, lsegetet		
LOGANIACEAE			
Nuxia congesta Fres.	imatapokai, libiroi, loiborshao		
Strychnos henningsii Gilg			karaa
Strychnos mitis S. Moore	itagurmot		karaa
OLEACEAE			
Jasminum eminii Gilg	longuaroi, loenieni		
Jasminum floribundum Fresen	loseisiai		
Jasminum fluminense Vell.	imanumanu, loitegomi		
Olea africana Mill.	gluyinei, nerie, larok, lorien, tamiyai, letoto, ilnyirei, tomeiu		ejas, ejerisa
Olea hochstetteri Bak. (O. capensis)	loliandu, loliontoi, lngilai lopurkei, siampat		
Schrebera alata (Hochst.) Welw.	letoto, ndoto, lkormozioi		

	S	R	G-B
APOCYNACEAE			
Adenium obesum (Forsk.) Roem. & Schult. s.l.	ilperintai		obe, sarba arba, lalafto
Carissa edulis (Forsk.) Vahl	limuria, lamuriei, misigio		dagams
Wrightia demartiniana Chiov.	lekule		
ASCLEPIADACEAE			
Calotropis procera (Ait.) Ait. f.	laibelecii		
Caralluma speciosa N.E. Br.	lmanyani		
Ceropegia sp. cf. euracme Huber	laugodai		
Ceropegia sp. cf. stenantha K. Schum.	nkerioi		
Ceropegia stenoloba Chiov.	njihilongi		
Raphionacme sp.	naisigo		
Tylophora sp.	lakiti		
RUBIACEAE			
Canthium rubrocostatum Robyns	larugach		
Canthium schimperanum A. Rich.	itiesi		gali
Cardenia volkensii K. Schum.	murgisian		
Oldenlandia wiedemannii K. Schum.	ukejuyolongoi		
Oxyanthus speciosus DC.	nabulotua		
Pentanysia ouranogyne S. Moore	marugeroi		
Psychotria kirkii Hiern	lekuruki		gadala
Rytigynia neglecta (Hiern) Robyns	lekipiria		
Tarenna graveolens (S. Moore) Bremek	masei, lmasiei, imoisol, lekuriki		korkorei
Vangueria acutiloba Robyns	igumi, imaludei, igormosiyoi, ngoromosui		bururi
Vangueria linearisepala K. Schum.	ngururusie, ilkoromosoi		
COMPOSITAE			
Aspilia mossambicensis (Oliv.) Wild.	loiyabasei, yabasai		hadda
Blepharispermum lanceolatum Chiov.	legruki		
Crassocephalum bojeri (DC.) Robyns	laitangeshoi		
Crassocephalum mannii (Hook. f.) Milne-Redh.	likyawai, saputiti, lagarmon, lugugutt		

	S	R	G-B
Crassocephalum montuosum (S. Moore) Milne - Redh.	laroka		
Delamera procumbens S. Moore			urgo
Erlangea tomentosa S. Moore	saali-loldolnyo		
Erlangea sp.	lodaporo		
Kleinia kleinioides (Sch. Bip.) M.F.R. Tayl.	longaaloi		
Lactuca capensis Thunb.	ndaa-ontore		
Microglossa pyrifolia (Lam) O. Ktze.	somati		
Psiada punctulata (DC.) Vatke	labai		
Vernonia aurantiaca O. Hoffm.			mukma chuma
Vernonia brachycalyx O. Hoffm.	lokumati		
LOBELIACEAE			
Cyphia glandulifera A. Rich.	ikurjiji		
BORAGINACEAE			
Cordia africana Lam.	chibulukwa		wondesi
Cordia ovalis DC.	se'eki, lmanturre	gaer	mader, modera, marer-gom
Cordia sinensis Lam.	ilgoita, ilgueita, fruit = ndorogoi	gaer, kohh, gaer ti dahan	
Ehretia cymosa Thonn.	lechachuri, lukukutian		
Heliotropium albohispidum Bak.	lekulupani		
Heliotropium gorinii	mesigilai		
Heliotropium somalense Vatke	lmasigiroi		
Heliotropium steudneri Vatke	leminyanyi		
SOLANACEAE			
Solanum cf. aculeastrum Dunal			iddi
Solanum arundo Matei	sikawai, dolele, untumire		ano, iddi
Solanum coagulans Forssk.	ntulelei		
Solanum incanum L.	ltulelei		
Solanum renschii Vatke	ntulelei, loibalayok		
CONVOLVUCACEAE			
Ipomoea arachnosperma Welw.	naseyopowal		
Ipomoea cicatricosa Bak.	lokitengi		
Ipomoea erythrocephala Hallier f.	nayopowal		kalala
Ipomoea kituiensis Vatke	lokitengi		

	S	R	G-B
Merremia ampelophylla Hall. f.	semalelei		
SCROPHULARIACEAE			
Alectra parasitica A. Rich.	larmed		
Craterostigma plantagineum Hochst.	ukejuonkutuju		
Pseudosopubia hildebrandtii (Vatke) Engl.	likidamperoi		
BIGNONIACEAE			
Kigelia africana (Lam.) Benth.	imombi, imomi, lumomwai		
PEDALIACEAE			
Sesamothamnus busseanus Engl.			lellaafto
ACANTHACEAE			
Acanthus eminens C.B. Cl.	ildigilde		
Anisotes parvifolius Oliv.	saali, le ngiron		
Barleria acanthoides Vahl	sucha lyousay, sucha oibor, sutchia	sotya	chicha, kelteppe
Barleria eranthemoides C.B. Cl.	sotcha	sucha	
Barleria proxima Lindau	sucha	sucha	
Barleria spinisepala Bruce	sucha, sotah		
Barleria volkensii Lindau	segiet, loiepokot		
Blepharis linariifolia Pers.	lmarak	hanja, lemaruk	kutumbule
Blepharis maderaspatensis (L.) Roth	imusawa		
Crossandra mucronata Lindau	lmunbririt		hidima
Crossandra nilotica Oliv.	lokimeki		
Dicliptera laxata C.B. Cl.	segit		
Duosperma eremophilum (Milne-Redh.) Napper	lduru kunyanto	dyewah	sarim
Dyschoriste radicans Nees	lekulupani		
Hypoestes forskalei (Vahl) R. Br.	lekulupani onyorii		
Justicia diclipteroides Lindau	sigit, sigiet		
Justicia matammensis Oliv.	muile		
Justicia odora (Forssk.) Vahl	argii, oibor		
Monechma debile (Forssk.) Nees	lekulupani, onyeri		
Ruttya fruticosa Lindau	mbipia		

	S	R	G-B
VERBENACEAE			
Chascanum marrubiifolium Fenzl ex Walp.	lekolopanyi		
Clerodendrum myricoides (Hochst.) Vatke	makutikuti		
Lantana rhodesiensis Moldenke	seketeti lengoruo		
Lantana viburnoides (Forssk.) Vahl	seketeti		kate
Lippia carviodora Meikle	nyamnyani		
Lippia somalensis Vatke	sunoni		
Lippia ukambensis Vatke	sunoni		
Premna oligotricha Bak.			dadessa
LABIATAE			
Erythrochlamys spectabilis Guerke	lokilidia		
Leonotis nepetifolia R. Br.	ilkisheni		
Leucas urticifolia R. Br.	limural		
Ocimum suave Willd.	lemurani		hanjabbi
Orthosiphon suffrutescens (Thonn.) J.K. Morton	idololit		
Plectranthus igniarius Schweinf.	ibolan		barbarisa
Satureia biflora (D. Don) Benth.	imadalakua		
Satureia pseudosimensis Brenan	legneiyia		
Tinnea aethiopica Hook. f.	longildia		

	S	R	G
LILIACEAE			
Aloe secundiflora Engl.	sakutari		
Asparagus africanus Lam.	lumei		
Chlorophytum sp.	ihehe		
Gloriosa superba L.	siss, sakutari		
ARACEAE			
Stylochiton angustifolius Peter	nkaijangishoi		
AMARYLLIDACEAE			
Ammocharis tinneana (Kotschy & Peyr.) Milne-Redhead & Sch.	laur, lauri		
Crinum kirkii Bak.	naitengecoi		
DIOSCOREACEAE			
Dioscorea quartiniana A. Rich.	ikateiyai		
AGAVACEAE			
Dracaena ellenbeckiana Engl.	nkokidongi		bute
Sansievieria robusta N.E. Br.		eima	jake
PALMAE			
Hyphaene coriacea Gaertn.		bar	meti
CYPERACEAE			
Cyperus blysmoides Hochst.	ikurto		
Cyperus rotundus L.	seiyai		
Kyllinga alba Nees	ikurt-neput		
Kyllinga flava C.B. Cl.	seiyai		
GRAMINAE			
Brachiaria leersioides (Hochst.) Stapf.	lanana		
Cynadon nlemfuensis Vanderyst	lamruai		
Dactyloctenium aegyptium (L.) Willd.	lokusukusu		
Leptochloa obtusifolia Hochst.	iperesi		
Pennisetum mezianum Leeke	imoto		
Setaria haareri Stapf & Hubbard	ikawa		
Setaria verticillata (L.) P. Beauv.	nelipa		
Sporobolus fimbriatus Nees	ndalangwanyi		
Sporobolus nervosus Hochst.	loipuyupu		
Tragus berteronianus Schult.	nderian		

APPENDIX 3.

SPRINGS AND WATER HOLES ON MOUNT KULAL.

This list, dated 1955, was copied from files in the Forest Department Office, Marsabit. It is included here in order to make it available in a published form, and because it is clearly relevant both for investigations and for development. (It is recommended that all perennial or nearly permanent water supplies in all parts of the IPAL area, including the nearby mountains, should also be listed, and that they should be considered for piping, well-capping or other measures for conserving soils and water).

1. NJOROI (TIGILITE) : in summit forest, comprising hand-dug holes, only reliable during and shortly after rains.

2. NJOROI (GILITE LUAGA) : in summit forest, spring with small flow, excellent water.

3. TOORA : seasonal water in rock holes in otherwise dry lugga in summit forest.

4. NGOI-NGOI : In basin at top of big lugga dividing N & S Kulal, on the east side, permanent spring and running water.

5. OL-KAJARTA : in the same big lugga, at foot of mountain; said to be permanent.

6. MUGULIE : seasonal water at foot of mountain, below Arabel on eastern side.

8. LOMIRIMIRIANA : seasonal water a short distance from foot of mountain at its northwest corner.

9. PANO : seasonal water a short distance from foot of mountain at its NW corner.

10. LABARNYUKY : as 8 and 9

11. DEBAN : permanent water in lugga at SW end of mountain.

12. LARACH : permanent water in big lugga halfway between Kulal and Loiengalani.

IPAL Technical Report Number D - 2b

A REPORT ON PROSPECTS, PROBLEMS AND PROPOSALS FOR TREE PLANTING

by
T. J. Synott(Consultant, Forest Ecology and Tree Planting)

May 1979

UNEP - MAB Integrated Project in Arid Lands

CONTENTS

Appendices

1. INTRODUCTION

The terms of reference for this assignment were for a study "concerned with the feasibility of arid zone forestry in the project area. The aim will be to advise on practical and reasonably rapid methods of providing tree cover in arid areas, particularly round water points and villages, where vegetation destruction has been severe. The feasibility of providing forest products from arid zone plantation forestry will also be examined".

This assignment, in the form of a consultancy for UNESCO, occupied six months from mod-November 1978 to mid-May 1979, mostly within the IPAL project area, (see Figures 1 and 2 of D - 2a) with headquarters on Mount Kulal. The period was divided between this study and a study on montane forest vegetation, reported separately. Field work included extensive travelling to assess site conditions and the achievements and needs for tree planting, as well as work in existing small nurseries.

The main emphasis in this report is on the dangers of destroying trees and shrubs, the many benefits of tree planting, and the importance of including many types of planting trials and programs in this and any other project designed for desert control, range improvement and human welfare in arid areas. Great emphasis has also been placed, in this report and in the field, on providing information about suitable species, and the most elementary nursery and planting techniques, which may help people interested in small-scale private and village tree planting. Techniques for large-scale nurseries or extensive land-reclamation and erosion-control programs are not dealt with here, partly because they are not yet appropriate for IPAL and partly because the general techniques are well described in books and reports whereas suitable local adaptations have yet to be developed.

No attempt is made to describe the background to the project or the project area, or the general vegetation, soils or climate, since these subjects will be fully described elsewhere.

This study could not have been carried out in isolation, and I am particularly grateful for help and valuable information from IPAL staff, particularly Dr. C.R. Field, Dr. D. Herlocker, Mr. Hussein Yussuf, and from missionaries at Gatab, Loiengalani, North Horr, Ngurunit and Kalacha. Their assistance, and important contributions to tree planting in the area, are gratefully acknowledged.

2. DESERTIFICATION THROUGH VEGETATION DESTRUCTION

Desertification is considered by UNEP to be a process of ecological degradation in arid, semi-arid and subhumid lands by which the productivity of the land is lost or substantially diminished. We are thus concerned with the processes of declining productivity from a wide variety of causes (including climate, fire and intervention by man and his animals). The rate of decline may be fast or slow, and may occur in situations with widely differing initial productivity, but always leading to a situation with a very low or substantially reduced productivity. We are also concerned with existing deserts and subdeserts formed by earlier desertification processes.

Although desertification can be caused by many factors, several of which are induced by man, this paper is concerned with the processes of deterioration initiated or sustained by the use or destruction of trees and shrubs by man and his animals.

The potential productivity of the sites and soils and the actual production of the vegetation are interdependent. The vegetation is clearly dependent on the site quality, but in addition the soil leaching, nutrient cycling (including retrieval of nutrients from deeper layers) and rates of erosion by wind and water are influenced by the density and annual growth rates of the vegetation. One of the many ways in which desertification processes can start is the removal of herbaceous or woody vegetation in such quantities, or such frequencies, as to induce a permanent loss in the productive capacity of the site. It is worthwhile to list some of the processes involved:

- if the herbaceous cover is severely reduced by heavy grazing or burning, the soil surface may become compacted and also exposed to accelerated water and wind erosion, even when shrubs remain, because the herb cover and litter are essential for protecting the soil surface and promoting infiltration of water. If the penetration of water into the soil is reduced, there is not only increased runoff and soil erosion but also less soil moisture available for plant growth thus reducing the actual and potential production from the site.

- if the tree and shrub cover is destroyed or severely reduced by cutting or burning, there is an equally serious danger of site deterioration, especially in more arid areas (although not necessarily in well watered areas which can sustain a permanent herbaceous cover). The physical protection provided by perennial plants, even when leafless, against wind, rainfall impact and intense heat, is of great importance for the soils and for plant growth; the tree and shrub root systems are also important for reducing damage caused by active erosion. A light, dry herbaceous layer, especially if heavily utilised, is inadequate for effective erosion control at the transition from dry to wet seasons when heavy storms may produce the greatest danger of erosion.

- woody plants provide important food for man and livestock, in the form of young shoots, fruits and flowers, rich in energy and often also in protein; in arid areas, their removal may result in a net loss of available food since they will not necessarily be replaced by similar quantities of herbaceous fodder plants. (In less arid areas, this is not always the case, and "encroachment" by trees and shrubs may reduce the quantities of food available for stock; livestock yields may be increased if trees and shrubs can be removed without accelerating erosion.)

- woody plants often develop very deep root systems, frequently up to 20 m deep, occasionally 50 m or more, allowing them to tap water and nutrients unavailable to herbs. If rainfall is limiting, this allows sustained growth during dry periods, which may be lost if the trees and shrubs are removed especially if they are replaced by shallow rooted annuals. In addition, it is assumed that a "nutrient pump" operates, bringing nutrients up from deeper layers of soil or bedrock, and eventually releasing them in or on the upper layers of soil, available for continued recycling within the plant system. This nutrient retrieval system has not been well quantified in arid areas, but it may be as important here as it is in rainforests which are capable of sustaining very high rates of production on inherently infertile soils by means of an almost closed system of nutrient cycling.

- the very high levels of radiation and potentially high surface temperatures found in arid areas may be as damaging for soils, plants and animals as the low actual rainfall. The stresses caused by high incident radiation, plus high air temperatures, and the consequent need for mechanisms in plants and animals for temperature regulation and control of water loss, result in reduced productivity in arid areas (and indeed in all areas when available water, or the system's ability to keep itself cool, becomes limiting). Deep rooted trees and shrubs are well adapted for temperature regulation, partly through tapping subsoil water. They provide shade for the soil, which may have its fertility and structure damaged by high temperatures; also for plants which may easily be killed by high soil temperatures or excessive water loss, especially in the seedling stage and which often grow faster in the improved nutrient, water and temperature environment under an open tree canopy; and also for livestock which often seek shade around mid-day, thereby reducing heat stress and need for drinking water, and which may decline in health and productivity if shade trees are destroyed.

- trees and shrubs provide many important human requirements, notably fuel and building materials. If these woody materials are not available, the area becomes less suitable, or more stressful, for human habitation; often, dung is used as fuel, or for plastering walls and roofs instead of returning to the soil; fodder plants may be burned, or used for buildings, instead of sustaining livestock, and the productivity of the system is reduced.

Thus, there are many situations in which the destruction of trees and shrubs leads to desertification, and also where a change or intensification in land use will inevitably lead to desertification in a treeless area while it could produce a sustained yield in the same area if adequate trees and shrubs were present. (It is worth remembering that on a historical timescale desertification may arise from a net decline in average rainfall without a change in the intensity of human interference, or even in the absence of humans.)

3. PRESENT TRENDS IN VEGETATION DESTRUCTION IN THE IPAL AREA

It is necessary to assess the extent to which tree and shrub cover is being reduced in the project area, and to what extent this is resulting in desertification.

The IPAL area includes many soil types, derived from quartzitic or volcanic bedrock or sand drift, with widely different depths, salt and nutrient contents, rainfall and local drainage. These differences are partly responsible for the observed range of tree and shrub densities, ranging from completely barren ground, through thickets and woodland to well developed stands of trees along rivers, and limited areas of true forest on the mountain tops.

The annual and spatial variability in rainfall probably affects the woody vegetation much less than the herbs. The trees and shrubs are adapted to cope with occasional very wet or very dry years without dramatic changes in numbers. Nevertheless, it is certain that occasional long droughts such as 1968-76 resulted in increased mortality of trees and shrubs with probably big differences between different species and soil types. Large trees may be completely eliminated from certain areas by bad droughts, but they may survive even the worst known droughts in certain favoured localities, while greatly extending their range during wetter periods. It also appears that local abundance of some species, particularly of Acacia, may be related to certain rare but local occurrences such as a coincidence of seed production, floods and appropriate weather.

Therefore, the woody vegetation which we now see in the IPAL area is partly a result of entirely natural influences; these include grazing and browsing by all forms of wildlife and by livestock managed for many centuries by various forms of nomadic and transhumant pastoralism which still continue today, more or less modified.

It appears that all these influences have resulted in a form of dynamic equilibrium; there is as yet no evidence that human influences and livestock grazing have resulted in a major widespread decline in productivity of the system. Over periods measured in decades, changes in regional productivity are probably closely correlated with climatic fluctuations, and there may have been little or no change in regional productive capacity, caused by human use, for many decades.

On the other hand, there are clearly many areas where large visible differences in standing tree and shrub biomass (possibly with only very small but unknown differences in annual production) have resulted from differences in human use and grazing intensity. The main example of this is seen in the 'zone of insecurity', a large block of land E and SE of Kulal, which is scarcely used for grazing and carries well developed, locally dense bushland. More heavily used land carries a lower tree and shrub biomass but it does not necessarily produce a correspondingly lower annual yield of plant or animal production.

However, continued destruction of the vegetation has led locally to a declining annual production and later to a permanent or semi-permanent decline in productive capacity or site potential : desertification.

Various stages of this process are clearly visible in and around most of the permanent settlements in the IPAL area. The villages are surrounded by areas more or less denuded of trees, shrubs and many other perennial plants, and the production depends largely on the erratic flush of annual or unpalatable plants; their actual production has certainly declined, and in many cases soil erosion has advanced so far that restoration of their original production will be impossible, slow or very costly.

Thus serious desertification is certainly occurring, but is largely restricted to the neighbourhood of permanent settlements. Most of these settlements did not exist, or were used only irregularly or seasonally, until this century. They have been growing steadily in size and permanence during the last few decades, largely because of new influences, introduced from outside, including shops, improved water supplies, schools, missions, security forces, famine relief stations. Meanwhile, the human and livestock population of the whole area has been growing steadily in recent years as a result of increased security, medical and veterinary facilities and quarantine regulations. Neither the vegetation nor the traditional land use systems have evolved to cope with the effects of steadily increasing populations and settlements.

These trends, of increasing population and increasing settlement, have occurred throughout the Sahel and are frequently associated with increased desertification. They are still in their early stages in the IPAL area, partly because important changes in land-use intensity or in life-styles have arisen or been introduced only relatively recently. For various reasons, including the fact that similar vegetation may respond differently in different soils or rainfall regimes, desertification has gone further and faster in neighbouring regions such as parts of Karamoja, Turkana and Somalia, and similar processes operated in other parts of arid and semi-arid Africa centuries ago.

There can be no doubt that if present trends continue, vegetation density, annual production, and site potential will continue to decline locally and then regionally throughout the project area. It will eventually become quite impossible to maintain increased numbers of people and livestock without major investments in land rehabilitation and major changes in land-use systems. On the other hand, since the existing system is largely undamaged and productive, modest interventions now can prevent further serious deterioration, maintain existing systems and allow an ordered transition to more productive, sustainable land use systems.

4. UTILIZATION OF LOCAL TREES AND SHRUBS

No measurements have been made of the quantities of wood used per head per year in the project area or elsewhere in northern Kenya, although Grum (1975) stated that firewood is plentiful almost everywhere and the consumption insignificant. In many agricultural areas of tropical Africa, surveys have found that firewood consumption has amounted to the equivalent of 1(-2) m^3 of solid wood (often burned as small branches, twigs and semi-woody material). Planning exercises have often assumed an overall average of 1 m^3 when no data have been available. In some regions, very little wood is available for fuel, as in the fringes of the Sahara and in densely populated parts of Rwanda, Burundi and elsewhere. In a World Bank project in Somalia, the trade in firewood is assumed to be only 0.1 m^3 per head per year. However, even in these areas, where cowdung, leaves and agricultural crop residues are burned, the dry weight and calorific value of the fuel used may be as large as in areas with more adequate fire-wood. The annual consumption of wood for building poles and other forms of construction is commonly of the order of 10% of the quantities used for fuel, but there are very great regional differences.

Some nomadic or seminomadic people use significant quantities of fuel for cooking grain-foods, and sometimes even larger quantities for drying surplus milk during seasons of abundance for use later. In dry regions with cold winters (e.g. from the Mediterranean eastwards to S. Russia and Afghanistan) very large quantities of fuel may be burned for heating. Total consumption of fuel by nomads in W. Afghanistan amounts to the equivalent of 4 m^3 of solid wood per head per year. However, in the IPAL area and neighbouring districts where the main food is uncooked milk, sometimes with fresh blood, and much less frequent meals of meat and imported grain, and where fuel is not needed for warmth, the consumption of fuel is certainly much lower. It may be of the order of 0.1 m^3/head/annum of solid-wood-equivalent.

In general, there was almost no evidence of shortages of fuel in the project area. Live trees and shrubs are widespread, and even in and around manyattas and many villages there are often dead branches and twigs lying around within easy collecting-distance. However, certain villages such as Kargi are becoming seriously denuded.

The consumption of house poles in the region is also low relative to many agricultural areas in Africa, partly because the houses are very small and it is not uncommon for herdsmen to sleep out without houses, and partly because the sticks and poles are conserved with care. The care given to prolonging the use of house poles applies also to other locally made materials such as milk pots, and is necessary when replacement poles with the right size, strength and suppleness are not always available nearby when needed.

The total consumption of house poles is not known, but it is substantially less than the quantities of fuel used. One house in an Ariaal-Rendille village between Korr and Ngurunit consisted of 54 poles 1-4½ m long, mostly of Cordia sinensis totalling approximately 0.5 m^3 solid volume. 27 curved poles stuck in the ground formed the main frame, with 18 straight poles of 1-2 m forming a sloping apron in front and 9 curved poles over the roof. Brushwood and small bushes, together with Sansievieria mats, skins and sacks, covered the frame, held together with many metres of ropes made of leather and Sansievieria. To protect the poles against termites, the poles are rubbed with fat and ashes when first cut and dried, and they receive continued protection from the smoke of cooking fires. I was told that these portable hut poles last up to 10 years.

In the villages, increasing numbers of more permanent houses are being build, using strong straight building poles up to 20 cm thick (usually Hyphaene palm-stems or Acacia tortilis), numerous straight roofing poles (of Acacia, palm-leaf stalks or imported Olea or other poles from Marsabit or elsewhere) and roofing of palm-leaf thatch or corrugated iron. This style of house-building, introduced comparatively recently, uses much larger quantities of wood, but so far amounts to only a very small proportion of total wood consumption in the region.

However, it is in the villages, with the permanent concentrations of people, that changes in house-building methods and in diet (with increased quantities of cooked food) are taking place most rapidly; wood removals are steadily exceeding rates of regrowth over widening areas around each village.

Generally, the largest use of wood is probably the construction of bomas (see note below). In some parts of the IPAL area, in the absence of predators, bomas are used only for young animals, but there is evidence that bomas have a social significance and are built even when unnecessary (and possibly ineffective) for protection against lions.

A high degree of nomadism probably maximises the total consumption of wood over the area as a whole, and the consumption may be reduced as each boma is used for longer periods, with increasing sedentarisation. However, this sedentarisation around villages, combined with the steadily increasing size of many villages, has resulted in an enormous local increase of consumption, together with the associated increase of sustained grazing and browsing, and this is the main cause of deterioration around the villages.

The largest sizes of trees are also used in small quantities. Thorny trees such as *Acacia* and some *Commiphora* are lopped to provide boma materials, and soft-timber trees such as *Delonix*, *Commiphora* and sometimes *Erythrina* are used for milk pots, bowls, stools and drinking troughs.

In addition, many trees and shrubs have foliage or fruits which are used as human food (sometimes only by children, or as a famine-food) and many are also browsed by livestock. Very many also provide medicines, even when they have no other material uses. Probably the quantities of foliage, shoots and fruits of woody plants consumed by livestock are larger than the quantities of woody plant products used for all other purposes combined.

Some of the identified material uses of some species (apart from browse) are listed below:

Acacia tortilis : house poles, bomas
Acacia spp. : bomas
Asparagus spp. : fibres for making and mending water containers
Cordia sinensis : hut frames, spears, rungus
Combretum aculeatum : donkey baskets
Delonix : water containers, stools, camel bells, troughs
Erythrina : pots, stools
Commiphora spp. : water containers, stools, camel bells, bomas
Grewia bicolor et al. : hut frames, walking sticks, spears
Hyphaene : posts, thatch, mats, woven bags
Lawsonia inermis : packing frames for camels, and house entrance screens
Salvadora : a preferred fuel
Sansievieria : mats, ropes

A note on wood consumption for bomas

Very little information is available about the quantities of wood cut for bomas. Lewis suggested that each family cuts 6 trees for boma construction each time it moves. Following certain assumptions, this might amount to 1 m^3, equivalent to c. 0.2 m^3/head/move.

Hussein Yussuf has collected data for trees and branches cut for a Gabbra manyatta in early 1979 (see below). Following the same arbitrary assumptions, this was calculated to be equivalent to 0.4 m^3/head/move. Yussuf also weighed the wood left in bomas after 2 moves of another manyatta; the data suggest c. 0.33 m^3/head/move.

If we assume an average of 6-8 moves per family per year, these figures suggest a total use of c. 1.5-3.0 m^3/head/an. The apparent similarity between the three separate estimates of consumption arises partly because of the assumed conversion factors, which require checking and testing. Further, the forah herdsmen and the settled villagers have patterns of consumption quite different from those in the main nomadic and transhumant manyattas. However, an overall figure of 1.5-3 m^3/head/annum for bomas may be of the right order of magnitude, and roughly 20 times the rate of consumption of fuelwood.

The desertification impact of this rate of cutting depends on the ability of the cut stumps or lopped branches to resprout, and on their rate of growth. These in turn depend on the soils and climate and perhaps most of all on the intensity of browsing of the regrowth (which is presumably the dominant feature near permanent settlements). There is some doubt about whether many of the clear-felled fully grown *Acacia* trees are able to regrow. It should also be noted that the collection of fuel is much less environmentally destructive than the cutting of similar quantities of boma materials; dead, fallen wood and small branches are often used for fuel, while large, whole trees, often many years old, are destroyed for bomas - just as they are destroyed for fuel in areas of heavy fuel use and dense settlement.

The destructive impact of all forms of wood cutting would be greatly reduced if people cut only a few of the main branches of each tree used; some main branches should always be left on lopped *Acacia tortilis*, and some main stems on partially felled *A. mellifera*. In this way, continued shelter, soil protection and regrowth are more likely.

Summary of Hussein Yussuf's wood consumption data:

1. 11 houses (of which 6 belonged to near-relations)
   49 people including children
   c. 2500 sheep and goats in 3 separate herds
   96 cattle
   152 camels
   Many other livestock currently in forah herds
   Bomas built for one move:
   3 large bomas for sheep and goats
   1 small boma for kids and lambs
   2 " " " camel calves
   1 " " " cattle calves
   Adult camels and cattle not kept in bomas
   Wood consumption:
   Acacia reficiens totally cut down : 36
   A. mellifera " " " 24
   A. tortilis branches lopped 214 out of 56 trees
   Assume 6 Acacia trees per solid m^3, (c. 300-400 kg dry weight).
   ∴ 116÷6 = c. 20 m^3 = c. 0.4 m^3/head/move.

2. Two vacated manyattas, occupied for 1 and 2 weeks, each of 17 huts, average 4-5 people per hut, c. 70-80 people. Total wood remaining weighed 15,700 kg, equivalent to c. 40 m^3 solid wood @ S.G. 0.4 or say 50 m^3 to allow for losses and light branches = c. 0.33 m^3/head/move.

5. REQUIREMENTS AND POTENTIAL FOR TREE PLANTING

5.1 General

Tree planting activities in Kenya started in the earliest years of this century, and were very quickly extended to all administrative centres and areas of agricultural development. (The Annual Report for 1927-8 of the DC Marsabit, Mr. H.B. Sharpe, listed 78 species of trees and shrubs planted on the mountain, including 6 Australian species of Acacia and 9 of Eucalyptus.) These plantings throughout the country, by farmers, gardeners, councils and the Forest Dept., were to supply poles (for buildings, fences, telephones and later electricity), fuel for cooking and for industry (especially for the railways), for national timber requirements, and for ornament. In due course, fast-growing trees suitable for fuel, poles and shelter in the more fertile agricultural areas became well known and widely distributed, including Eucalyptus and Cupressus spp. Farmers had little difficulty in obtaining supplies of plants, and in raising trees for domestic fuel, poles and posts, and sometimes for large shelter belts, supported by a modest extension service from the Forest Dept. There is now a very large total area of private tree planting in Kenya, mostly in very small farm wood-lots. Similarly, interested gardeners introduced, tested and distributed an enormous variety of trees and shrubs for ornament, fruits and shade, without intensive support from Government.

The Forest Dept. had two main areas of responsibility and activity: the protection of existing areas of indigenous closed forest, after gazetting as Forest Reserves (for the combined aims of providing forest products and protecting soil and water resources), plus the provision of the anticipated national requirements of sawtimber and other industrial wood products. In addition, large plantations were maintained around the larger towns, for fuel and pole supplies. In most rural parts of Kenya, for many years, supplies of fuel and poles for domestic purposes could easily be obtained either by farm-planting or from the surrounding forest and bush; this applied even in arid and semi-arid areas. The Forest Dept. had little cause to be deeply involved in rural forestry; the problems which gradually developed around the rapidly growing towns and trading centres of the agricultural areas could quickly be solved with the fast growing trees which thrive in the high rainfall areas. The arid areas, which were deteriorating many years ago, were interpreted as a rangeland not a forestry problem.

In recent years, the general increases in population, the improved standards of housing (requiring more poles), the continued growth of towns and villages in all areas, and the widespread domestic use and large exports of charcoal have resulted in wood shortages in very many parts of the country, particularly the semi-arid areas but also locally, especially around settlements, in the arid and the wetter areas. This has resulted in a need for tree planting in rather new and unfamiliar situations. Problems have included

1) the lack of a Forest Dept. infrastructure in many of the areas where advice and supplies of seedlings are needed;

2) the lack of information and experience about successful species for the arid and semi-arid areas;

3) uncertain control over land ownership or land use, especially in communally grazed land.

It is also possible that the relatively small emphasis placed on rural forestry by the Forest Dept. in the past may stem from the professional training of foresters which, for historical reasons, has been concerned mainly with the tending and management and often the planting of forests and the marketing of timber. In the countries where professional forestry training developed, domestic requirements were well provided by the efforts of private farmers or traders, and Governments were mostly concerned with national timber requirements (often for strategic reasons).

The Kenya Forest Dept. and several other agencies are now increasingly interested in problems of rural forestry, to help prevent the uncontrolled destruction of vegetation and to enable rural people and villagers to satisfy their requirements. Rural forestry is now receiving increasing emphasis throughout the tropics and subtropics, and is often associated with the growing efforts to combat environmental deterioration and desertification. There should therefore be no difficulty in obtaining funds for investigation and implementation of rural tree-planting programs.

Sections 1-3 have described the uses and requirements for trees, shrubs and their products for humans and livestock, and also the manner in which trees and shrubs protect the soil from damage by water, wind and sun. There are many places in Marsabit District where the remaining supplies of trees and shrubs are now seriously deficient, principally around permanent settlements such as Korr and Kargi. The problems are manifest in the lack of shade, shelter and soil cover, and in the increasing distances which people must travel to obtain essential supplies of fuel and boma material and to take their stock for grazing. Some villages which have numerous large trees such as Kalacha, or abundant water such as Loiengalani, are still deficient in some items such as building poles or browse.

The first requirement for tree planting is therefore to satisfy existing needs for protection and essential supplies, and to prevent the continued destruction of the existing vegetation cover, especially where deterioration is already far advanced. It is already apparent that the indigenous vegetation in the immediate vicinity of villages is not capable of providing all the wood requirements of a growing settled population, particularly when heavily browsed by livestock. Tree planting to achieve a measure of local self-sufficiency and protection is a realistic alternative to the continuation of environmental deterioration and long-distance wood-collection.

In addition there is scope for improvements in protection, material benefits and supplies, and for increasing the plant and animal production from the land, by means of appropriate tree and shrub planting, and also for diversifying land use systems and providing additional sources of income and employment. Thus there are several different, but overlapping and complementary, objectives of planting, appropriate for different situations. A selection of the main site-types in the IPAL and neighbouring areas is given in Appendix 5.

5.2 Planting for provision of human requirements and benefits

In Appendix 6, there is a list of all the trees and shrubs which I have seen planted in the IPAL project area (excluding Marsabit town) with comments on their performance. These amount to over 50 types which are potentially or already successful for appropriate sites in subdesert areas. Virtually all of these have been planted within the past 10-12 years, and most since 1976. Experience in other countries, including practical achievements in very large planting programs, suggest many other species which may be expected to grow well in certain situations and for certain purposes. A long list of recommended species is given in Appendix 1, with notes on their soil and treatment requirements, and their uses and characteristics.

The achievements so far, with particularly successful tree-planting in Missions such as North Horr, Kalacha, Loiengalani and Ngurunit, have demonstrated that any household or institution with access to water and with control over its own compound can quite easily grow a wide range of trees and shrubs to provide at least some of its own day-to-day needs for fuel and building poles; for fruits and some edible leaves; for some of its boma requirements; and for shade from the sun, shelter from the wind and protection from dust.

Institutions such as schools, missions, medical centres and police posts often have enough ground for many hundreds of trees, including boundary hedges and large shade trees. Even the smallest household in a crowded village can maintain and would benefit from one or two trees or shrubs near the house, exactly as has recently been implemented in North Horr.

To promote tree planting activities, small nurseries will be required in the larger villages (perhaps 6 within the IPAL area), so that seedlings and sometimes seeds and cuttings are readily available for all who require them, where they are most needed. These nurseries will require workers for up to 6 months of the year for seasonal nurseries, or even full time, as well as materials such as polythene tubes, watering cans and regular supplies of fresh seeds. However, the main requirement is for dedicated extension workers, who should regularly visit tree planters and planted areas providing advice and encouragement.

The initial reaction of many farmers and householders is often that they have no space for tree planting. However, even in the most intensively cultivated areas, and certainly in towns and villages, there are always numerous places where individual trees or groups, lines, avenues or small woodlots and windbreaks can be fitted in. These trees can often provide their benefits without diminishing the production from other resources such as grazing land or fields, and in fact they can increase the total production from the system by making use of unexploited soil and water resources, by physically protecting other plants and by reducing the pressure on the indigenous vegetation.

In villages, the following situations are particularly recommended for planting:-

1. Near wells and boreholes, some shade would be welcome and water is often spilled and could be used by trees.

2. Near the wash-houses of schools, police stations, hospitals, etc., abundant water often runs to waste, while it could support vigorous tree growth.

3. Near any houses, shade and protection from wind is particularly welcome, and often a metal roof can be used to concentrate rainfall around the plants.

4. In a belt around the windward side of villages, schools, stations, etc. shelterbelts will reduce wind and dust.

5. Around all compounds, a live hedge, especially of species not eaten by livestock, will help to control livestock movements while increasing the shelter and security of the compounds.

6. Along roadsides, lines or avenues of shade trees and ornamentals add to human comfort while utilising run-off from the roads.

7. In schools, nurseries and woodlots will contribute to the school's own needs for fuel and poles and will improve the environment, while providing valuable practical training for the children.

8. In all these situations, appropriate trees will at the same time contribute to supplies of fuel and foods from leaves, fruits and seeds.

5.3 Planting to prevent or remedy soil deterioration

Strong winds affect all parts of Marsabit District from time to time, and the area between Mt. Kulal and Lake Turkana is notorious. In addition, rainfall is often in the form of violent storms. The erodibility of soils in the project area has not yet been studied, but evidence of surface erosion and gulley formation is widely visible, with numerous areas of bare rock, stone pavements and dust devils, mobile sand and wind erosion. These indicate that wind and water erosion are old processes still able to remove topsoil and destroy productive land surfaces, especially when soils are exposed by excessive cutting or browsing or by natural drought-mortality of the vegetation.

Human welfare in all the permanent villages would benefit from windbreaks and shelterbelts, and indeed from any kind of shade trees, which can reduce windspeeds and wind erosion as well as providing fuel, timber, fruits and fodder. Similarly, the long term productivity of the land would be improved by soil protection and reclamation plantings designed to stabilise mobile sand, check sheet and gulley erosion and to strengthen river banks. In most cases, an effective planting program is not yet feasible in the uncontrolled, communal grazing lands typical of Marsabit District and other arid lands. There is little point in replanting eroded hillsides (as in Kargi) or mobile sand (as near North Horr) until the grazing pressure can be controlled.

It is anticipated that grazing intensities will gradually come until control, with the possibility of excluding grazing for longer or shorter periods, perhaps first in the villages and later within designated parts of controlled 'grazing blocks'. When that time comes, it will be feasible and desirable to carry out planting for erosion control and soil stabilisation. It is important that suitable techniques, and locally tested species of shrubs and ground-cover plants should be available when required.

Techniques for soil conservation and stabilisation, erosion control etc. are described in many books and reports (e.g. FAO (1976)) and need not be described here; there are many different situations requiring attention (rocky hillsides, steep active gullies, mobile sand dunes), each with various appropriate techniques. However, there is a considerable need to test a wide range of plant species so that the techniques, species and experience will be available locally when required for larger scale work. On a pilot scale, certain conspicuous sites which have degraded seriously may be planted with browse-resistant species for trial and demonstration purposes (App. 2).

5.4 Rangeland improvement

Planting shrubs to increase the carrying capacity of rangeland.

In many arid lands, including Algeria, Tunisia, and Israel, very large planting programs, often of several thousand hectares p.a., have been carried out with fodder shrubs (as well as herbs and trees) to increase the food supplies for livestock. The shrubs which have been commonly planted include Prosopis, Atriplex, Acacia, Opuntia, and Haloxylon spp. Many of these form rangeland which yields enormously more fodder, and hence animal products, than the best indigenous pastures. For example, Atriplex spp. in Tunisia produce 1-3,000 kg of edible dry matter/ha/an with 150 mm rain/an (FAO 1976); Prosopis tamarugo in Chile can support 1 sheep/ha at 5 years old, and 10-20/ha at 25 years old, in an area with almost no rain and a shallow brackish water-table (N.A.S. 1975).

At present, in a region of unrestricted grazing, it is not feasible for any private livestock owner or for Government to plant significant areas of rangeland shrubs. However, with the introduction of grazing blocks, each with internal regulation of livestock movements, it may be possible to establish shrubs by planting or seeding if parts of the rangeland can be closed to grazing for 1-2 years.

There has been almost no experience of rangeland improvement by tree- and shrub-planting in arid areas of tropical Africa south of the Sahara; the North African project areas are equally arid but they have different temperature and rainfall regimes. It is not possible to be sure that equally successful species and techniques for rangeland can be found, but the success achieved locally with a few species in favourable situations suggests that field trials will be well worthwhile, and the rewards of success may be very great.

Under favourable circumstances, some of the recommended range-improvement plants, such as Acacia and Prosopis, may be distributed as undigested seeds by livestock; others may be established as rooted or unrooted cuttings, including Tamarix; others may spread themselves vegetatively under certain circumstances, including Opuntia. These possibilities may enormously reduce the cost of rangeland improvement. However where there is a possibility of the indigenous vegetation being invaded and replaced by exotic species, the potential risks and benefits must be carefully considered. Probably, the risks are much less in arid than in semi-arid or wetter rangelands. Furthermore, species such as mesquite (Prosopis sp.) may be considered a pest in high quality grazing land, because it competes with grasses and its sugar-rich pods interfere with the digestion of the more protein-rich grasses; whereas the same species may be a valuable fodder plant in arid and inferior rangeland where it may greatly increase the total food supply, particularly during dry periods.

The IPAL team can therefore do very valuable work by first testing a wide variety of fodder plants in numerous small trial plots on different sites, and then establishing field-scale rangeland plantings of 5-50 ha for trial and demonstration or, if staff resources permit, for assessment and comparison of yields in terms of plant and animal production.

Several of the fodder plants, including Acacia and Prosopis, contain large quantities of protein in their seeds, which pass through livestock undigested. Suitable methods of milling the pods have been developed elsewhere, and might in due course be introduced here. The processing of high quality foodstuff from Prosopis pods would not only greatly increase the productivity of the system, but would also help to compensate for the current steady increase in sedentarisation of stock: a permanent supply of food for the permanently resident flocks will help to reduce environmental degradation.

5.5 Cash-crops: alternative land uses

It is expected that livestock in open rangeland will be the main land-use and source of livelihood in Marsabit and neighbouring districts for the indefinite future. Rainfed agriculture has no significant potential over the majority of the land. However, there are many other possible forms of land use which have sufficient potential to be worth testing. If these allow people to obtain higher standards of living, or to support themselves with less land or less environmental degradation, then they may be worth implementing on a large scale. They also hold out the possibility of moving from a subsistance economy towards contributing to national wealth.

The IPAL area already includes activities, other than pastoralism, which generate wealth locally without necessarily degrading the environment or damaging its long-term productive capacity - these include lake fishing, the Loiengalani hotel, the cultivation at South Horr and the palm weaving enterprise in North Horr. In neighbouring arid areas such as Turkana, there are significant areas of irrigated agriculture, based on permanent rivers; there is probably some potential for more crop cultivation in villages with abundant surface water, such as Loiengalani and S. Horr. Here, however, we need to consider the scope for planting perennial woody crops, particularly those which can supply saleable exportable products.

There has been some discussion about the prospects for timber plantations in the higher-rainfall areas such as Mt. Kulal and the Hurri Hills. The performance of several species of trees in Marsabit, at Gatab (since 1977) and to a small extent in the Hurri Hills suggests that plantation-grown trees could survive and produce useful timber at elevations above about 1500 m on Kulal and perhaps above 1000 m on the Hurri Hills, using currently available species of Pinus, Acacia, Casuarina, Grevillea etc. In addition, other introduced species such as Pinus caribaea and P. eldarica, dry-land Eucalyptus spp., Cupressus, Callitris and several indigenous species may be suitable for plantations (cf. App. 2).

However, the economics of plantations for timber (as for any other marketable product) make it essential to examine the annual production, the local costs, the local markets, the distance to the export market and the alternative sources of supply. Timber production appears unpromising in all these aspects, and principally because Kenya has very large areas of forest land and potentially highly productive plantation land much closer to the main internal timber markets and closer to sea ports for export. It is probable that volume production will be relatively low in any part of the Hurri Hills and Kulal, with the added danger from the occasional long droughts lasting some years; the damp misty conditions of the hill tops aid survival but are not necessarily conducive to high volume production. In addition, local costs will probably be higher and local demand for timber lower than in the well-roaded, richer parts of the Kenya highlands where many existing timber plantations have been established. However, it is clearly desirable that a wide range of indigenous and exotic timber species should be tested in suitable areas, with a view to satisfying some of the small local requirements for timber and to provide the information and experience needed if circumstances change in future.

There is now much interest worldwide in certain desert plants which can provide food materials and chemical products required on the world markets. It is probable that several of these plants can be grown successfully in the project area, although the economics of large-scale production will remain uncertain for some years to come. App. 2 includes the species which should be tested, but some require less arid sites.

Acacia senegal: gum arabic
Anacardium: Cashew nut: edible fruits and seeds
Argania: Argan tree: edible oil and lamp oil from seeds
Cassia: senna: medicinal chemicals
Citrus: oranges, lemons, etc.
Cordeauxia: yeheb nut: edible and marketable seeds
Cucurbita: buffalo gourd: oil seeds, and starchy roots
Olea: olive: valuable products, but not successful in tropics
Parthenium: guayule rubber: an excellent rubber plant.
Simmondsia: jojoba: a valuable wax from seeds
Euphorbia: waxes and hydrocarbons

Many other trees and shrubs produce edible fruits, seeds and leaves which are potentially marketable. It is recommended that these should be distributed as widely as possible to schools, missions and households, since they will provide shelter and fuel even if the fruit production is small. The other species, whose products need to be exported, should be tested in trial plots in all potentially suitable sites before productive plantations are considered.

Acacia senegal, yielding apparently good quality gum arabic, is not uncommon in the IPAL and neighbouring areas, although the trees seldom grow to a large size. It is possible that collection and marketing of gum from wild trees may be feasible, even if the establishing of new plantations is not. A specialist study is required, covering a larger area than the IPAL area, to assess the scope for collection, marketing, quality control and improvement of gum arabic.

Any investment program designed to improve or maintain production should include an appropriate tree-planting component. This applies both to rangeland development, where fencing materials, shade and shelter trees and fodder plants are needed, and also to agricultural programs, when hedges, shelter belts and the needs of the villagers must be provided. Considerable investigation is needed to find the species, shelter-belt designs and management methods suitable for growing trees in association with agriculture in arid areas. There is scope for developing techniques involving alternate rotations or intimate mixtures of trees and agricultural crops. Collaboration with ICRAF should be arranged for this work.

6. RECOMMENDATIONS FOR IPAL PHASE 3

1. Species trials and demonstration plots
2. Rural nurseries
3. Extension effort : P.R.
4. Range-improvement trials and studies
5. Survey of wood consumption
6. Development of methods for erosion control, live fences, boma substitutes, fodder production

6.1 Species trials and demonstration plots

It is recommended that a wide range of potentially suitable species should be tested

- in all villages, partly to demonstrate the potential benefits to villagers, including informal plantings around schools and missions

- in formal trial plots, with detailed records and regular inspections, where rates of growth can be measured and compared (in the newly established plots in Loiengalani, Balessa and Kargi, and elsewhere)

- in a wide variety of sites (App. 5)

- in collaboration with ICRAF for combinations of trees and agriculture

- including provenance trials of the most promising species, using seeds from several origins, to determine the best provenances for local conditions and also to indicate the potential for improving production by breeding-trials and selection.

6.2 Rural nurseries

Nurseries for raising several of the most promising tree and shrub species should be distributed throughout the area

- to avoid transport problems, and ensure that plants are available locally when required

- to teach and demonstrate the elementary techniques of raising and tending plants, especially to school children

- to serve as a focus for publicity and demonstration

Nurseries are currently required at Gatab, Kargi, Loiengalani, N. Horr, Kalacha and perhaps elsewhere. One should be an IPAL nursery in the lowlands, used for advancing skills and raising new and difficult species, including plants for IPAL rangeland improvement trials. Some may be temporary, operating for only 3-6 months p.a. before the main rains, or during school terms. An annual production of 2-10,000 plants p.a. is recommended for each nursery. Basic techniques are described in Appendix 4.

6.3 Extension effort

It is recommended that P.R. and other IPAL staff should make a particular effort to encourage planting of trees and shrubs

- to introduce the material benefits to the villages

- to extend local experience of sites, species and techniques as widely as possible

- to provide a visible demonstration of the practical impact of IPAL, which would be valuable publicity for locals and visitors

- as an immediate way (and perhaps the only currently feasible way) of combating desertification on a local scale, without waiting for the major land use decisions and grazing controls which may combat desertification on a regional scale.

The effort will require ensuring the availability of seedlings, providing advice and demonstrations, frequent visits to representative households, and perhaps some subsidies such as provision of seedlings and nursery or fencing materials at a reduced (or Nairobi-cost) price .

5.4 Range improvement trials and studies

It is recommended that rangeland planting and associated grazing trials and productivity studies should be included in the proposed field-scale trials in phase 3. Many species which appear successful in species-trial plots should be planted out, at a spacing of 1-5 m, in blocks which may be as small as 1 ha, but larger if costs are low and if animal production studies need larger plots. Plots of 5-50 ha in many different areas will be needed before large scale implementation can be embarked on.

Suitable species for trials are described in App. 2 and 3, including Acacia, Atriplex, Cassia, Calligonum, Haloxylum, Opuntia, Prosopis, and associated protective but less palatable species such as Casuarina and Tamarix.

6.5 Survey of wood consumption

At the moment we are ignorant of the quantities of wood used per head, or per village, or in total

- for bomas in villages, among the nomadic families and in forah herds

- for fuel among self-sufficient pastoralists, in villages where cereal-foods are eaten, or in villages where fish are dried and eaten

- for building poles in villages with semi-permanent houses.

As in other instances, this information is most needed for villages, where consumption per unit area (and probably per head) is greatest and where the consequences of undersupply are most serious.

It is recommended that surveys, including questioning, observation and weighing should be carried out to determine the quantities (in dry weight and dimensions) and species of wood used. At the least, the priority requirements are the need to know

- the fuel and pole requirements in villages, expressed finally in terms of kg dry weight per head per year, with some information about family sizes and sizes of poles needed

- the boma-material requirements in villages and among more mobile pastoralists in relation to numbers of livestock and numbers of people.

Much of this information can be collected only by accompanying people during their regular collection and use of woody material and weighing, describing and identifying everything used.

6.6 Miscellaneous investigations

1. Erosion control

In association with species trials and fenced grazing trials, planting techniques should be tried with the aim of testing and demonstrating methods of stopping active gully erosion, stabilising stream banks, mobile sand and steep slopes, and maintaining ground cover to inhibit wind-blow and surface wash.

It is recommended that any proposed trial areas of the order of 500 ha should include high-intensity areas where special efforts are made by mechanical and planting techniques to stabilise and protect soils, and maximise rain infiltration and plant production.

These will not only serve as valuable training and trial areas for new techniques, but will also be important "model" demonstration and publicity areas to show how the productivity of the system may be revolutionised, and the desert held at bay, with suitable techniques.

6.6.2 Live fences

The testing of species and techniques for hedges and live fences can be carried out with the other species trials. However, live fences have such an important potential role in environmental improvement in villages and in livestock control, and they provide such conspicuous publicity features, that they merit special attention.

It is recommended that a particular effort should be made to provide all IPAL working areas in the desert (Balessa, Kargi, Kalacha) and all co-operative institutions (Ngurunit, schools, missions) with hedges and avenues of browse resistant species.

In due course, these may provide an alternative to thorn-tree or fenced bomas. For example, a group of several small, adjacent, hedged paddocks used in rotation, may allow a village family to boma their flock without cutting bushes and without disease risk.

6.6.3 Boma techniques

Any alternative to wood cutting for bomas is relevant to wood-supply and environmental protection. Substitutes such as wire, bamboo hurdles, electric fencing and close-herding without enclosure should be investigated.

At the same time, suitable opportunities such as P.R. programs and training courses should be used to stress the importance of less destructive lopping and felling methods, leaving some branches and stems to regrow from each tree cut.

6.6.4 Fodder protection

Alternatives to open grazing are already of interest, and will become increasingly important as livestock populations grow, and human populations become more settled.

The development of techniques for grinding legume pods and seeds, and even for hay or silage production in the Hurri Hills, are of relevance to the whole grazing-browsing economy.

6.6.5 Gum arabic survey, on a regional basis.

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Appendix 1. A TREE-PLANTERS GUIDE TO SPECIES

Species suitable for planting in arid and semi-arid areas of N. Kenya; their site requirements and silvicultural characteristics.

This list includes indigenous and exotic species of trees and shrubs which are known from experience to be suitable and worth planting in certain situations, and also some species which have seldom or never been planted in dry areas of Kenya but which are worth testing.

Numerous species are known to be suitable for arid areas in Mediterranean or temperate regions; these are not included in this list when there is no evidence that they are successful in tropical regions, but any arid-land species should be tried if seeds become available.

N.B. These notes refer especially to arid and semi-arid areas, with average annual rainfall of up to c. 600 mm, and many species widely planted in Kenya are therefore not mentioned. References to "generous water" or "wetter areas" refer to areas with more than 500 mm rain, or accessible groundwater, or seasonally flooded water courses in dry areas.

Acacia albida Del. Apple-ring Acacia

Indigenous. Green in dry season, but leafless in wet season, so ideal for cultivated areas. Good effects on soil fertility, and valuable shade and pods for livestock. Suitable for sites within reach of fresh groundwater. Good fuel and browse.

Acacia aneura F.v.Muell. Mulga

Australian, occasionally planted in EA and widely planted N. of the Sahara (Tunisia) for windbreaks, fuel, fence posts, honey and fodder. Suitable for rainfall down to c. 150 mm.

Acacia cyanophylla Lindl. W. Australian golden wattle

Australian, planted in many arid countries for grazing, windbreaks, erosion control, binding sand, and for hedges. Salt tolerant. Coppices freely. Suitable down to 2-300 mm.

Acacia ligulata (and/or salicina) Small cooba

Australian. For soil protection, fodder and shade, suitable down to c. 150 mm.

Acacia mearnsii De Willd. Black wattle

Australian. Moderately drought resistant, suitable for higher, moister areas, for windbreaks, fuel, poles, honey and tan-bark.

Acacia nilotica (L.) Willd. ex Del. (= A. arabica (Lam.) Willd.) Sunt.

India, Arabia and N. Africa. Very drought resistant, but best grown near drainage lines where rain is supplemented by occassional floods. Excellent poles and fuel; good fodder from leaves and pods. Subsp. indica recommended.

Acacia senegal (L.) Willd. Gum arabic; hashab

Indigenous. Extremely drought-resistant, down to 100 mm, but best with 250+ mm. Easily established by planting or direct sowing. Good fuel, useful fodder, and valuable gum: yields of 30-300 (max. to 1000)g/trees/an.

Acacia seyal Del. Gum tahl.

Indigenous. Palatable bark and twigs are valuable drought fodder. Widely planted in Sahel. Var. fistula is tolerant of heavy, poorly drained soils.

Acacia tortilis (Forsk.) Hayne

Indigenous. Very drought resistant. Good poles and fuel, and fodder. Slow growth, but reliable.

Acacia victoriae

Australian. A promising forage species, planted in subdesert areas of N. and W. Africa down to 150 mm.

Adenium obesum (Forsk.) Roem & Schult. Desert Rose.

Indigenous. A poisonous but highly drought resistant ornamental shrub.

Albizia lebbeck (L.) Benth

Asian. Recommended for woodlots and shelter in less arid areas of dry tropics.

Anacardium occidentale L. Cashew nut

Suitable for semi-arid areas. Excellent for soil protection and sand stabilisation. With valuable fruits and nuts but not a profitable crop in drier areas.

Anogeissus leiocarpus Guill. & Perr.

Recommended for fuel woodlots or windbreaks in semi arid or favoured areas.

Argania sideroxylon Roem. & Schult. Argan tree; lulu

Very drought resistant. Seed-oil used for cooking and lighting; foliage and pods used by livestock. Good charcoal and timber.

Atriplex spp. Saltbushes

Extremely resistant to salt and drought. Deep-rooted. Many are highly palatable and nutritive. Should be raised from seeds or cuttings in nursery, planted at 1-5 m spacing, and may be opened from grazing when 1-1.5 m high at 2-3 yrs old. The following species are recommended for trials: A. canescens, coriacea, glauca, halimus, lentiformis, nummularia, semibaccata, vesicaria.

Azadirachta indica A. Juss. Neem

Tolerant of most soils; very successful in moister areas or within reach of groundwater. Foliage used as fodder. Good poles and useful fuel, useful for shelter. Seeds quickly lose viability.

Balanites aegyptiaca (L.) Del. Desert date

Indigenous, especially near seasonal rivers and heavy clay soils. Often conspicuous near villages when other trees removed. Good timber, camel fodder and edible fruits.

Borassus aethiopum Mart. Borassus palm

A palm suitable for semi-arid or moister sites, or near groundwater. Excellent wood, and edible fruits.

Butyrospermum parkii Kotschy. Shea butter nut

Requires moister sites but yields valuable edible nuts.

Calligonum spp.

Excellent for soil stabilization, sand dune fixation. Many species, with varying palatability and salt tolerance. The following are worth testing: C. arich, azel, comosum.

Callitris spp. "cypress pines"

Slowgrowing, but good termite-resistant poles and timber, suitable for semi-arid and moister areas. Species worth testing on Hurri Hills and Kulal mid-slopes include: C. calcarata, glauca, intratropica, robusta.

Carica papaya L. pawpaw

Successful in all areas if given adequate water.

Cassia acutifolia, C. angustifolia Senna

A potential cash crop for semi-arid areas yielding medicinal purgatives.

Cassia siamea Lam.

Suitable for semi-arid areas, yielding fuel and poles and acceptable fodder. Easily raised, coppices readily. Termite resistant. Ornamental flowers.

Cassia sturtii R. Br.

Australian. Very drought resistant. Highly palatable and nutritious fodder plant.

Casuarina spp.

Several species, with moderate resistance to drought and salt, yielding excellent fuel and poles, and acceptable fodder. One of the best windbreaks. Some fix nitrogen. In arid areas, most species will require accessible ground water.

C. cristata: fodder; salt tolerant

C. cunninghamiana: fodder, fuel, windbreaks; tolerates clay soils

C. equisetifolia: fuel and poles, shelterbelts; salt tolerant

C. glauca: shelterbelts, shade; tolerates salt and flooding

C. stricta: fodder _etc_.

Ceiba pentandra (L.) Gaertn. kapok, silk cotton tree

Very large tree, good shade, useful kapok in fruits; can grow well in arid areas if within reach of adequate groundwater. Can be grown from cuttings.

Ceratonia siliqua L. Carob

Thrives in poor alkaline soils; good food and fodder from pods. Highly drought resistant, but not widely tested in tropics.

Citrus spp.

Successfully grown in semi-arid, sometimes in arid, zones if well watered. Some varieties have some salt-tolerance.

Cocos nucifera L. Coconut

May grow well but slowly in dry areas if watered or within reach of groundwater. Fruiting uncertain in dry climates. Salt tolerant.

Conocarpus lancifolius Engler Damas

Extremely promising for timber, poles, fuel, shelterbelts and foliage-fodder. Salt tolerant. Tolerates a wide variety of soils. Requires generous water from rain or groundwater, yielding high volume production. Seeds lose viability quickly.

Cordeauxia edulis Hemsl. Yeheb nut

Very drought resistant, yielding highly nutritious seeds. Prefers alluvial soils over calcareous layer. A true subdesert plant, intolerant of wetter areas. Native to Somalia and Ethiopia (Ogaden), successfully raised near Voi.

Cordyla somalensis

Native to Somalian and Ethiopian Ogaden, requiring 250 mm rain, yielding highly palatable fruits.

Cucurbita foetidissima HBK. Buffalo gourd

Native to deserts in Mexico and SW USA. A creeper, yielding valuable seeds rich in protein and oil, and enormous perennial roots rich in starch. Drought resistant, for subdeserts. A potential cash crop.

Cupressus spp. Cypress

Some species from mediterranean-type climates may grow in higher or moister areas in semi-arid tropics. Good for shade, shelter, timber. Potentially suitable species are C. arizonica, dupreziana, sempervirens.

Cyanopsis tetragonoloba (L.) Taub. guar

Sometimes cultivated in semi-arid area for its fodder-fruits. Herb.

Dalbergia sissoo Roxb. Sissoo

Requires generous water, yielding excellent timber and useful fuel and poles. Raised by seed, suckers or cuttings.

Delonix elata and D. regia Flamboyant

Ornamental trees, quite drought resistant, moderately salt tolerant. Soft wood, seldom used.

Dodonaea viscosa (L.) Jacq.

Tall shrub, very tolerant of drought, fire and poor soils. Not palatable, so excellent for soil protection and hedging in dry areas.

Ephedra spp.

Desert plants suitable for soil protection and reclamation in very arid areas.

Erythrina spp. Flame trees

Ornamental spreading trees, easily raised from cuttings, suitable for less arid areas. E. melanacantha and E. burttii are particularly drought resistant.

Eucalyptus spp.

There is a great number of potentially suitable species for dry areas, but most have not been widely tested in E.A. The best success in semi-arid sites in eastern Africa has been with E. camaldulensis, citriodora gomphocephala, microtheca, tereticornis; in wetter areas above 1000 m with E. saligna, grandis, regnans; in areas above 2000 m with E. globulus.
In tropical dry areas, the following species should be tried:
Arid areas: E. astringens, brockwayi, leucoxylon, occidentalis, oleosa, salmonophloia, sideroxylon, tereticornis, torquata
Semi-arid areas: E. astringens, camaldulensis, corynocalyx, maculata, melliodora, crebra, microtheca, occidentalis, rudis, sideroxylon.
Irrigated or well-watered areas: astringens, camaldulensis, gomphocephala, leucoxylon, maculata, occidentalis, paniculata, rudis, salmonophloia, salubris, sideroxylon, tereticornis.
Relatively salt-resistant: astringens, camaldulensis, cornula, gomphocephala, leucoxylon, occidentalis, robusta, sargentii, spathulata, melliodora
Relatively wind-resistant: stricta, gomphocephala, microtheca.
Tolerant of clay soils: microtheca.

There is great variation within and between species, in form, growth and resistance to salt, drought, wind, termites and soil conditions. Under suitable conditions, eucalyptus can produce excellent poles, fuel and windbreaks.

Euphorbia antisyphilitica Zucc. Candelilla

Grows in poor soils in Mexican and Texan deserts. Provides good forage and a valuable wax: a potential cash crop.

Euphorbia tirucalli L.

Poisonous shrub, valuable for shelter and stock-proof live fences, usable for fuel. Grows in very arid areas if within reach of groundwater. Easily raised from cuttings.

Ficus sycomorus L. Sycamore fig

Indigenous. Large shade tree, with edible fruits, easily raised from cuttings.

Grevillea banksii

Drought resistant, and propagates naturally on rocky hills; suitable for soil protection in overgrazed land.

Haloxylon spp. Saxaouls

Rangeland shrubs, valuable for soil protection, fodder and fuel. Mediterranean and mid-Asian plants, but H. articulatum et al. may be worth trying in arid subtropics. Extremely drought resistant.

Hyphaene coriacea Gaertn. Doum palm

This and other Doum palms thrive in depressions in arid areas with some access to groundwater or floods. Salt tolerant. Useful poles, leaf-fibres and edible fruits. Easily raised from seeds.

Kochia spp.

Rangeland shrubs with palatable foliage, worth testing for range improvement.

Leucaena leucocephala (Lam.) de Wit

Fast growing shrub or tree, providing poles, fuel and fodder suitable for wetter areas.

Mangifera indica L. Mango

Can grow well in semi-arid area if extra water is available. Requires deep, free-draining soils.

Melia azedarach L. Persian lilac

Very decorative, can be fast growing and quite drought resistant. Used for shade and avenues, fuel and timber and foliage-fodder for goats, but fruits are poisonous.

Moringa spp.

Some indigenous species, easily raised from branch cutting; leaves eaten like spinach. Moringa oleifolia yields useful oil. Very drought resistant.

Nerium oleander L. oleander

All parts very poisonous. Decorative shrub, moderate resistance to salt and drought. Easily raised from cuttings.

Opuntia spp. Prickly pears

Several species, some extremely drought resistant. Best on sandy or loamy soils. Spiny varieties form good hedges, spineless varieties make excellent fodder.

Oxytenanthera abyssinica (A. Rich.) Munro Bamboo

Forms solid-stemmed or thick-walled poles 4-10 m high, in long-lived clumps. Excellent building poles. Grains used as famine food. Occurs in woodland, by water-courses and on rocky hills in many African countries (not in Kenya). Probably best raised from root-stocks.

Parkia spp. W. African locust

Suitable for woodlots and windbreaks in less arid areas. Edible seeds.

Parkinsonia aculeata L.

Very drought resistant, but vigorous growth with adequate water. Excellent for windbreaks, soil cover, live fencing. Used for fuel; not palatable to livestock. Decorative flowers.

Parthenium argentatum Gray Guayule rubber

A potential cash crop for subdesert areas with up to 500 mm rain. Yields excellent rubber. Grows well on calcareous (and other) well drained soils.

Phoenix dactylifera L. Date palm

Valuable fruits, and good salt tolerance. Requires generous ground water.

Pinus spp. Pine

The tropical and subtropical pines such as P. caribaea are endangered by long droughts, but may be successful in wetter semi-arid areas. The

Pinus brutia/eldarica/halepensis complex is more drought-resistant and may be successful in tropical dry areas, but has not yet been much tested outside Mediterranean and mid-Asian regions.

Pithecellobium dulce (Roxb.) Benth. Madras thorn

Very drought resistant, and very rapid growth in moister areas. Planted for fuel and posts, windbreaks, hedges, Good edible seeds. Fodder from foliage. Salt tolerant.

Plumeria rubra L. Frangipani

Ornamental shrub, fairly resistant to salt and drought.

Prosopis spp. mesquites, etc.

Very promising shrubs and trees, highly tolerant of drought and salt. Foliage and pods make excellent fodder. Seeds are rich in protein but require grinding as fodder. Some species fix nitrogen. P. chilensis is successfully planted in Kenya. P. tamarugo is the most salt tolerant. Many provide good fuel (especially charcoal) and timber. Strongly recommended for arid areas within 10 m of groundwater and in semi-arid areas. The most promising species are:-
P. affinis, alba, caldenia, chilensis, cineraria, juliflora, nigra, pallida, tamarugo.

Salvadora persica L. Tooth-brush tree

Indigenous. Extremely resistant to salt and drought, provides useful browse and good fuel. Some shrubby or pendulous forms provide good soil stabilisation.

Schinus molle L. Pepper tree

Suitable for semi-arid or watered areas. Useful shade and fuel; not palatable to livestock.

Sclerocarya birrea Hochst.

Suitable for less arid areas, yielding useful fuel, timber and edible fruits.

Simmondsia chinensis (Link) Schneider Jojoba

Native to deserts in Mexico and SW USA. Yields a valuable seed-wax, a potential cash crop, for areas with 100-500 mm rain. Palatable browse. Fairly salt tolerant.

Tamarindus indica L. Tamarind

Suitable for moist sites or semi-arid areas. Good timber, shade and edible fruits. Can be raised from cuttings.

<u>Tamarix</u> spp. Tamarisk

Resistant to salt and drought, excellent for windbreaks and sand stabilisation and provide good fuel and poles. Moderately resistant to browsing. Easily raised from cuttings. Recommended species include <u>T. aphylla</u>, <u>nilotica</u>, <u>pallasii</u>, <u>stricta</u>.

<u>Tecoma stans</u>

Very resistant to drought and fire. Foliage palatable to stock. Useful wood. Raised from cuttings. Ornamental.

<u>Terminalia catappa</u> L. Indian almond, baidan

Relatively drought resistant, for less arid areas. Good shade tree, used for windbreaks, yielding edible seeds.

<u>Thevetia peruviana</u> (Pers.) K. Schum.

Poisonous shrub, decorative flowers, drought resistant. Useful for hedges and ornament.

<u>Ziziphus</u> spp.

Drought and salt tolerant. Yield good fuel, foliage fodder, edible fruits; used for soil protection and shelter. Often found along drainage lines, but also very deep-rooted on alluvial plains. Useful species are <u>Z. jujuba</u>, <u>nummularia</u>, <u>spina-christi</u>.

<u>Persea gratissima</u> Gaertn. f. Avocado pear

Produces highly nutritious fruits. Does well in some dry areas if well watered.

Appendix 2. SOME SITE PREFERENCES AND TOLERANCES, AND PRINCIPAL USES OF RECOMMENDED SPECIES

Shade or ornament:

Acacia albida, Adenium, Albizia lebbeck, Cassia siamea, Ceiba, Cupressus, Dalbergia, Delonyx, Erythrina, Ficus sycomorus, Melia, Moringa, Nerium, Parkia, Plumeria, Prosopis, Schinus, Tamarindus, Tecoma, Terminalia, Thevetia.

Hedges, live fences:

Dodonaea, Euphorbia tirucalli, Nerium, Opuntia, Parkinsonia, Pithecellobium, Thevetia.

Cash crops:

Acacia mearnsii, A. senegal, Anacardium, Cassia acutifolia, Cucurbita, Euphorbia antisyphelitica, Parthenium, Simmondsia.

Timber:

Albizia lebbeck, Balanites, Borassus, Callitris, Conocarpus, Cupressus, Dalbergia, Pinus, Tamarindus.

Windbreaks:

Acacia aneura, A. cyanophylla, A. ligulata, A. mearnsii, Albizia lebbeck, Azadirachta, Casuarina, Conocarpus, Eucalyptus, Moringa, Parkinsonia, Tamarix.

Fuel and/or poles:

Acacia albida, A. aneura, A. ligulata, A. mearnsii, A. nilotica, A. senegal, A. tortilis, Albizia lebbeck, Argania, Azadirachta, Anogeissus, Casuarina, Conocarpus, Dalbergia, Eucalyptus, Parkia, Pithecellobium, Prosopis, Schinus, Oxytenanthera.

Honey:

Acacia, Eucalyptus, Prosopis.

Heavy, clay and/or seasonally waterlogged soils tolerated:

Acacia ligulata, A. seyal, Azadirachta, Balanites, Eucalyptus microtheca, Prosopis alba.

Saline soils tolerated:

Acacia cyanophylla, Atriplex, Casuarina, Cocos, Conocarpus, Hyphaene, Phoenix, Pithecellobium, Prosopis, Salvadora.

Calcareous and/or alkaline soils tolerated:

Acacia cyanophylla, Ceratonia, Cordeauxia, Parthenium.

Gulleys, river banks or areas with extra water from watertable or floods preferred:

Acacia albida, A. nilotica, Anogeissus, Butyrospermum, Borassus, Casuarina, Conocarpus, Dalbergia, Delonyx, Eucalyptus, Hyphaene, Phoenix, Prosopis, Salvadora, Tamarindus, Tamarix, Ficus sycomorus, Zizyphus, Oxytenanthera.

Moister or less arid areas preferred, with >500 m rain or adequate groundwater:

Acacia mearnsii, Anacardium, Albizia lebbeck, Anogeissus, Azadirachta, Borassus, Butyrospermum, Callitris, Carica, Ceiba, Conocarpus, Dalbergia, Delonyx, Erythrina, Eucalyptus, Leucaena, Mangifera, Parkia, Pithecellobium, Prosopis, Tamarindus, Terminalia, Oxytenanthera. Some of these cannot grow without generous water; others can grow in more arid areas but grow very vigorously in moister areas.

Higher ground preferred: mostly >1000 m in EA

Acacia mearnsii, Cupressus, Pinus.

Soil protection, erosion control or sand stabilization:

Acacia aneura, A. cyanophylla, A. ligulata, Anacardium, Calligonum, Dodonaea, Ephedra, Euphorbia tirucalli, Grevillea banksii, Parkinsonia.

Rangeland improvement:

Acacia aneura; A. cyanophylla, A. ligulata, A. victoriae, Atriplex, Cassia sturtii, Ceratonia, Opuntia, Prosopis.

Supplementary fodder:

Acacia albida, A. nilotica, A. seyal, A. tortilis, Argania, Azadirachta, Balanites, Cassia siamea, Casuarina, Ceratonia, Conocarpus, Cordeauxia, Cucurbita, Leucaena, Opuntia, Pithecellobium, Prosopis, Salvadora.

Edible fruits, seeds and/or leaves:

Anacardium, Argania, Balanites, Borassus, Butyrospermum, Carica, Ceratonia, Citrus, Cordeauxia, Cordyla, Cucurbita, Cyamopsis, Mangifera, Moringa, Parkia, Phoenix, Pithecellobium, Prosopis, Sclerocarya, Tamarindus, Terminalia, Ziziphus.

Appendix 3. FOLIAGE-PALATABILITY RATINGS OF SOME RECOMMENDED SPECIES FOR LIVESTOCK (APPROXIMATE)

Unpalatable or poisonous:

Dodonaea, Euphorbia tirucalli, Opuntia (spiny), Thevetia, Nerium.

Indifferent (not favoured but may be eaten):

Parkinsonia, Tamarix, Schinus, Casuarina equisetifolia, Acacia mearnsii, A. seyal.

Eaten:

Acacia nilotica, A. senegal, Atriplex, Azadirachta, Melia, Pithecellobium, Tecoma, Salvadora, Balanites (fruits).

Favoured:

Acacia albida, Conocarpus, Balanites (esp. by camels), Opuntia (spineless), Prosopis, Ziziphus.

Appendix 4. A GUIDE TO TREE PLANTING TECHNIQUES IN N. KENYA

These notes concern the simplest possible techniques for small rural nurseries and village woodlots or private tree planting, operating on a small budget, suitable for schools, missions and small agricultural or livestock projects which have a need for shelter, soil protection or tree-products such as fuel, poles, fruits, fodder, etc.

Trees can be raised and grown by many methods, and no attempt is made here to describe all the possibly suitable and successful methods (for example, nursery seedlings may be grown in boxes, beds, bags, tubes, tin cans, pots, or compressed soil "bullets"). However, for those who would like some guidelines, which may then be modified to suit local conditions, here are some recommendations.

Note that these guidelines may differ from the standard practices in large forestry nurseries. In some cases the standard practices are no longer efficient, and need revision; in other large modern nurseries, certain techniques may be possible because of the economies of scale and because of the skilled, permanent staff available, although not necessarily suitable for temporary, small or inexperienced nurseries.

Nurseries:

Nurseries should be flat or gently sloping, with an abundant supply of fresh, permanent water. They should be well protected by a fence or hedge, preferably with some natural or planted wind protection.

It is useful to have a hut or shade for protecting materials and equipment, and perhaps a larger shelter for wet weather work.

Plant containers:

Survival during transport and planting is usually best if plants are raised in individual containers. The cheapest are polythene tubes (not bags). Individually sealed polythene bags are much more expensive as well as often providing a less suitable rooting environment. Wooden boxes are also more expensive, and old tin cans are suitable only for plants kept for several years, e.g. in debis.

Polythene tubes:

Tubing is manufactured in Nairobi in several small factories (e.g. Metaplastics, Cosmoplastics). It is sold in rolls of continuous tubing weighing several kg, and prices vary according to thickness (150-250 gauge recommended), lay-flat diameter (8-10 cm recommended for normal trees and shrubs, or up to 20 cm for special purposes) and colour (white or colourless recommended). The total length, and hence the number of tubes, per kg and the cost per tube vary correspondingly.

The cost of tubing of 150-250 gauge, of 8-12 cm flat diameter, colourless, is c. 15 shs. per kg for orders of 100 kg or more, or c. 20 shs for small orders. Black or white tubing is c. 3 shs/kg more expensive. If tubes are cut 15 cm long, at 10 cm lay-flat diameter, the tubing will provide the following approximate yields per kg:-

150 gauge	:	925 tubes at	2.2 cents each			
200 "	:	700 " "	2.8 " "			
250 "	:	550 " "	3.6 " "			

Large orders may be substantially cheaper.

The tubing can easily be cut into the required lengths, to form tubes of c. 15 cm (usually c. 12-20 cm) in length: roll the tubing several times around a piece of board about 5-8 cm across, then cut across one size with a razor, cutting several lengths of tube simultaneously.

<u>Nursery soil</u>:

Suitable soil can usually be obtained by mixing a fertile clay or loam agricultural or forest soil with some sand. A local alluvial soil may be suitable without additions. The soil should have enough sand to ensure good drainage and avoid water-logging in the tube, and enough clay to hold moisture and to bind the soil together. If the soil is infertile, add some well-rotted manure. The soil should be very well mixed and preferably sieved.

<u>Filling tubes</u>:

Tubes may be filled by hand, using a stick to compress the soil enough to ensure that there are no large air-gaps and that the tube is firm enough to hold its shape. A skilled worker can fill some hundreds of tubes per day. If the mixture has the right amount of clay and moisture, the soil does not easily fall out of the bottom if handled with care.

<u>Nursery beds</u>:

The filled tubes should be stacked vertically, packed close together in beds about 1 m across and 5-10 m long. The edges of the beds should be strongly made of boards or split poles to keep the tubes upright and firmly in place.

<u>Sowing seed</u>:

Seeds may be raised in special seed beds, and then carefully transplanted when 1-2 cm high. Good success, with less risk and trouble, may be obtained by sowing the seeds direct into the tubes. It is best to carry out a preliminary test to determine the quality (germination %) of the seeds. 1-5 seeds are then sown together in the centre of each tube (the lower the quality, the more seeds) so as to obtain, on average, one seedling per tube. If more than one seedling germinates in some pots, it is possible, with care, to transplant some to empty pots, but very great care is needed to avoid damage to roots and stem. Best results are obtained by leaving the extra seedlings to grow on, and then clipping away all but the strongest one per pot.

Seed pre-treatment:

Many species have seeds protected by a hard, shiny or waxy coat which is water-resistant. These seeds often germinate extremely slowly unless they are treated before sowing to allow water to penetrate. For some species, it may be enough to soak the seeds in cold water for 1-2 days. For large seeds like Parkinsonia, it is helpful to clip a small piece off one end of each seed. For most species of Prosopis, Cassia and Acacia, a boiling water treatment is recommended: put the seeds in a tin or plastic container, and pour on enough boiling water to generously cover all the seeds, then leave them to cool and soak for 1-2 days.

Seed storage:

All seeds should be kept dry, in a closed airtight container until ready for use. Many, especially Acacia species, should be treated with an insecticide, or mixed with a small quantity of insecticide powder. Heat is often fatal to seeds, and the life of most seeds is prolonged by storing them in a refrigerator. Some species, especially Neem and Conocarpus, have a very short life, and should be sown within a couple of weeks of collection.

Ground preparation:

Adequate preparation is often critical to the survival and success of a plantation. Normally, all vegetation must be cut down to ground level, and then burned or piled into rows or heaps if necessary to facilitate planting or weeding. For many species, it is necessary to plough or cultivate the soil; for example, Eucalyptus species are very sensitive to grass competition. Preferably, a suitable agricultural crop (often maize) should if possible be raised at the same time, to utilise the cleared ground and to cover some of the costs. A suitable intensity of ground preparation will need to be tested and developed to suit local conditions of soil and vegetation.

Spacing:

The planting-spacing will vary according to species, objectives and soils. Spacings of 1.7-2.5 m are often used in moister areas for pole and timber plantations, but in arid areas a spacing of 3-4 m is often suitable for trees for fuel, poles or shelterbelts, and 5-7 or even 10 m for fruit and shade or timber trees. On fertile soils, with adequate water, a closer spacing will help to suppress weeds, but suppression and stagnation will result if the spacing is too close to suit the species and soils, especially if the trees are not cut when planned. In the early years, widely spaced trees may not fully utilise the site, and then the trees should be combined with agricultural crops.

It often helps to reduce weeding costs if plants are arranged in more widely spaced rows, with closer spacing within the rows. Thus, trees 2 m apart in rows 8 m apart may be easier and cheaper to arrange than a square spacing of 4 x 4, but the overall stocking is the same.

Pegging:

It is recommended that the spot for each tree should first be marked with a peg or stake of 30-100 cm. After digging the planting holes, the peg should be replaced in the centre of each hole to mark the exact planting position, and then stuck in beside each newly planted tree. The pegs help to ensure that the required spacing is correctly implemented, and to locate each tree for weeding among the grass and regrowth, and they have been proved to improve the water supplies reaching each plant.

Planting spots:

Survival and growth rates are greatly improved if all individual planting spots are prepared well in advance of planting. This is partly because the seedling roots can more quickly establish themselves in the prepared, moist soil, and partly because the planting operation can be carried out much more quickly, making use of the best possible planting weather. The individual spots are commonly prepared from 1 week to 3 months before the expected planting date, often during the long dry season. Each spot should be excavated (e.g. by jembe) to a depth of c. 30 cm, and c. 30 cm across, with all soil removed and then replaced, preferably with the fertile topsoil at the bottom of the hole and rougher soil on top.

Terracing and water catchment:

On sloping ground, each planting spot should be prepared as a small, inward-sloping terrace, 30-50 cm across. This helps to prevent erosion and to concentrate any surface runoff into the prepared planting spot.

On steep or easily eroded soil, some extra soil or water conservation measures will often be worthwhile, such as contour 'bunds', ditches or rows of stones or brushwood. Sometimes more expensive water-catchment or -spreading measures may be needed to ensure good survival and growth (cf. FAO 1976).

Planting season:

Ideally, planting should take place when the soil is wet, just after the start of a long rainy season. This is usually hard to judge, and the shorter and less predictable are the rains, the greater are the risks of failure, and the greater the importance of planting on the right day. Wet soil from rain, flood or irrigation is essential. The plants and spots must be ready in advance so that planting can be done immediately conditions are favourable.

Plant transport:

Plants should be carried from the nursery to the planting site with the minimum of shaking and disturbance. If they must be carried substantial distances on a vehicle, if often helps to arrange them in temporary beds for a few days watering and recovery at the planting site if possible; on the vehicle, the plants should be protected from the full sun and wind, and should have good circulation of air.

Planting techniques:

It is important to try to avoid breaking the column of soil in the tube or pot, since this usually also breaks some roots.

Polythene tubes should be slit along their length (*e.g.* by a razor blade partly protected by a wooden sheath) and carefully pealed off, and the cylinder of rooted-soil planted in the prepared spot. The soil-level for the transplant should be level with, or higher than, the soil level at the root-collar in the nursery, never lower. The root stock or side roots must not be exposed, but it is important not to twist or bend the roots to fit them into the hole. The roots should lie in their natural position, embedded in soil without air pockets. After planting, the soil around the seedling should be well firmed in with the heel until it is firm and up to the right level.

Weeding:

After planting, hand weeding will usually be required, for 1-2 or even more years, to reduce competition for water, nutrients and light. Often it will be enough to slash the weeds and regrowth in a strip 1-2 m wide along the planted rows, or to slash a circle 1-2 m diameter around each tree. Sometimes complete slashing, or clean cultivation with hoes may be essential, with or without agricultural crops. Suitable methods should be worked out locally.

Appendix 5. SITE-TYPES IN THE IPAL AREA

Some of these site types are extremely widespread in arid areas, and all are worth trials to find suitable tree and shrub species.

1. Mobile sand: with various depths of sand to water table. *e.g.* North Horr.

2. Heavy clays: with some "black cotton soils", and more or less wet season waterlogging and dry season cracking. *e.g.* Loiengalani drainage line.

3. Soils with permanently accessible water table: low-rainfall area, with abundant water within reach of established more-or-less deep-rooted trees, *e.g.* Loiengalani and near Kalacha.

4. Saline soils or water: *e.g.* Loiengalani, and near North Horr and Kalacha.

5. Soils with seasonally abundant water: along drainage lines, especially along the Balessa Kulal and along the lava-edge between Korr and Kargi.

6. Dry land areas, watered by rainfall: lowland areas on sand or silt; lava plateau soils; medium altitude sites on the mid-slopes of mountains.

7. Calcareous or alkaline soils: *e.g.* Kargi.

Appendix 6. TREES AND SHRUBS PLANTED IN IPAL AREA

Almost all the trees and shrubs which have been planted in the IPAL study area are listed here, together with the locations where I have seen them, and brief comments on their success.

Planting in Marsabit town is excluded because conditions and species-performance there are not relevant to the subdesert parts of the IPAL area.

Most of the planting dates from 1977-79, but there are some older trees up to 5 years old in Ngurunit and up to 10 years old in Loiengalani, North Horr and Gatab missions.

Acacia albida: N. Horr, Loiengalani, Kalacha, Hurri Hills, generally surviving with only slow growth, but some vigorous at N. Horr and Kalacha when well watered.

Acacia mearnsii: Hurri Hills, young plants but apparently vigorous.

Acacia mellifera: N. Horr, Kalacha, Hurri Hills, surviving.

Acacia nilotica: Hurri Hills, just surviving.

Acacia nubica: N. Horr, just surviving.

Acacia podalyriifolia: Gatab, vigorous.

Acacia senegal: N. Horr, Kalacha, Hurri Hills, surviving.

Acacia tortilis: N. Horr, Kalacha, Hurri Hills, Kargi, Balessa, Loiengalani, surviving but slow growth.

Acrocarpus fraxinifolius: Hurri Hills, surviving well.

Adenium obesum: N. Horr, growing well from branch cutting.

Anacardium: failed at N. Horr.

Atriplex halimus: N. Horr, few survivors, growing well.

Azadirachta indica: N. Horr, Kalacha, Loglogo, fairly vigorous.

Bauhinia: Hurri Hills, just surviving.

Bougainvillea: N. Horr, barely surviving.

Caesalpinia: Loglogo, good.

Calligonum comosum: N. Horr, few surviving.

Carica papaya: Korr, Ngurunit, Loiengalani, Loglogo, Karari, vigorous.

Cassia siamea: Loglogo, Karari, Kalacha, Hurri Hills, surviving and growing well.

Cassia spectabilis: Loglogo, good.

Cassia senna: N. Horr, surviving.

Casuarina ? equisetifolia: Gatab, Loglogo, Hurri Hills, successful and sometimes vigorous.

Citrus: Various kinds at Loglogo, Loiengalani, Ngurunit, Kalacha, not always vigorous or healthy but successful fruiting within 4-8 years.

Cocos: Loiengalani, very slow.

Cupressus: Gatab, 50 planted in 1968 at close spacing, many dead but remainder now thriving.

Delonix regia: Loglogo, Ngurunit, good.

Erythrina burttii: Kalacha, Loiengalani, N. Horr, mostly just surviving but a few very vigorous.

Eucalyptus: Gatab, 50 planted in 1968, many survived until 1976, now only 2 windswept survivors.

Euphorbia tirucalli: Loiengalani, Karari, Kalacha, Korr, Loglogo, some very vigorous hedges, but rather weak in Loiengalani and barely surviving so far in Kalacha.

Grevillea robusta: Gatab, Hurri Hills, Karari, Kalacha, growing satisfactorily.

Hyphaene: Ngurunit, N. Horr, surviving.

Jacaranda: Gatab, Kalacha, Loglogo, N. Horr, Hurri Hills, growing satisfactorily but not vigorous.

Mangifera indica: Ngurunit, Kalacha, Kararwe; growing satisfactorily but fruiting uncertain.

Melia azedarach: Ngurunit, Loglogo, Karari, good,

Moringa: N. Horr, one growing from a branch-cutting.

Morus (?): Ngurunit, young, healthy.

Nerium oleander: Loiengalani, Kalacha, some vigorous.

Olea africana: Gatab, slow.

Opuntia: Loglogo, Ngurunit, vigorous.

Parkinsonia: Ngurunit, one, vigorous; elsewhere in 1979.

Persea gratissima: Gatab, Ngurunit, growing satisfactorily but fruiting uncertain.

<u>Phoenix</u>: N. Horr, Ngurunit, very slow but steady.

<u>Pinus elliottii</u>: Gatab, 50 reported planted in 1968, all dead within 2 years.

<u>Prosopis chilensis</u>: N. Horr, Kalacha, vigorous; elsewhere in 1979.

<u>Psidium guajava</u>: Loiengalani, Ngurunit, healthy but fruiting uncertain.

<u>Salvadora</u>: N. Horr, good.

<u>Schinus molle</u>: Gatab, Karari, good.

<u>Schrebera alata</u>: Gatab, Hurri Hills, healthy but slow.

<u>Simmondsia</u>: N. Horr, failed.

<u>Tamarindus</u>: N. Horr, Hurri Hills, Kalacha, Loiengalani, usually slow and unthrifty, but some very vigorous in Loiengalani planted in 1969 and later.

<u>Tecoma</u>: Ngurunit, Gatab, good.

IPAL Technical Report Number D - 2c

IMPLEMENTING FORESTY PROGRAMMES FOR
FOR LOCAL COMMUNITY DEVELOPMENT, SOUTH-WESTERN MARSABIT DISTRICT, KENYA

by
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UNEP - MAB Integrated Project in Arid Lands

CONTENTS

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1. INTRODUCTION

1.1 Physical features

Marsabit District occupies 76,858 square km in arid and very arid north central Kenya (Anonymous, 1976) (see Figures 1 and 2, D - 2a). Siturate in the trough between the highlands of south-western Kenya and Ethiopia, the district is mostly between 500 and 1,000 metres elevation but has a few isolated mountains which rise from 1,500 - 2,400m in height (Survey of Kenya, 1970). Geologically, the district is composed of quarternary and tertiary volcanics, precambrian granites and gneisses of the basement system, and quarternary sediments (Saggerson, 1969).

Temperatures are high (max. annual mean of 30-34 degrees C; min. annual mean of 18-22 degrees C) (Survey of Kenya, 1970), as is evaporation (2,400-2,600mm/yr) (Woodhead, 1968). However, precipitation, which occurs bimodally with peaks in April and October/November, is low (under 255mm/yr) (Survey of Kenya, 1970). This amount is expected to be exceeded only 1 year in 10 (East African High Comm., 1961). This pattern of low rainfall and high rate of evaporation places Marsabit District primarily in the very arid eco-climatic zone (Pratt and Gwynne, 1977). Zones of higher ecological potential (mostly arid) occur only on the few mountains in the district. The highest elevations of these may receive up to 760 - 1,015mm precipiation annually and have a sub-humid climate (Pratt, et.al., 1966; Pratt and Gwynne, 1977).

2. VEGETATION

Reflecting this arid situation the vegetation is primarily *Acacia* bushland and *Duosperma*-*Indigofera*-*Sericócomopsis* dwarf shrubland. *Chrysopogon* and *Aristida* annual grasses are the principal component of the herb layer. Zones of vegetation associated with successively less extreme environmental conditions occur at increasingly higher elevations on the mountains, which are capped by *Juniperus*-*Olea*-*Teclea*-*Croton* dry montane forest. *Carissa*-*Rhus*-*Lippia*-*Ormocarpum* evergreen to semi-deciduous bush land and *Acacia* woodland occur on the mountains below the forest zone and *Acacia* woodland also occurs in riverine stands at lower elevations. The eco-climatic gradients and associated vegetation types on the mountains are sharp on the higher, steeper and drier leeward slopes (FAO, 1971; Herlocker, 1979). Overall, the ecological potential of the district rises no higher than rangeland of low potential (Pratt and Gwynne, 1977).

3. PEOPLE/OUTSIDE INFLUENCES/RESULTING SITUATION

As befits its low ecological potential, Marsabit District has one of the lowest population densities in Kenya (under 1 person/km2) (Survey of Kenya, 1970).

The people of the district are predominantly cushitic major tribes being the Gabbra, Boran, Rendille and Samburu (FAO, 1971). They are almost exclusively pastoral in economy and conservative in outlook. Estimates of livestock numbers made since 1963 show from 655,000 to 1,128,000 head within the district. From 17 - 21% of these are camels (FAO, 1971).

Although these tribes have probably in the past existed in balance with their arid environment, they have recently been exposed to outside influences which are difficult to adapt to easily and quickly. Thus, the depredations of the 'shifta' during the 1960's and the present troubles in Ethiopia have caused loss of life and property as well as restriction of traditional grazing areas. Also, inter-tribal raiding has left certain areas of the district little used because of lack of security. The establishment of new missions within the district has created cores for the settlement of the poor and the dispossessed, while increased school attendance is drawing the young from the pastoral economy (FAO, 1971). Unfortunately, once educated, there are often no jobs available to be taken up and no desire by the educated to return to the old herding way of life.

Finally, the recent period of drought during 1970-1976, associated with the drought in north Africa, has increased the numbers of people without the means to continue in their traditional way of life and, often, because of the availability of government famine relief programmes, without the interest in doing so.

The result has been a trend in movement of pastoral peoples away from the herding economy to a settled existence based on administrative centres and new mission stations. There are associated trends in:

- destruction of vegetative cover (and subsequently soils) around these settlements due to increased requirements for wood products and fodder, and;

- increasing numbers of people requiring employment outside the pastoral economy.

4. APPROACH

Various organizations have recognised these trends and have begun to deal with this problem now rather than wait until it has attained unmanageable proportions. With the support of the Kenya government several Roman Catholic and Protestant missions, the National Christian Council of Kenya, and the UNESCO/UNEP Integrated Project in Arid Lands have begun a cooperative effort to implement rural forestry programmes for local community development. The objectives are:

- to provide employment for residents of settlements;
- to provide supplies of wood products for fuel and building materials for local use;
- to establish tree crops usable as cash crops or for subsistance; and
- to help restablish stabilizing vegetative cover for denuded areas.

So far, all involved have shown an eagerness to cooperate in this task. However, fragmentation of effort and lack of expertise have limited overall efficiency. The usefulness of the work would be increased considerably if approached within the context of a coordinated district-wide scheme in which local objectives could be viewed within a larger perspective. This paper is a first approximation of this perspective.

5. POSSIBILITIES

5.1 Species trials under rainfed conditions

Marsabit District has little area capable of supporting fast growing tree species under moderate to high rainfall conditions. Where such areas do occur competitive uses (urban, agricultural, dry season grazing, wildlife reserves) already exist for the land. Thus, forestry schemes, even when supplying the needs of inhabitants of the higher potential areas, must be sited primarily within the drier areas. Unfortunately, because of the emphasis by Kenya foresters on growing high yielding plantations of exotic tree species in high rainfall areas, there is little experience in dryland forestry to draw upon. Thus, it is important that species trials of both exotic and indigenous species be carried out on a wide variety of sites, which are both potentially productive (relatively speaking) and accessible (close to population centres).

For instance, on Marsabit Mtn. dryland forest plantations could be sited in the narrow sub-humid/semi-arid eco-climatic zone which is close to population centres. The only apparent conflicting land use is grazing of perennial grasslands. Much of this land is now in poor condition and requires some form of grazing control over and above traditional controls. This would be particularly necessary should dryland forest plantations be established because of the greater area of these required to compensate for the slower tree growth within these zones.

5.2 Species trials under irrigation

An alternative or supplementary approach would be to attempt irrigated forest plantations on sites with large and continuous supplies of water. Interestingly enough such sites may exist along the perimeter of the Chalbi Desert, presently the least productive zone within the district. A number of perennial springs and high water table sites occur here, which are probably maintained by rainfall on the porous volcanic soils of nearby Mts Kulal, Marsabit, and the Huri Hills. These sites support use of the desert perimeter for dry season grazing and are nuclei for permanent settlements. The latter are centres of supply and for settlement for pastoral populations up to 80km away.

Supplies of fast growing trees from irrigated plantations at these points would fulfill local needs and reduce pressure on nearby slow growing natural vegetation. Also, some of these sites appear to be close enough to Marsabit Town to make it economically feasible to supply it with wood products as well.

However, it will be necessary first to establish that sufficient and continuous water supplies exist. Secondly, the effect of irrigation on salinazation of soils under high evaporative conditions should be considered.

5.3 Utilization of existing natural resources

5.3.1 Acacia tortilis woodlands

Woodland stands of *Acacia tortilis* subsp. *spirocarpa* dominate valley bottoms at the base of the Nyiru, Ol Doinyo Mara, and Ndoto Mountains on the south-western perimeter of the study area. Elsewhere they occur along seasonal streams and on soils derived from the old Chalbi lake bed. This tree species provides a high quality charcoal which is in enough demand to be shipped to Marsabit Town from as far away as 130km.

There is an opportunity here for sustained yield management of these woodlands for the production of charcoal and perhaps other wood products as well. This is especially so in valley stands where tree density, mature size and overall growth rate appear greater than elsewhere. Valley bottoms also provide ideal management units.

Some knowledge of the ecology of this species already exists (Parry, 1954; Fahn, 1959; Halevy and Orshan, 1972, 1973; Lamprey, et. al., 1974; Herlocker, 1976; Jarmon, 1976; Herlocker and Dodd, in prep.). This allows a first approximation of management procedures which can be eventually updated based on practical experience and further ecological research planned by UNESCO (IPAL).

Although these valley sites are inhabited by pastoral Rendille and Samburu there should be a minimum of conflict between the two land uses as they already largely exist in equilibrium. Furthernmore, management of these stands would provide local employment and revenue as well as insure lasting supplies of charcoal, firewood and building material. Considerable care will be needed to safeguard overexploitation of the resource.

5.3.2 Acacia reficiens bushland

Similarly, *Acacia reficiens* bushland, which dominates an extensive area between Marsabit Mtn., Mt. Kulal and the Ndoto Range, could be utilized along similar lines as *Acacia tortilis* woodland.

However, this species presents different problems to management than *Acacia tortilis*. Its small size and multiple stems will make handling more difficult. Its probable slow growth and lower densities will require management based on extensive exploitation of large areas. Hence, the input in terms of time and money will be greater per unit of wood product and probably receive a lower return than with *Acacia tortilis*. Still, it remains a possible source of employment and revenue for the people of the area.

Furthermore research into the ecology of this tree species planned by UNESCO (IPAL) should provide information on its growth and regeneration characteristics needed to optimize exploitation and management.

In the case of both *Acacia tortilis* and *A. reficiens* the greatest problem is one of adequate control of their exploitation. Overcutting of the arid and semi-arid areas in which these species occur would be extremely dangerous and could tip the ecological balance toward environmental degradation and, ultimately, desertification. Because of the virtual absence of private ownership of land in this area, the responsibility for control of such cutting would rest with either the Central Government or the Marsabit District Council.

5.3.3 Acacia senegal; gum arabic

Acacia senegal, exploited on a large scale for its gum exudate in the Sudan, occurs within the study area. Although not abundant it is common throughout much of the area, usually occurring as single trees. The local Rendille have shown an interest in collecting gum arabic (Andersen pers. comm.) but efforts to do so have not progressed, apparently because of the need to organize the gathering of fairly large amounts before down-country buyers will become interested (Miller pers. comm.).

It would be worthwhile undertaking a pilot effort at collecting and selling gum arabic. UNESCO(IPAL) plans to carry out a survey of its availability within the study area, which should help determine the overall feasibility of the project. Should a pilot attempt at exploitation of existing trees succeed it may be worthwhile attempting to increase the numbers of Acacia senegal through cultural measures.

Indeed, experimental plantings of Acacia senegal are presently being carried out at two sites within the study area (Bussman, pers. comm; Tyroller, pers. comm).

Much is already known about the ecology of this tree species (Parry, 1954; Kaul and Chitnis, 1964; Gerakis and Tsangarakis, 1970; Obeid and Seif el Din, 1971a, 1971b; Seif el Din and Obeid, 1971a, 1971b; Cheema and Quadir, 1973; Herlocker, 1976). This should help expedite such a scheme.

5.3.4 Aloes

Aloe species occur within the study area primarily between 1000 and 1500mm elevation on volcanic, granitic and gneissic soils. As with Acacia senegal they are seldom abundant but are common, expecially in association with Commiphora species in bushland.

Aloe species are collected periodically within the study area, and are sold at Marsabit where they undergo a rather simple primary processing before being sold again down country. Thus, they are obviously an exploitable resource. However, as collection apparently consists of uprooting whole plants whenever and wherever found, continued exploitation of Aloes could easily lead to substantial diminishment of this natural resource within the study area. Therefore, it seems worthwhile to attempt growing these plants as agricultural crops.

For logistical and control purposes this should be done near population centres at settlements in areas where Aloe sp. do not naturally occur. Whether this is possible to do is a case for some small pilot schemes at or near these settlements to determine.

5.4 Huri Hills reafforestation project

The Huri Hills, which extend for some 75km from the Chalbi Desert to near the Ethiopian border, rise to 1,600m elevation and are about 2,400km^2 in area, contain the largest area of perennial grassland in Marsabit District. As such they are a major grazing area for the Gabbra tribe.

However, a paucity of permanent water supplies limits use of the Huris by the Gabbra to a few months at the end of each wet season. The latter part of the dry season is spent near permanent water at the edge of the Chalbi Desert, and around boreholes to the east of the hills. This is a reversal of the usual procedure of using highland areas as dry season grazing areas.

To make better use of the productive potential of these grassland areas the National Christian Council of Kenya has initiated a scheme oriented towards long term multiple-use development of the Huri Hills. Boreholes and dams being sited around the base of the hills will allow more extensive use but not permanent settlement of the highland perennial grasslands. Permanent settlement would probably eventually result in overuse of the area.

Oral tradition suggests the Huri Hills once supported forests, now confined to the deeper east facing canyons (Anders n, pers. comm.). The possibility of reestablishing forests in some areas is being pursued by experimental plantings of potentially successful and useable tree species. Heavy mists occur for several months of the year and it is possible that condensation of water from fog may be the major factor in maintaining forests in these hills.

Should species trials be successful further planting of selected areas may be advisable. For instance, reafforestation of certain watersheds might eventually - through condensation of mist by tree canopies - bring back into existence small springs on the lower slopes. This would insure more extensive and continuous use of the area by livestock.

However, it is important that establishment of forest plantations be carried out carefully so as to maintain grazing of the perennial grasslands as the primary land use. Otherwise, a very important grazing area of the Gabbra will be lost to them forcing them into increased dependency on arid lowland rangelands. This could only be detrimental to both the Gabbra and to those rangelands.

6. COORDINATION/SUPPORT

Although presently small in size the UNESCO (IPAL) Project provides a good opportunity for provision of advice, coordination and, often, material support for other individual projects within its study area. However, its primary responsibilities include studies of livestock/habitat/human interactions, studies of population ecology, of livestock species and monitoring of the major environmental/ecological patterns within the area. Thus, this project should also be able to provide the basic ecological context into which further development of the district may be fitted.

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