THE VEGETATION OF MOLE NATIONAL PARK

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Front cover: *Cochlospermum tinctorium* (Cochlospermaceae) a rhizomatous suffrutex whose bright yellow flowers appear near the ground after the annual bush fires. Mole National Park, Top of Konkori Scarp near Konkori Camp (Photo K. Schmitt 22.02.1993).

PREFACE

The area now occupied by Mole National Park was heavily populated before 1870 but has never been densely populated since and protection began in 1958. To date human impact - with the exception of poaching - has been fairly limited. The dominant vegetation type is open savanna woodland (Guinea savanna), most of which is burnt annually. Mole National Park therefore represents an undisturbed **typical Guinea savanna ecosystem** of substantial size (4 840 km²).

Fire is not considered as a disturbance to a savanna ecosystem, but plays an integral part in its perpetuation. "There is good evidence that fire in vegetation is a phenomenon of great antiquity, antedating the arrival of man by many millions of years ... but it was not until the arrival of man that fire assumed an importance comparable to existing climatic factors in shaping the composition, structure and distribution of plant communities and thereby, the animal populations with which they are inseparably linked." (Rose Innes 1972, p. 147).

The effective long-term management and protection of this important ecosystem requires scientific baseline data and ongoing research and monitoring. Much scientific research was carried out in the late 1960's and throughout the 1970's and monitoring programmes were initiated at that time and in the late 1980's (FAO 1968, Hall and Jeník 1968, Lawson et al. 1968, Jeník and Hall 1969, Pegg 1969, Jamieson 1972, Aberdeen University Ghana Expeditions to Mole National Park 1974-1978; Institute of Renewable Natural Resources, UST Kumasi; Arlangdong 1986, Komoah 1987, Gelman 1989). Unfortunately the monitoring programmes were not followed up and no further research has been conducted with the exception of a recent study of the trace element budget (Bowell and Ansah 1993).

ACKNOWLEDGEMENTS

Important contributions to this report from the following are gratefully acknowledged:
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SUMMARY

Mole National Park represents a fairly undisturbed Guinea savanna. The geology is dominated by sandstones and schists forming a generally flat topography which is interrupted by a prominent scarp and a few granite outcrops. The soils are mainly rhodic Nitisols and plinthic Ferralsols. The numerous rivers which cross or originate in the Park drain into the White Volta. The climate is a 'Tropical humid - summer climate' with a single-peak rainy season and an average annual rainfall of 1000 to 1100 mm.

Human impact is mainly limited to annual burning of the vegetation and collection of fruits and firewood. The burning plays an integral part in the perpetuation of the savanna vegetation.

The dominant vegetation type is open savanna woodland with a grass-layer that can reach up to 3 m in height. Low, open grassland, so-called boval, is found on areas with shallow soils and iron pan and narrow bands of riverine forest grow along most of the streams.

The majority of the 742 plant species found in Mole are widespread throughout the savanna zone, however the number of species of conservation value (4 endemic, 12 disjunct and 24 species which are rare or have a very limited distribution) is relatively high. Their abundance is generally low and they are often confined to plant communities of small extent.

Based on the analysis of 60 relevés, using the Zürich-Montpellier Method (Braun-Blanquet 1964), the vegetation of Mole National Park could be grouped into five vegetation types comprising 16 plant communities. In addition three communities are described based on observations only. Soil depth and drainage are the main determinants for the distribution and composition of the plant communities.

OPEN SAVANNA WOODLAND is the dominant vegetation type. The tree cover varies from 5 to 65% with an average of 30%. The average tree height is 11 m with individuals reaching up to 22 m in height. The ground-cover, which can reach up to 100%, is dominated by tall, up to 3 m high, bunch-grasses between which scattered herbs are found.

The savanna woodland was divided into two main groups: The *Burkea africana* - *Terminalia avicennioides* community group and a community group with a similar ground-layer but without *Burkea africana* and *Terminalia avicennioides*. The first community group was divided into two sub-groups:

- The *Vitellaria paradoxa* sub-group comprises all savanna woodland on well-drained and often deep soils. This sub-group contains four communities.
- The *Detarium microcarpum* sub-group is confined to shallow and rocky soils. Two communities could be delineated within this sub-group.

BOVAL. The boval vegetation (*Loudetiopsis kerstingii* - *Polycarpaea tenuifolia* community) comprises all plant communities on flat iron pan with patches of shallow soil. Only annual species can compete on such sites which are flooded and species-rich during the rainy season and subject to extreme water-stress during the dry season.

RIVERINE FOREST is found along most of the rivers in the Park. It often forms bands of generally dense and species-rich forests of up to 38 m in height. The width of these bands varies from a few metres to more than 100 m on either side of the river and is mainly determined by topography and geology. Four communities were delineated.

FLOOD-PLAIN GRASSLAND AND SWAMPS. This vegetation type comprises four plant communities of seasonally water-logged valley bottoms and badly-drained depressions and areas around water-holes which are mainly dominated by grasses and sedges.

COMMUNITIES COVERING SMALL AREAS. Special sites such as old termite mounds or depressions in sandstone plateaux which are water-filled during the rainy season harbour an often highly specialised vegetation.

The following management recommendations have been proposed in order to protect and maintain this fairly undisturbed ecosystem as a whole, its wildlife and vegetation, and to preserve their genetic diversity:

1) To institute a research and monitoring programme to provide the management with scientific data for management decisions; and to establish a research station

2) to apply a fire policy which will maintain the perpetuity of the ecosystem and protect its soils and watercatchment function

3) to develop the tourism and education potential

4) to allow public use of selected botanical resources through sustainable harvesting in approved zones (Traditional Use Zone) and during limited periods

Finally a list of possible research topics has been given.

1. INTRODUCTION

Mole National Park is situated in Northern Ghana between 09°12'-10°06' North and 01°25'-02°17' West and covers an area of 4 840 km² (Fig. 1). The elevation ranges from 120 to 490 m asl. The geology of the Park is dominated by Voltaian sandstones and Birimian schists which have developed mainly into rhodic Nitisols and plinthic Ferralsols. The topography of the generally flat country is dominated by a scarp which runs north south through the Park and reaches up to 250 m in height. The numerous rivers which cross or originate in the Park drain into the White Volta. Only the rivers originating on the Upper Voltaian sandstone east of the scarp and the south-eastern part of the Mole river are permanent. The other streams break into stagnant ponds or dry out completely during the dry season.

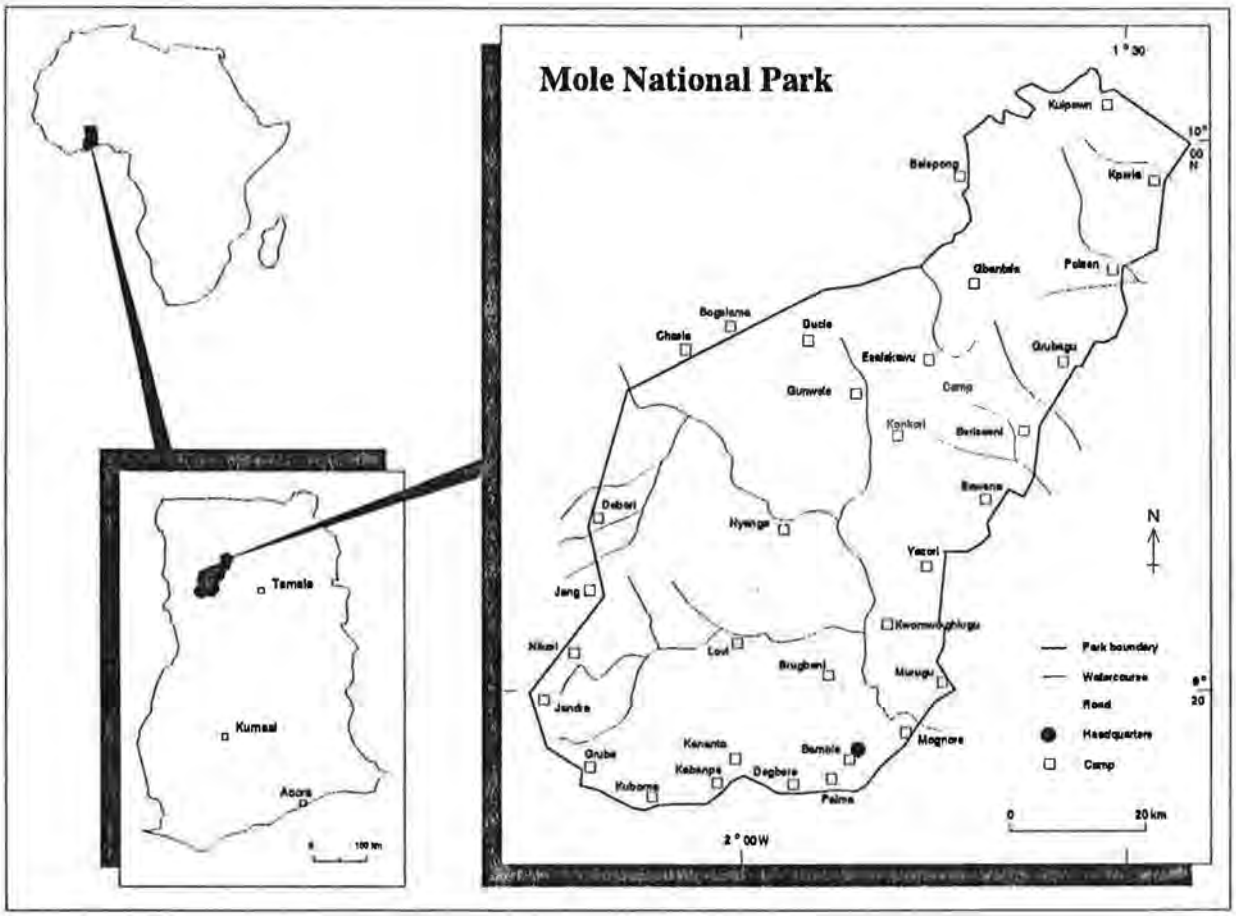

Fig. 1: Location of Mole National Park

The Park lies within the Guinea Savanna Zone. The dominant vegetation type is open savanna woodland with a grass-layer that can reach up to 3 m in height during the rainy season and which is burnt annually. Low, open grassland, so-called boval, is found on areas with shallow soils and iron pan. Narrow bands of riverine forest grow along most of the streams. Other plant communities, such as swamps and flood-plain grasslands, cover only small areas.

The area which is now the National Park was fairly heavily populated by the Bole Division of the West Gonja tribe before 1870. After a war between the Kong and Bole Divisions the remaining people congregated in a few villages which never grew to great size. Most of the people were hunters and farmers.

In 1958 about 2 330 km² of the area which is now the southern part of the National Park were made a Game Reserve. In 1964 all the inhabitants of the five villages in the Game Reserve were resettled. In 1971 the Reserve was extended to cover more than 4 000 km² and made into a National Park which was in 19?? extended to its present size. This extension led to the inclusion of Gbantala village whose inhabitants were removed in December 1992.

2. GEOLOGY AND SOILS

2.1 Geology

The western part of the Park (west of the Kananto - Ducie road) consists mainly of the Lower Birimian System, Middle Precambrian schists which are more than 2 000 million years old. Granitic rocks (Dixcove and Cape Coast granitoid complex, 1 800 - 2 100 million years old) were intruded into the schists, and form a band along the western boundary. The Precambrian rocks in the eastern half of the park are overlain by sandstone of the Voltaian System (Fig. 2A). The age of the Voltaian System is controversial. The Geological Survey of Ghana considers the age to range from Upper Proterozoic to Paleozoic (620 - 1 000 m.y.), while Jones (1978, cited in Kesse 1985) proposed a range of 320 - 1 000 m.y.. The rocks of this System are divided into three stratigraphic divisions, namely the Lower, Middle and Upper Voltaian.

Laterites (up to 20 m in depth) and alluvial deposits of highly weathered granite are the most common Quaternary deposits. (Geological map, Survey of Ghana 1969; Benzie 1976, Kesse 1985)

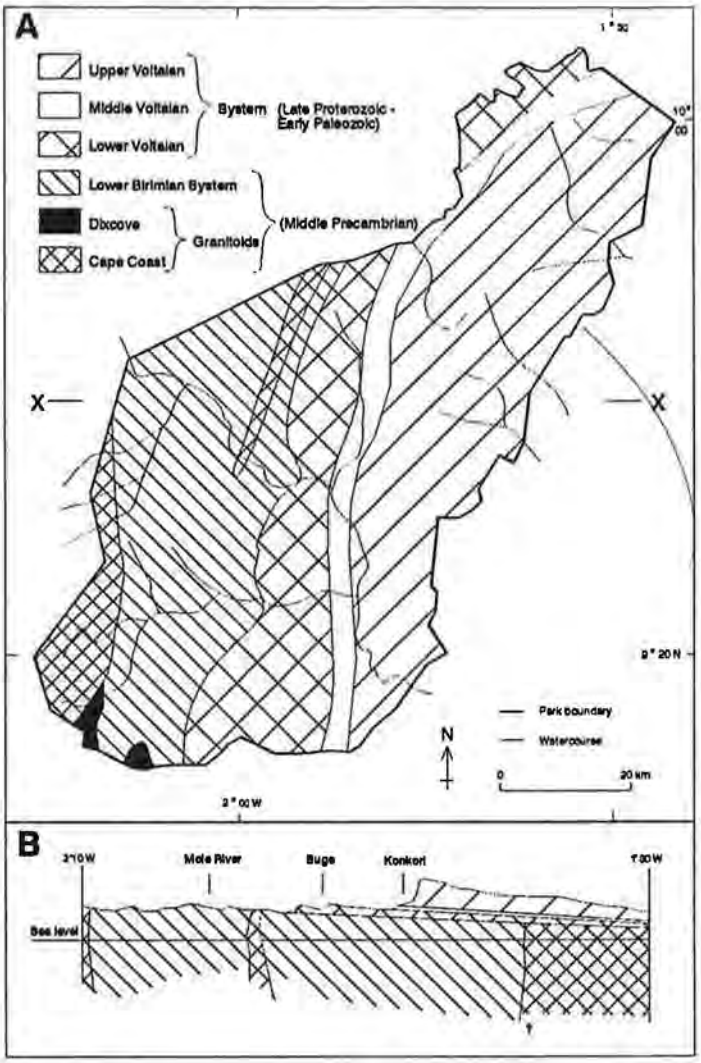

Fig. 2: The Geology of Mole Nat. Park (from Benzie 1976):
A: Geological map.
B: Cross section along 9°39'N (marked X- -X in Fig. 2A).

2.2 Soils

The soils of Mole National Park are mainly rhodic Nitisols and plinthic Ferralsols[1] (Soil map, Survey of Ghana 1969; SRI 1971, FAO 1988). The latter soil develops a hardened layer[2] at a depth of 0.2-1.2 m. Iron pan or laterite[3] outcrops, which are the result of the exposure of iron-rich horizons (plinthite) in the process of erosion, are common throughout the Park.

Seven soil profiles were described and analysed during the Aberdeen University Ghana Expeditions to Mole National Park in 1974 and 1975 (Sobey 1974, Geddes 1975). Their findings can be summarised as follows: The 10-18(35) cm thick top layer is mainly dark brown and slightly humic and consists of sandy clay loam. It overlies a 30-80 cm deep yellowish red clay horizon with angular iron concretions. An indurated layer (either ferricete or pea gravel, see footnote 2) was found in the subsoil of some of the profiles. The soils in the

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1 Savanna Ochrosol and Groundwater Laterites are the old names.

2 The development of the hard pan in the subsoil of the groundwater laterites (name commonly used in older literature) of gently sloping soils seems to be related to the movement of iron-rich soil water (Ahn 1970).

3 "The word laterite, originally applied by Buchanan in India in 1807 to iron-rich soil material which hardened on exposure, has been used subsequently to describe such a variety of materials that its present meaning is confused." (Ahn 1970, p. 99). Therefore, the use of the word laterite will be avoided. The terms ironstone or iron pan will be used to describe hard, rock-like sheets of indurated iron-rich material. Such sheets are the result of the drying out of plinthite (iron-iron clay with quartz), an irreversible process.

southern part of the park were investigated recently by Bowell and Ansah (1993), who studied the concentration of selected trace elements. They described four soil types (Tab. 1).

Tab. 1: Soils of Mole National Park

Soil type	Characteristics	Location	Geology
Ferralsol	ferralic B horizon, ie. highly weathered and a high content of Kaolinite and sesquioxides	upper slopes	Voltaian System, central ridge and Cape Coast Granitoids
Nitisol	argic B horizon, ie. clay content higher than in overlying horizon	middle slopes and flat valley plains away from streams	
Vertisol	clay rich (> 30% in the top 18 cm) dark soil	valley floor in the centre of the Park	
Solonchak	halomorphic soil high salinity	around Mole and Lovi rivers	

3. CLIMATE

The climatic setting of Mole National Park is illustrated in Fig 3. The climatic diagram for Damango clearly shows the rainfall pattern characteristic of Guinea Savanna (see section 6.3). More than 90% of the average annual 1 104 mm (1961-1990) of rain falls during the single rainy season from April to October, with maxima occurring in July and September. The dry season lasts for 5 months from November to March. This kind of climate has been classified as 'Tropical humid - summer climate' (Troll and Paffen 1964).

The isohyets map (Fig. 3) does not show details of rainfall within the Park area. A rainfall value for Kulpawn camp was calculated using the distance to rainfall stations with long-term records (Tab. 2). Mole Headquarters was not used in the calculation, because this station has only 6 years of complete recordings.

Tab. 2: Rainfall stations used for the calculation of rainfall at Kulpwan camp.

Station	Period of recording (years)	Average annual rainfall (mm)
Damango	30 (1961-1990)	1104.6
Tamale	30 (1961-1990)	1033.4
Walewale	19 (1972-1990)	853.6
Navrongo	30 (1961-1990)	986.1
Tumu	14 (between 1961 and 1985)	998.8
Wa	30 (1961-1990)	1022.4

The algorithm[4] used to calculate the rainfall at Kulpwan is:

$$\frac{\Sigma(d \times r)}{\Sigma d}$$

d: distance between Kulpawn camp and the rainfall stations
r: rainfall in mm

The calculated value for Kulpawn camp is 1009 mm of rain per year.

The mean annual temperature (27.8°C) varies little from month to month (26.1°C to 30.5°C) while the average diurnal range is 13.3°C. The coldest month is December and the hottest March.

[4] A similar algorithm was used to calculate rainfall values in a National park in Kenya (Schmitt 1991).

The Harmattan, a hot dry wind from the Sahara, blows from the north-east between December and February. Lawson et al. (1968) observed prevailing calm air during March and April.

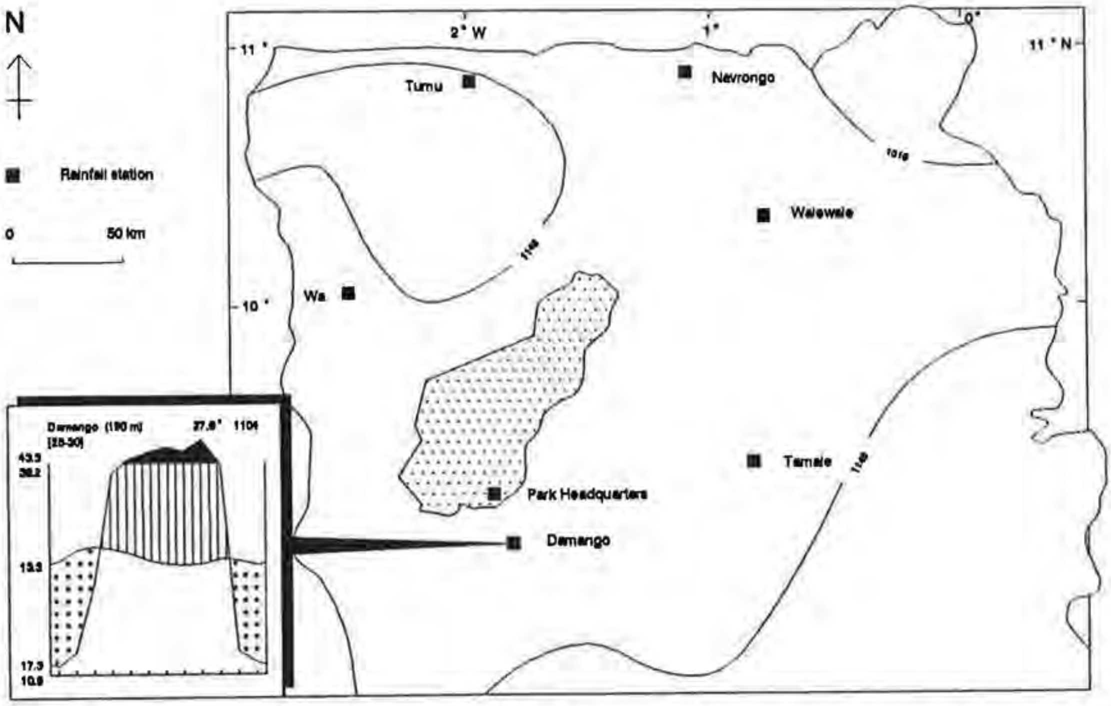
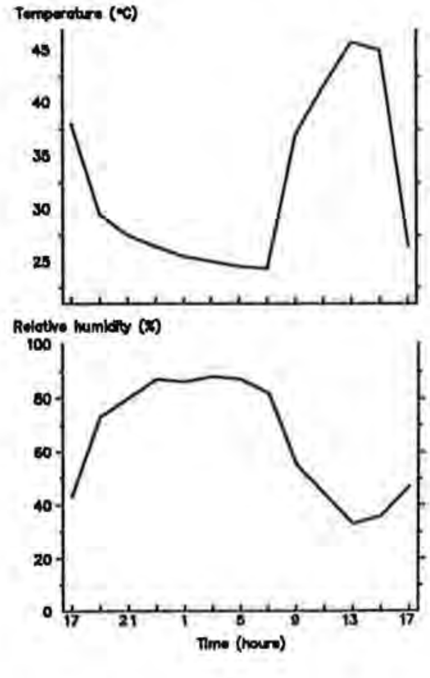


Fig. 3: Climatic setting of Mole National Park, showing a climatic diagram after Walter and Lieth (1960-67) typical of the area (data from Ghana Meteorological Services Department), and isohyets from the 'Average Annual Rainfall' map (Survey of Ghana 1969).

Climatic diagrams: arid periods (ie. rainfall < 2 x temperature) are dotted; parallel lines mark periods when rainfall > 2 x temperature and black areas show rainfall above 100 mm (scale 1: 10). The y-axis divisions represent 10°C and 20 mm of rainfall respectively. For more details see Schmitt (1993).

Isohyets map: figures on the original map are given in inches.

Observations on the microclimate in typical savanna woodland and riverine forest near Lovi Camp in March and April 1967 were published by Lawson et al. (1968). The diurnal variation in temperature and relative humidity is shown in Fig. 4.



Lawson et al. (1968) clearly showed that cloudless weather results in significantly higher maximum temperatures (up to 45.9°C near the ground; 32.8°C on a cloudy day), larger 24h temperature ranges (up to 21.4°C near the ground; 8.5°C on a cloudy day) and an evaporation which is on average three times higher than on a cloudy day.

Studies along a transect from the upper slope to the riverine forest showed marked differences in microclimate. Relatively higher night temperatures and relatively lower day temperatures were recorded on the upper slope as compared with the middle-slope; generally cooler temperatures prevailed in the riverine woodland.

Fig. 4: The diurnal variation in temperature and relative humidity in a middle-slope savanna near Lovi Camp on a cloudless day (1-2 April 1967); readings were taken 10 cm above ground. From Lawson et al. (1968).

4. HUMAN IMPACT

Not much is known of the history of the Mole area before 1870, but it seems that the area was fairly heavily populated by the Bole Division of the West Gonja tribe. This changed after a war when the survivors congregated in a few villages. These people were mainly hunters and farmers and the villages never grew to great size.

The area of Mole National Park was part of the Game Clearance Area for tsetse control which was established in the early 1950's and covered the whole northern part of Ghana (Asibey, pers. comm.). Large numbers of wildlife were shot in order to restrict the spread of the tsetse fly. Protection of the wildlife began in 1958 when the Mole Game Reserve was created, covering the southern part of the present National Park. The inhabitants of the five villages remaining inside the Game Reserve were finally resettled in 1964. In 1971 the Reserve was made into a National Park and after two extensions and the removal of a further village now covers 4 480 km^2.

Indiscriminate burning during the dry season was carried out before 1964 when an early burning policy along the roads was introduced to improve visibility. However, due to the lack of fire breaks, this normally resulted in the burning of most of the area. Early burning is still practised but no attempt is made to restrict it to particular areas. Fires set by poachers inside the Park and fires which sweep from outside the Park contribute to the almost complete burning of the vegetation every dry season. During four transect flights for animal counts at the beginning of March 1993 average burnt areas from 74 to 92% were recorded for the subareas. These figures are conservative, because spots where some dry grass culms covered the burnt plot may have been recorded as not burnt from a height of 100 to 120 m.

Human impact after 1870 seems to have been fairly limited and mainly affected the wildlife population. Hunting has never ceased and poaching is still very common. Fire, also a result of man, is not considered as a disturbance to a savanna ecosystem, because it plays an integral part in its perpetuation - however its impact on the animal and insect populations can be devastating.

5. FLORA

Plants have been collected from within the present area of Mole National Park since 1916, with the bulk of the collection having been carried out during the Aberdeen University Expeditions and J.B. Hall's studies (Hall 1976c). Hall published a provisional check-list (Hall 1976c) containing 719 species and subspecies. An extended list including the authors' samplings (November/December 1992 and February/March 1993) is given in appendix 3. It contains 742 species of vascular plants which include 148 tree, 61 shrub, 166 grass and 284 herb species, 75 climbers and 8 ferns. Species of conservation value are listed in Tab. 3.

Details of the distribution, ecology and use of the plants of Mole National Park (and all the other protected areas surveyed in this project) have been entered in a data base, which will be an appendix to the 'Manual for Vegetation Survey, Analysis and Mapping' (Schmitt 1993).

Local endemism is generally low in West African savanna, and only two endemic species which are confined to northern Ghana, *Kyllinga echinata*, a sedge, and *Aneilema setiferum* var. *pallidiciliatum* are found in Mole. In addition two species which are endemic to Ghana were recorded, namely *Gongronema obscurum* and *Rhinopterys angustifolia*.

The 12 disjunct species of Mole are confined to the savanna woodland with the exception of *Mimusops kummel*, a tree which is found in riverine forests.

To date six species have been identified which have not been recorded in Ghana outside Mole National Park: *Croton pseudopulchellus*, *Indigofera conferta*, *Indigofera trichopoda*, *Jatropha neriifolia*, *Pleiotaxis newtonii* and *Pandanus candelabrum*. *Tephrosia letestui* and *Raphionacme keayii* have each been recorded at only one other location outside Mole.

Anthocleista vogelii, a tree of wet sites in the south-western forest zone, has been recorded for the first time in Mole. *Apodostigma pallens* is a climber which is otherwise also restricted to the forests in the south-west. *Amblygonocarpus andogensis*, a savanna tree widespread in central, east and south tropical Africa, has been recorded for the second time in Ghana. *Mischogyne elliotiana*, a tree which is commonly found in the wet and moist forest zones, was also recorded in Boabeng-Fiema, Bui and riverine forests in Mole (see Fig. 5). Two woody climbers found in Mole, *Apodostigma pallens* and *Usteria guineensis*, are otherwise mainly

confined to the wet and moist evergreen forest zone. A number of species from Mole are otherwise confined to the drier types of forests in the south-eastern part of Ghana: *Vepris heterophylla* is a tree which has been recorded in Mole, Kogyae and in and around Shai Hills; the trees *Drypetes parvifolia*, *Commiphora dalzielii* and *Uvaria ovata* are found in the southern marginal and south-east outlier forest zones, while the climbers *Premna quadrifolia* and *Triclisia subcordata* additionally occur in the dry semi-deciduous forest zone.

Tab. 3: Species of conservation value of Mole National Park (information from Hutchinson and Dalziel 1954-72, Hall 1976c, 1979, Brunel et al. 1984, Lock 1989, WCMC 1993 and Hawthorne and Juam Musah 1993).

1.	ENDEMIC SPECIES (FWTA):	Aneilema setiferum var. pallidiciliatum	Kyllinga echinata
		Gongronema obscurum	Rhinopterys angustifolia
2.	SPECIES WITH LIMITED DISTRIBUTION, Ghana and one other country (from FWTA and Lock 1993[a]):		
		Indigofera barteri	Loudetiopsis thoroldii
		Indigofera trialata	Raphionacme vignei
		Jasminum kerstingii	Rhytachne furtiva
		Jatropha neriifolia	
3.	DISJUNCT SPECIES (from FWTA, Hall 1976c and Lock 1989):		
		Ammannia auriculata	Hydrolea macrosepala
		Aristolochia albida	Mimusops kummel
		Bacopa hamiltoniana	Pleiotaxis newtonii
		Chrysochloa hindsii	Rotala welwitschii
		Combretum collinum ssp. binderianum	Striga passargei
		Croton pseudopuchellus	Tephrosia letestui
4.	SPECIES RARE IN GHANA, but otherwise widespread (from Hall 1979):		
		Breonadia salicina	Vincentella passargei
5.	IUCN categories (WCMC 1993)	Indeterminate:	Rare:
		Breonadia salicina	Tephrosia letestui
		Indigofera conferta	
		Vincentella passargei	
6.	STAR RATING (based on species rarity in Ghana & internationally; Hawthorne & Juam Musah 1993)		
	Black star species:[b]	*Blue star species*:[b]	
	Ruellia togoensis	Afraegle paniculata	Sabicea brevipes
		Chlorophytum togoense	Sansevieria liberica
		Mischogyne elliotiana	Triclisia subcordata
		Ochna afzelii	Uvaria chamae
		Pandanus candelabrum	Vangueriopsis spinosa
		Parinari congensis	Vincentella passargei
		Polysphaeria arbuscula	Zanthoxylum xanthoxyloides
		Pouchetia africana	

a The species listed were found in Ghana and one other country according to FWTA (Flora of West Tropical Africa), ie. before 1954 - 1972. 38 species with limited distribution in West Africa are not listed here, however six of them are included in the star species and one in the IUCN categories.

b Black star: Species which are rare internationally and at least uncommon in Ghana
Blue star: Species which are widespread internationally but rare in Ghana, or vice-versa

Ruellia togoensis, a rare herb of dry forests (Mole, Tain Tributaries II Forest Reserve, Koforidua, Ejura Scarp and Shai Hills), has been also found in the wettest region of Ghana near Ankasa Game Production Reserve (information from FROGGIE). A detailed study of the ecology of this Acanthaceae would be necessary to explain this unusual distribution pattern.

38% of the plants recorded in Mole are also found in the forest zone. 39% of these species (or 15% of all the Mole plants) were classified as 'non forest species' by Hawthorne and Juam Musah (1993). 461 or 62% of the plants found in Mole are savanna species.

Ordination values according to Hall and Swaine (1981) are available for 43 species found in Mole, they include 17 trees, 3 shrubs, 18 climbers, 4 herbs and 1 fern. The mean species values for all of them is 50 (axis 1) and 36 (axis 6), which would place the forests of Mole in the 'Dry semi-deciduous zone'. This does not mean that Mole harbours forest characteristic of the 'Dry semi-deciduous zone', but indicates that most of the forest species found in Mole are representatives of this zone.

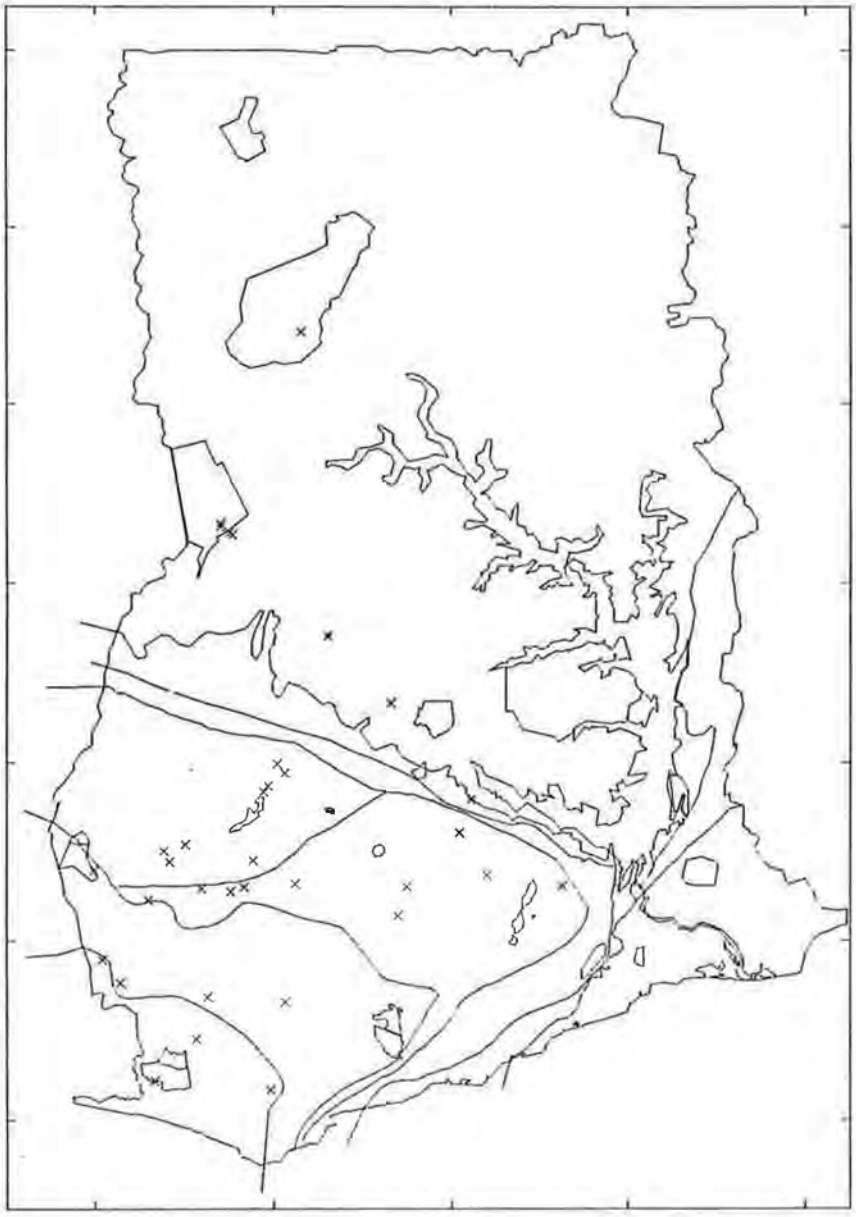


Fig. 5. Distribution of *Mischogyne elliotiana*. Each X represents a location where *Mischogyne elliotiana* has been collected. Data from FROGGIE (Hawthorne 1993) and this survey.

6. VEGETATION SURVEY AND CLASSIFICATION

The semi-quantitative Zürich-Montpellier Method (Braun-Blanquet 1964) was used for the vegetation survey and classification. A detailed description of the methodology is given in a separate report (Schmitt 1993).

6.1 Vegetation mapping

The vegetation of Mole National Park was mapped using a colour print (scale 1: 125 000) of a Landsat-TM Image 4-5-3 195/053 from 18.11.1986. This image was chosen because it provided a cloud-free cover of the Park before the beginning of the fire season. The resulting vegetation map is shown in appendix 4.

6.2 Savanna and its classification

The term savanna is believed to be derived from the old Carib word "sabana" which was applied to land without trees but with many short and tall grasses (de Oviédo y Valdes 1535, cited in Bourlière and Hadley 1983). However, since the publication of Griesbach's book "Die Vegetation der Erde" (1872), savanna has commonly been defined as vegetation with a continuous grass layer and usually scattered trees.

In 1956 the Scientific Council for Africa presented a physiognomic classification of vegetation types in Africa south of the Sahara, the Yangambi classification. They defined savanna as follows: "Formations of grasses at least 80 cm high, forming a continuous layer dominating a lower stratum. Usually burnt annually. Leaves of grasses flat, basal, and cauline. Woody plants usually present.". Savanna can be divided into four types: savanna woodland (trees and shrubs forming a canopy which is generally light), tree savanna (trees and shrubs scattered), shrub savanna (trees absent, shrubs scattered) and grass savanna (trees and shrubs normally absent) (CSA 1956).

White (1983), in his book/map on the vegetation of Africa, presents a different classification. He criticises the use of the term 'savanna' in the Yangambi classification because of the difficulties with its precise definition and the fact that it is a word foreign to Africa. He uses the term 'woodland' (including scrub woodland) instead. We have not adopted White's system in this report, although it is the most recent, because the term savanna is so widely used that we feel replacing it would only create confusion.

These and other approaches[5] to the definition of an ecosystem which is located in a transition zone between rain forest and desert reflect the fact that tropical savanna is extremely variable both in space and time. Lamotte and Boulière (1983) stated:

> "There is no such thing as a typical savanna ecosystem. Rather there is a gradient of related ecosystems, ranging from open woodlands to almost treeless steppes.". Characteristic features of tropical savannas are: alternating wet and dry phases; a structure which is primarily determined by competition between woody plants and grasses for available soil moisture and which is modified by fire, herbivores and soil nutrients.

A zonation of the West African savanna into three main zones - Guinea, Sudan and Sahel - has been widely accepted (Chevalier 1900, Keay 1959). Mole National Park falls within the zone north of the rain forest, the Guinea zone. Here the rainfall of the single-peak season ranges from about 900 to 1 250 mm per year. White's (1983) approach in contrast differs from this conventional concept and following his system Mole would fall within the 'Sudanian woodland with abundant *Isoberlinia*'. However, as for the term savanna, we will apply the widely used term 'Guinea savanna' to avoid confusion.

The plant communities within the savanna have been classified using a number of different approaches, ranging from physiognomic to purely floristic. Savanna trees often have a wide ecological amplitude and are therefore of limited value for the classification of plant communities. This is in contrast to herbaceous plants and grasses whose distributions often reflect smaller differences in site conditions. The Zürich-Montpellier approach, which uses

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[5] For a comprehensive overview of the different approaches see White (1983) and Sanford and Isichei (1986).

species with restricted distribution to delineate plant communities, takes this into account (cf. Hall and Jeník 1968, Werger 1977). The analysis of communities defined in this manner reveals which plant species are indicators of specific ecological factors. This provides important information for the design of monitoring programmes. Our original plan of applying such a Zürich-Montpellier approach had to be modified because of time constraints in combination with the seasonal nature of the vegetation.

West African savanna is highly seasonal and most of the plant species can only be identified at the end of the rainy season, between September and November. We were not able to start the field work until mid November 1992 (by which time burning had already started) because of the work-plan for the whole project and because of the poor conditions of the roads in Mole. As a result only the first 22 relevés established contain fairly complete species inventories (relevés nos. 49-70, November 1992), while the ground layer in the next 12 relevés (nos. 73-84), which were established before the middle of December, was already dried out and many of the species could not be identified. The 25 relevés, established in late December 1992 and in February and March 1993, were all burnt and only trees and shrubs could be recorded.

This made it necessary to base the classification mainly on physiognomic criteria, ie. presence of trees (see appendix 3). However, where possible we will follow Hall and Jeník's (1968) floristic classification.

More relevés containing complete information on the herbaceous layer will be necessary for a final classification and the establishment/distinction of the indicator values of the individual species.

7. VEGETATION

Fairly extensive literature on West African savanna exists (see Lawson 1986) and some accounts on the Guinea savanna in Ghana have been published.

Taylor (1960) and Vigne (1936) based their classification mainly on trees, while Charter (no date) and Brand and Brammer (1956) classified savanna purely as grass-communities. Rose Innes (1967), looking at land-use and vegetation in Northern Ghana, classified the vegetation of Mole National Park as 'Fire-proclimax tree savanna with perennial grasses; nil to light cultivation and grazing'. Hall and Jeník (1968) provided a preliminary classification of the savanna in Ghana using the Braun-Blanquet method and described four different plant communities for the area of Mole, namely *Isoberlinia doka - Loudetiopsis scaettae*, *Terminalia macroptera - Loudetiopsis thoroldii*, *Andropogon gayanus* var. *gayanus - Mitragyna inermis* and *Loudetiopsis kerstingii - Polycarpaea tenuifolia* communities. Lawson et al. (1968), who studied the relationship between vegetation and site conditions, adopted this classification and in addition gave a general description of 'riverain woodlands'. During five expeditions by students from Aberdeen University to Mole National Park (1974-1978) further studies on the flora and vegetation were carried out (for details see literature list), but no further classification of plant communities was given apart from general descriptions such as *Anogeissus* woodland, *Acacia* shrub, *Andropogon gayanus* grassland, monospecific stands of *Detarium*, scarp forest and petrographic vegetation on flat rocks.

Based on the analysis of 60 relevés (appendix 3), the vegetation of Mole National Park could be grouped into five vegetation types comprising 16 plant communities (Fig. 6). These communities contain ten subcommunities and three types. Furthermore three communities are described in terms of their physiognomy based on observations in the field and descriptions in Hall and Houston (1974).

Soil depth and drainage are the main determinants for the distribution and composition of the plant communities. An overview of the hierarchical structure of the plant communities and their site conditions are given in Fig. 6.

	sites
SAVANNA WOODLAND	
Burkea africana – Terminalia avicennioides community group	
Vitellaria paradoxa sub-group (on deep and well-drained soils)	
Isoberlinia doka – Loudetiopsis scaettae community	deep soils on well-drained plains and gentle slopes
Daniellia oliveri – Vitellaria paradoxa community	well-drained plains
Afzelia africana – Vitellaria paradoxa community	well drained rocky sites on steep slopes and hilly areas
Terminalia macroptera – Loudetiopsis thoroldii community	badly-drained seasonally-flooded plains with deep soil
Detarium microcarpum sub-group (on shallow and rocky soil)	
Typical Detarium microcarpum community	shallow and rocky soil
Erythrophleum africanum – Detarium microcarpum community	shallow soil
Savanna woodland community group without Burkea africana and Terminalia avicennioides	
Acacia gourmaensi – Acacia dudgeoni community	waterlogged or very shallow and rocky sites
BOVAL	
Loudetiopsis kerstingii – Polycarpaea tenuifolia community	iron pan
RIVERINE FOREST	
Anogeissus leiocarpus community	
Mitragyna inermis – Andropogon gayanus var. gayanus community	seasonally waterlogged valley bottoms and flood-plains
754 – Pterocarpus erinaceus community	steep river banks
764 – Khaya senegalensis community	seasonally water-filled depressions
FLOOD-PLAIN GRASSLAND AND SWAMPS	
Andropogon gayanus – Terminalia laxiflora community	flat areas bordering Mitragyna – Andropogon riverine forest
Schizachyrium spec. community	depressions of seasonal streams
Cyperus spec. community	flat, water-filled sites
Kyllinga spec. community	flat, water-filled sites
COMMUNITIES COVERING SMALL AREAS	
Termitaria	old termite mounds
Wet gully vegetation	deeply incised gullies
Pterophytic vegetation	flat tops of sandstone rocks

Fig. 6. Hierarchical structure and site conditions of the plant communities of Mole National Park.

7.1 Savanna Woodland

Open savanna woodland is the dominant vegetation type in Mole National Park. The tree cover varies from 5 to 65% with an average of 30%. The average tree height is 11 m with individuals reaching up to 22 m in height. The ground-cover, which can reach up to 100%, is dominated by tall, up to 3 m high, bunch-grasses between which scattered herbs are found.

The savanna woodland, which is characterised by dominance of the bunch-grasses *Andropogon tectorum* and *Andropogon gayanus* var. *bisquamulatus*, can be divided into two main groups: The *Burkea africana - Terminalia avicennioides* community group and a community group with a similar ground-layer but without *Burkea africana* and *Terminalia avicennioides*.

7.1.1 *Burkea africana - Terminalia avicennioides* community group

The *Burkea africana - Terminalia avicennioides* community group encompasses all open savanna woodland communities which are characterised by the frequent occurrence of the two trees after which the community group is named and the scattered presence of trees and shrubs of *Annona senegalensis*, *Gardenia aqualla* and *G. ternifolia* and *Lannea acida*. The different species of *Combretum*, grouped together in the *Combretum* species group, are found in all six communities of the *Burkea africana - Terminalia avicennioides* community group. These communities constitute most of the vegetation of Mole National Park.

Two sub-groups, which are confined to different sites, could be delineated within this community group according to the frequent occurrence of the differential species *Vitellaria paradoxa* and *Detarium microcarpum* respectively.

7.1.1.1 *Vitellaria paradoxa* sub-group

Vitellaria paradoxa, the shea-nut tree (formerly named *Butyrospermum paradoxum*) is commonly found in savanna woodland on well-drained soils. One community of deep but poorly-drained soils is included in this sub-group. Frequent companions are *Pterocarpus erinaceus*, *Piliostigma thonningii* and *Grewia ventusa*. They differentiate the following four communities from those on shallow soils.

7.1.1.1.1 *Isoberlinia doka - Loudetiopsis scaettae* community (Hall and Jeník 1968)

Isoberlinia doka is a tree which is commonly found on deep, well-drained soil throughout Guinea savanna (cf. Keay 1960, White 1983). It dominates the often dense and around 15 m high tree cover of a savanna woodland community on gentle slopes and plains which was classified as *Isoberlinia doka - Loudetiopsis scaettae* community by Hall and Jeník (1968).

Their relevé from the south-eastern part of Mole (Hall and Jeník 1968, p. 87) has been been included in the vegetation table (appendix 3, relevé no. 0) and shows a lot of similarity with the community dominated by *Isoberlinia doka* (columns 1-7). The floristic differences of the ground-layer can be explained as a result of incomplete recordings after the burning started.

7.1.1.1.2 *Daniellia oliveri - Vitellaria paradoxa* community

A tall savanna tree with a characteristically shaped crown resembling an inverted cone, *Daniellia oliveri* typifies another woodland on well-drained plains, the *Daniellia oliveri - Vitellaria paradoxa* community.

It seems possible to provisionally distinguish five subcommunities within this community:

- The typical subcommunity, which is differentiated from the other subcommunities by the absence of any additional differential species.
- The *Pericopsis laxiflora* subcommunity,
- the *Lophira lanceolata* subcommunity and
- the *Dichrostachys cinerea* subcommunity are typified by one tree species each, but more relevés would need to be sampled before any conclusions about differences in the ecological amplitudes of these differential species could be reached.

- The *Afzelia africana* subcommunity (appendix 3, column 15) can be distinguished by the frequent occurrence of this tree which is confined to rocky slopes. It grows together with *Entada africana* and *Daniellia oliveri*, both species of well-drained plains, thus indicating the transitional position of this subcommunity between the *Daniellia oliveri - Vitellaria paradoxa* and the *Afzelia africana - Vitellaria paradoxa* community (see below). *Amblygonocarpus andogensis* was found occasionally in both communities.

7.1.1.1.3 *Afzelia africana - Vitellaria paradoxa* community

The *Afzelia africana - Vitellaria paradoxa* community can be easily distinguished by the frequent occurrence of *Afzelia africana*, a tree of rocky and well-drained sites on steeper slopes and in hilly areas. Rock-outcrops covered between 5 and 60% of the relevés and most relevés were found on slopes steeper than 10°.

Three subcommunities were delineated within the *Afzelia africana - Vitellaria paradoxa* community:

- The typical subcommunity, which resembles the description of the community itself. Relevés 139 and 140 were established on a round hill of about 1 km in diameter and c. 50 m in height. The shallow, brown soils are loamy and contain a high percentage of gravel (mainly quartz and some granite). The soil depth increases from the hill-top to the bottom, where it reaches up to 35 cm. This hill is located at the southern tip of the short band of Cape Coast Granite Complex running more or less parallel to the Konkori Scarp (see Fig. 2). A small stream encircles the entire hill. Here the soil is deep, black and silty and harbours the *Terminalia macroptera - Loudetiopsis thoroldii* community, which is found on badly-drained areas (see below).
- The *Diospyros mespiliformis* subcommunity is differentiated by the additional occurrence of this tree which is typical of termite mounds.
- The *Haematostaphis barteri* subcommunity is characterised by this small tree and is confined to steep and rocky slopes. Although only one relevé was established the delineation of a separate subcommunity seems to be justified, because *Haematostaphis barteri* is typical of steep rocky slopes and has been observed in similar sites. *Isoberlinia tomentosa* and shrubs of *Securidaca longependulata* were also recorded.

The granite outcrops of the Cape Coast Granite Complex in the eastern part of the Park harbour the *Afzelia africana - Vitellaria paradoxa* community with trees such as *Anogeissus leiocarpus* and *Detarium microcarpum* being fairly common while *Diospyros mespiliformis* was found only occasionally.

This list is not complete and further surveys will certainly come up with additional subcommunities. Hall and Houston (1974), who classified the dry semideciduous forest found on the escarpments as Scarp forest, recorded the following trees which are typical of the dry forest on the margin of the forest zone: *Dialium guineense, Drypetes floribunda, Ochna afzelii* and *Salacia leptoclada*. *Dacryodes klaineana* and *Antiaris toxicaria*, two trees which are common throughout the entire forest zone, were also found in the scarp forest (Hall and Houston 1974, Hall 1976c).

7.1.1.1.4 *Terminalia macroptera - Loudetiopsis thoroldii* community (Hall and Jeník 1968)

Terminalia macroptera is a tree commonly found in low-lying and badly-drained areas. Hall and Jeník (1968) classified a plant community characterised by this tree and the grass *Loudetiopsis thoroldii*, the *Terminalia macroptera - Loudetiopsis thoroldii* community. One relevé (appendix 3, column 22) was established in a similar site with scattered trees of *Terminalia macroptera*. The ground-layer was completely burnt and it is therefore impossible to conclude whether it is the same community or not. However, its location on a badly-drained and seasonally flooded plain, the presence of *Pseudocedrala kotschyi*, another tree of badly-drained soils, and the observation of similar vegetation dominated by *Terminalia macroptera* in several poorly-drained locations (eg. around Asibey-Pond) throughout the Park, justifies the provisional placement of relevé no. 138 in the *Terminalia macroptera - Loudetiopsis thoroldii* community.

7.1.1.2 *Detarium microcarpum* sub-group

A tree of shallow and rocky soil, *Detarium microcarpum*, was recorded frequently in two savanna woodland communities which were grouped together to form the *Detarium microcarpum* sub-group.

Two communities could be delineated within the *Detarium microcarpum* sub-group:

7.1.1.2.1 Typical *Detarium microcarpum* community

All relevés in which *Detarium microcarpum* more or less exclusively dominates the tree and shrub-layer were grouped as the typical *Detarium microcarpum* community. It is an open savanna woodland with trees around 10 m high and with an average tree-cover of 26%. This community is confined to shallow and rocky soils from flat to sloping ground up to 15°. The average rock-cover of the soil was almost 30%.

Three types could provisionally be distinguished within the typical *Detarium microcarpum* community, based on a combination of physiognomic, floristic and site criteria. However they will not be described as distinct subcommunities because the recording of the ground-layer is incomplete in most of the relevés.

- The pure *Detarium microcarpum* type:
  Detarium microcarpum forms pure stands (appendix 3, columns 23-25) in small areas with only very few other trees growing between them. A dominant grass in this community, in addition to the grasses commonly found in savanna woodland, is *Loudetiopsis kerstingii*, a characteristic constituent of the primary xerosere. Other grasses recorded in relevé 58, the only one established before the burning started, include *Oropetium aristatum*, a small densely tufted cushion-like annual bunch-grass, and *Loudetiopsis scaettae*. Benzie (1977) called this vegetation 'monospecific stands of *Detarium microcarpum*'. Based on measurements and estimations in 100 10m² quadrats he published the following average figures: tree-cover 42%, ground-cover 62.9%, grass height 77.7±8.6cm and soil depth 39.8±4.3 cm. The results from the Guinea savanna showed a higher canopy-cover (52.1%) and greater soil depth (56.6±5.3 cm).
- The *Detarium microcarpum* type on scarp and hill tops:
  An often denser tree/shrub-cover, the frequent occurrence of other trees such as *Burkea africana* and *Terminalia avicennioides*, and the clear distribution pattern make it possible to delineate a separate *Detarium microcarpum* type on scarp and hill tops (appendix 3, columns 26-31). Here the rock-cover is on average 15%. A *Detarium*-cover of more than 30% was recorded on flat plateaux at the top of hills, while the relevés established on the tops of scarps had a *Detarium*-cover of around 20%.
  Hall (1976a) wrote that *Detarium microcarpum* and *Parinari curatellifolia* are the dominant trees on the flat sandstone rocks above Konkori camp. Here he observed that fruits of these species were chewed open by baboons and were abundant on the rocky baboon habitat, where seeds of *Parinari* were common in baboon droppings.
- The *Detarium microcarpum* type on rocky slopes:
  The abundance of *Detarium microcarpum* decreases significantly on steep slopes with a very high rock-cover (>60%) while the species composition remains more or less the same. This difference justifies the delineation of a separate *Detarium microcarpum* type on rocky slopes (appendix 3, columns 32-33).

7.1.1.2.2 *Erythrophleum africanum - Detarium microcarpum* community

The *Erythrophleum africanum - Detarium microcarpum* community is characterised by the frequent occurrence of *Erythrophleum africanum*, a tree exclusively restricted to this community, an open savanna woodland of an average height of 12 m.

The *Erythrophleum africanum - Detarium microcarpum* community is confined to sites with soils deeper and less rocky than the typical *Detarium microcarpum* community. This is clearly shown by the lesser abundance of *Detarium microcarpum*.

7.1.2 Savanna woodland community group without *Burkea africana* and *Terminalia avicennioides*

A savanna woodland with a ground-layer similar to that of the *Burkea africana - Terminalia avicennioides* community group, but without any species of the *Burkea africana - Terminalia avicennioides* species group, has been assigned to a separate community group, the Savanna woodland community group without *Burkea africana* and *Terminalia avicennioides*. The only community found in this group is the *Acacia gourmaensi - Acacia dudgeoni* community.

7.1.2.1 *Acacia gourmaensi - Acacia dudgeoni* community

The *Acacia gourmaensi - Acacia dudgeoni* community can be classified as shrub savanna (CSA 1956). Shrubs of *Acacia gourmaensi* and *A. dudgeoni* are found scattered in a dense, 2 m high grass-layer. Other shrubs such as *Ziziphus mauritiana* are rare.

This community is confined to soils liable to extreme conditions in terms of water or air supply. It is found on flat, seasonally water-logged sites at the bottom of the scarps or on low-lying ground near rivers, where *Acacia dudgeoni* dominates. This community is also found on shallow soils on the very rocky (up to 90%) and steep lower slopes of the escarpments; here *Acacia gourmaensi* dominates.

Two herbs, *Lepidagthis anobrya* and *Pandiaca angustifolia* and the bunchgrass *Hyparrhenia subplumosa* are common in all savanna woodland communities and on meadows on iron pan and sandstone outcrops, so-called boval.

7.2 Boval

The boval vegetation comprises all plant communities on flat iron pan with patches of shallow soil. Only annual species can compete on such sites which are flooded and species-rich during the rainy season and subject to extreme water-stress even early on in the dry season. At this time the few remaining dry species burn very easily.

All boval vegetation, from lichens on bare iron pan to thick stands of annual grasses in patches where soil has accumulated, was classified as the *Loudetiopsis kerstingii - Polycarpaea tenuifolia* community (Hall and Jeník 1968).

Eight relevés[6] were established on iron pans. Here grass no. 638 was found frequently on deep and on very shallow soils. Less common grasses with a similar amplitude are *Andropogon pseudapricus*, nos R65 and 727.

Two subcommunities on sites with different soil depths could be distinguished:

- The *Loudetiopsis kerstingii* subcommunity (appendix 3, columns 44-47) is found on sites with deeper soil and is dominated by dense, up to 1.5 m high stands of the annual grass *Loudetiopsis kerstingii*. The cover can reach up to 100% and no iron pan is exposed between the grasses.
- The no. 638 subcommunity (appendix 3, columns 48-50) is confined to sites with a very shallow soil-layer and up to 80% of iron pan. The average grass-height is 20 cm and the average cover seldom exceeds more than 40%.

Tab. 4 is adopted from Houston (1974) who studied the boval vegetation on Sambara Flats and estimated the plant cover in 20% classes. He showed that soil depth and water supply are the main factors determining the distribution of the plant species. Columns 1 and 2 represent relevés on shallow and well-drained soils and columns 3 and 4 represent relevés on deep soils with a dense grass-cover. The relevé shown in column 4 was well supplied with water and here two ferns of the genus *Ophioglossum* were found. The last relevé, column 5, was established in a pool.

Soil depths from 0 to 34 cm were recorded by Houston (1974). Benzie (1977) measured an average soil depth of 20.6±2.8 cm and an average grass height of 29.9±4.4 cm. He estimated the average plant cover to be 48.1%.

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6 Only 7 relevés are included in the vegetation table (appendix 3), because relevé 53 was placed across the boundary between the two subcommunities.

Column	12345
Microchloa kunthii	31...
Heliotropium strigosum	+1...
Ilysanthes schweinfurthii	11...
Scytonema sp (moss)	1+...
Grass sp A	+1...
Pancrateum sp	+....
Archidium sp (moss)	+1.+.
Grass sp F	1..+.
Crotalaria microcarpa	..43.
Killinga tenuifolia	..++.
Melliniella micrantha	..+..
Scilla sudanica	...1.
Ophiglossum costatum	...+.
Ophiglossum gomezianum	1
Sedge sp J	1
Sedge sp H/K	....+
Desmodium hirtum	....+
Hygrophila sp	2

Tab. 4: Boval vegetation on Sambara Flats (modified from Houston 1974).

7.3 Riverine forest

Bands of generally dense and species-rich forests of up to 38 m in height are found along most of the rivers in the Park. The width of these bands varies from a few metres to more than 100 m on either side of the river and is mainly determined by topography and geology. The steepness of the river banks and the resulting width of the area with well-drained deep soils determines the potential sites for riverine forest. Wide bands of riverine forest are found on the Upper Voltaian sandstone where the rivers have not cut a deep bed and where the terrain is generally flat with sandstone outcrops in the river. Fire may be an additional factor reducing the widths of the bands of riverine forest.

Common tall trees are *Khaya senegalensis*, *Daniellia oliveri*, *Diospyros mespiliformis*, *Berlinia grandiflora*, *Vitex doniana*, *Manilkara multinervis* and *Anogeissus leiocarpus*. Conspicuous trees in riverine forests are the palm trees *Borassus aethiopum* and *Raphia sudanica* and the stilt-rooted trees *Pandanus candelabrum* and *Uapaca heudelotii*. Other trees found less frequently include *Kigelia africana*, *Lonchocarpus sericeus*, *Cassia sieberiana*, *Dacryodes klaineana*, *Terminalia avicennioides*, *Vitex chrysocarpa*, *Garcinia afzelii*, *Cola laurifolia*, *Ceiba pentandra* and *Pterocarpus santalinoides*.

Hall and Houston (1974) recorded the orchid *Calyptrochilum christyanum* in *Berlinia grandiflora*.

Common shrubs in the often dense shrub-layer are *Allophylus cobbe*, *Pterocarpus erinaceus*, *Psychotria vogeliana*, *Vocanga africana*, *Uvaria chamae* and *Uvaria ovata*. Lianas such as *Agelaea* spp. and climbers such as *Paullinia pinnata* form dense tangles/curtains at the edges of the forest or in gaps.

Only a few species were found in the herb-layer during our field work. They include the herbs nos. 755, 806, 807 and 808, the ferns *Adianthum* spp. [799] and nos. 962/3, the grasses *Cymbopogon giganteus* and *Sorghum arundinaceum* and the sedge *Scleria naumanniana*. The aquatic herb *Eriocaulon* cf. *mamfeense* with its conspicuous white subglobose flowering head was found in some rivers on the Upper Voltaian sandstone.

The above description is base on field observations. The description of the following four communities is based on the analysis of 7 relevés only and must therefore be considered as preliminary.

7.3.1 *Anogeissus leiocarpus* community

The *Anogeissus leiocarpus* community is a forest with a dense tree-cover (of up to 80%) which can reach a height of up to 22 m.

The *Anogeissus leiocarpus* community is found along streams and on abandoned village sites near streams. The tree-layer is often made up of almost pure closed-canopy stands of *Anogeissus leiocarpus*. Two trees typical of river-banks, *Lonchocarpus sericeus* and

Pterocarpus santalinoides, were occasionally found in these stands. The shrub-layer is often very sparse and the patchy ground-layer either harbours the same species as savanna woodland (eg. *Andropogon tectorum*) or is dominated by *Sporobolus pyramidalis* and another grass not yet identified (R73). A more detailed list of species is given in Sobey (1974), who sampled during the rainy season.

Trees found on abandoned village sites which were originally planted include *Blighia sapida* (akee apple), *Magnifera indica* (mango), *Ceiba pentandra* (the leaves are used for soup and the fruits for 'silk') and *Adansonia digitata* (baobab tree); the latter was only found in Gbunwele and on isolated spots on the top of some scarps. Acacia thickets are abundant in some village sites (*Acacia sieberiana, A. campylacantha* and *A. hokii*) and Hall (1974d) wrote "From what the game scouts told me, it seems likely that the foliage of these species was formerly used to provide dry-season forage for cattle.". *Borassus aethiopum* is common in all village sites and even in 1974 Hall mentioned that he found only young specimens without trunks. Almost 20 years later the situation has not changed very much, although some of the palms have developed trunks of up to 40 cm high. One *Borassus* palm of 20 m height was also seen near the old Ducie Camp and several large specimens were observed around Polzen Camp.

Grasses such as *Rottboellia cochinchinensis*, *Brachiaria lata* and *Heteropogon contortus* and common weeds such as *Calotropis procera, Cleome viscosa, Sida cordifolia* and *S. rhombifolia* are abundant in patches without trees.

Sobey (1974, 1978) studied an *Anogeissus* grove in Mole National Park to verify the hypothesis that *Anogeissus* groves have developed on abandoned village sites. He gave the following reasons to support his hypothesis:

1) *Anogeissus* groves are closely associated with settlement mounds derived from collapsed huts.
2) The soils have higher levels of P, N, Ca, K and organic matter than those of the surrounding savanna, which may be due to the former human occupation. However, the differences in soil chemistry might have been the result of, rather than the cause of, the colonization of *Anogeissus* because of the absence of burning inside the stands (Sobey 1978).
3) *Anogeissus* is fire-sensitive and its establishment must have occurred during a time with no or only light fires in the abandoned village sites. After development of a closed canopy, allowing the growth of only a sparse herb layer, fires would continue to be light.

He concludes "It is thus possible that a peculiar situation (the unusual soil conditions on the sites following village abandonment) has lead to the establishment of an unusual vegetation." (Sobey 1978, p. 98).

We do not share this point of view and believe that the *Anogeissus* stands on abandoned village sites are the result of the colonisation by trees from the *Anogeissus leiocarpus* riverine forests in whose vicinity the villages were originally built. This is supported by Sobey's finding that the soil fertility in an *Anogeissus* riverine forest was comparable to that in the village site.

Anogeissus leiocarpus is a tree which prefers moist sites and is often associated with riverine forest/woodland. It is of economic importance and its hard and durable wood is used for building, carpentry, charcoal and fire-wood. The building of settlements close to *Anogeissus leiocarpus* forests, and at the same time close to water, is common throughout the savanna region.

7.3.2 *Mitragyna inermis - Andropogon gayanus* var. *gayanus* community (Hall and Jeník 1968)

Hall and Jeník (1968) classified savanna woodland in valley bottoms and along stream as *Mitragyna inermis - Andropogon gayanus* var. *gayanus* community.

Seasonally water-logged valley bottoms and flood-plains adjacent to riverine forest are often occupied by an open shrub savanna dominated by *Mitragyna inermis* between 2 and 7 m high. *Mitragyna*, together with the shrub *Ziziphus mauritiana* and the grass *Andropogon gayanus*, occasionally forms dense thickets of around 10 m in diameter.

The grass-layer is generally dominated by *Andropogon gayanus* and *Sporobolus pyramidalis* is common around the thickets.

7.3.3 754 - *Pterocarpus erinaceus* community

A relevé established on the steep banks of the Mole river was almost exclusively dominated by the tree no. 754 about 17 m high. The only other tree, *Pterocarpus erinaceus*, was found rarely. The shrub-layer was extremely sparse and consisted of isolated saplings and shrubs of no. 754.

The forest floor was mainly bare soil with litter covering about 15% of it. The only liana recorded was *Paullinia pinnata*. Isolated herbs found include *Cisampelos mucronata* and the Amaranthaceae no. 755.

7.3.4 764 - *Khaya senegalensis* community

A dense, up to 20 m high, forest was found in a depression NE of Asibey-pond. This depression, which had a small pond in the centre, becomes water-filled during the rainy season. Typical riverine trees found here are no. 764, *Khaya senegalensis* and *Vitex doniana*. The trees grow on small hummocks which also provide sites for the sparse shrub-layer which is dominated by no. 754, *Campylospermum flavum* and the broad-leaved monocotyledons *Marantochloa* purpurea and *Costus afer*. The climbers *Ipomoea involucrata* and *Abrus precatoris* were occasionally found.

The ground between the hummocks is muddy, shows abundance of buffalo trails and supports mainly grasses such as *Acroceras zizanioides* and the sedges *Scleria depressa* and *Cyperus* spec..

The yellow-flowered no. 773 and *Lemna perpusilla* were common in the pond while the pink flowers of *Heterotis rotundifolia* were seen frequently at the edge of the pond.

7.4 Flood-plain grassland and swamps

Seasonally water-logged valley bottoms and badly-drained depressions and areas around waterholes harbour a vegetation which is mainly dominated by grasses and sedges. Similar site conditions are found on the alluvial sands along the Mole river in the southern part of the Park.

Most of the grasses were dry and sterile during our field work and therefore only four relevés were established in different sites. The analysis shows four plant communities and must be considered as preliminary pending the establishment of additional relevés.

7.4.1 *Andropogon gayanus - Terminalia laxiflora* community

Andropogon gayanus was found to dominate the ground-layer of a grassland on slightly sloping ground adjacent to a depression which harbours the *Mitragyna inermis - Andropogon gayanus* var. *gayanus* community. A few herbs were found scattered between the up to 1.7 m tall bunchgrasses. Isolated trees of *Terminalia laxiflora* up to 12 m in height are common in this community.

7.4.2 *Schizachyrium* spec. community

Two grass species, namely *Schizachyrium* spec. (no. 712) and no. 714 dominate a tall and dense grassland in a depression of a seasonal stream. So far none of the few herbs which were found scattered between the grasses could be identified.

7.4.3 *Cyperus* spec. community

A robust sedge, no. 741, dominates the swamp west of the dam at the Mole Motel. A tall Poaceae (no. 742) grows frequently in the sedge-tussocks. The only other grass identified is *Paspalum scorbiculatum*. The sedge-tussocks which were isolated by water during the dry season (December) must be flooded completely during the rainy season.

The attractive purple flowers of *Ipomoea asarifolia* were found occasionally on the tussocks.

7.4.4 *Kyllinga* spec. community

A sedge, *Kyllinga* spec. (no. 967), and three unidentified grass species constitute the dense grass-layer of a swamp community which is common around the Polzen Camp area. Several sterile herbs were found scattered between the grasses, but only one specimen (no. 972) was collected.

7.5 Communities covering small areas

Special sites such as old termite mounds or depressions in sandstone plateaux which are water filled during the rainy season harbour an often highly specialised vegetation. Three communities of such sites will be briefly described below. Further surveys, especially during the rainy season, will be necessary to obtain a more complete picture.

7.5.1 Termitaria

Termite mounds are found dotted throughout the Park. These mounds provide sites for plants which are fire-sensitive (eg. *Diospyros mespiliformis*) or which cannot compete on the seasonally flooded plains. The final stage of the sere on termite mounds after erosion has almost levelled off the original mound is very often a dense clump of forest with trees up to 26 m in height.

Twelve termite mounds with tree vegetation were investigated during the field work. The mounds were between 2 and 12 m in diameter and between 60 cm and 170 cm in height.

The most common tree on the mounds is *Diospyros mespiliformis*, a species of dry forests which is also common along river banks in the savanna zone. *Khaya senegalensis* and *Afzelia africana* were occasionally recorded on the mounds. The shrub-layer, which is generally poorly developed, is dominated by *Grewia vilosa* and *G. ventusa*. The climbing shrub *Uvaria chamae* is a character species of termite mounds, where it is often found together with *Paullinia pinnata*. The sparse herb-layer was often burnt and only seedlings of *Diospyros* and the fleshy leaves of the Agavaceae *Sansevieria liberica* were found regularly.

Lannea acida, *Mitragyna inermis* and *Balanites aegyptiaca*, the fruits of which are eaten by elephants, were found on mounds in water-logged depressions. The most common shrub found here was *Securinega virosa*.

The description of the following two communities is based on Hall and Houston (1974):

7.5.2 Wet gully vegetation

Hall and Houston (1974) described a wet gully vegetation on Konkori scarp above the camp. This type of vegetation was found in a gully with vertical sandstone walls about 10 m high. The walls were covered with ferns including: *Lycopodium cernuum, Pityrogramma calomelanos* and *Thelypteris microbasis*. The first two are abundant on road cuttings in the moist forest zone, the latter is rare in Ghana. Species found along the river include *Dissotis elliottii, Xyris decipiens, Aframomum baumannii* and the shrubs *Alchornea cordifolia* and *Ficus congensis*.

When we visited the same spot in February 1993 the ground-layer was completely dry and no ferns could be found. *Khaya senegalensis* was common at the head of the gorge.

7.5.3 Pterophytic vegetation

Hall and Houston (1974) described a pterophytic vegetation on flat rocks on Konkori scarp on shallow soil in cracks and pockets in the flat tops of sandstone rocks. For this type of vegetation they listed *Tephrosia letestui*, the small ferns *Ophioglossum costatum* and *O. gomezianum* and *Indigofera omissa*.

8. RECOMMENDATIONS

The vegetation of Mole National Park is a fine example of a typical and fairly undisturbed Guinea savanna ecosystem. The majority of its plants and plant communities are common and widespread throughout the Guinea savanna. However, the number of species of conservation value found in Mole is relatively high (see Tab. 3), but their abundance is low and they are often restricted to sites which cover only small areas within the Park.

The lack of disturbance and the remoteness, the scenic beauty, and the considerable amount of wildlife make Mole a prime area for tourism, recreation, education and research.

The only significant threat to the vegetation and the small and therefore vulnerable sites which harbour plant communities differing from the widespread savanna woodland is fire. A burning policy in conjunction with the education of the people living around the Park concerning burning are essential to allow the persistence of the Mole ecosystem.

8.1 Management objectives

The over all management objective, suggested from the botanical point of view, could be:

to protect and maintain this fairly undisturbed ecosystem including its wildlife and vegetation, and to preserve the genetic diversity

More detailed objectives to achieve this and at the same time to maintain the value of the Park for Ghana are summarized in the box below:

to institute a research and monitoring programme to provide the management with scientific data for management decisions
to apply a fire policy which will maintain the perpetuity of the ecosystem and protect its soils and watercatchment function
to develop the tourism and education potential
to allow public use of selected botanical resources through sustainable harvesting in approved zones and during limited periods

8.1.1 Monitoring and research

Research and monitoring provide the scientific data necessary for management decisions. This is an effective way to detect changes, to establish the significance of the changes (ie. acceptable short-term changes or unacceptable long-term changes), to determine the appropriate management response(s) and to assess the effectiveness of any measures carried out.

The establishment of a research station in Mole and close cooperation with universities and scientists both inside and outside Ghana is important for the successful running of a research and monitoring programme.

1) Vegetation monitoring

Vegetation changes should be monitored in two ways:
* A system of permanent transects and
* Fixed point photos of the dam below Mole Motel (for details see Schmitt 1993).

Special consideration should be given to the impact of fire on the status and dynamics of the vegetation. The impact of fire can be best monitored by using a system of permanent plots which are treated in different ways such as early burning, late burning and no burning (see Schmitt 1993).

Wind speed has a significant impact on the severity of fire and therefore detailed observations on the wind situation during the fire season could provide important information for the development of a burning plan.

2) Fire

A systematic documentation of the annual burning patterns would help the development of a fire plan. The micro-light aircraft could be used to fly along a system of fixed transects during the dry season and map the annual burn pattern.

The impact of fire on the status and dynamics of the vegetation and the availability of grassing and browsing material should be studied, using permanent plots (see above).

The impact of fire on the riverine forest should also be studied in two sites, namely riverine forest with an abrupt margin and that with a gradual transition into savanna woodland.

3) Climate

A network of rain-gauges should be established throughout the Park. The data would be of importance for the analysis of the vegetation monitoring data.

Wind speed should be recorded at selected sites where the effect of fire is to be monitored.

A weather station should be established at the head-quarters.

8.1.2 Fire policy

A fire policy should be developed which is based on the findings of monitoring and research as described above. This will not only stop unnecessary destruction of the vegetation but will also ensure that there will be always enough grazing and browsing material for the wildlife populations of the Park. It will furthermore contribute to the protection of the soil and the maintenance of the watercatchment function of Mole for the Volta River.

A number of fire exclosure experiments have been carried out in West Africa, several of them in the Guinea Savanna Zone (cf. Rose Innes 1972, Sanford and Isiche 1986). The results can be summarized as follows:

- Late burning, when carried out annually, will be devastating to the savanna woodland, while early burning (or complete protection) will lead to an increase in the number of trees (Keay 1960).
- Late burning results in a higher basal cover of perennial grasses than early burning, but causes greater loss of organic soil matter (Afolayan 1979).

A combination of a shifting pattern of regular early burning which leaves some areas unburnt and occasional (eg. every five years) late burning to maintain a balance between tree-cover and perennial grass-cover would be a possible policy.

8.1.3 Tourism potential and education

The tourism potential of the Park needs considerable development. This would include improvement of the accommodation at Mole Motel and Lovi Camp and construction of additional tourist camps eg. at Konkori Scarp and at the Polzen River near the water fall.

The existing Nature Trail should be improved (sign boards etc.) and an up-to-date version of the Guide to the Nature Trail should be produced.

The existing museum and visitor centre should be improved and expanded. Posters, guide books and slide shows prepared and an education programme initiated.

Conservation education should be extended to the communities around the Park. This is very important in order to enable a sensible fire policy to be conducted.

8.1.4 Utilisation of botanical resources

The communities around the Park should be allowed to use selected botanical resources within the Park through sustainable harvesting in approved zones and during certain periods.

The sustainable utilisation of botanical resources which have been used traditionally by the local people and which are not endangered could be permitted in restricted areas (eg. Traditional Use Zones).

Upper limits for the amount of resources harvested and the size of the Traditional Use Zones should be determined according to the experience of the Park staff who currently collect firewood, Shea-nuts and Dawa-dawa. As soon as possible an on-going monitoring programme should be carried out to ensure the sustaiability of the utilisation. The conditions of access and the amount of resources to be harvested may have to be modified as a consequence of the monitoring results.

1) *Vitellaria paradoxa* (Shea-butter tree): This tree is very common in Mole National Park. The fruits, seeds and wood of *Vitellaria paradoxa* are widely used. A review is given in Bakang (1981). The collection of the nuts and production of shea butter and cooking oil plays an important role in the local economy.

2) *Parkia biglobosa* (Dawa-dawa): *Parkia* is found throughout the Park, but far less frequently than *Vitellaria*. The seeds and a "yellow powder around the seeds" are used for food. Information on *Vitellaria*, *Parkia* and wood consumption and gathering practices is given in Norton (1988).

3) Grasses for thatching are abundant in the Park.

Firewood collection should not be permitted and the GWD staff should be encouraged to use other means for cooking such as gas and solar energy. Furthermore the GWD could help the people who are living around the Park with the establishment of communal woodlots, thus easing the pressure on the woody vegetation of the Park.

Lack (1976b) reported that the honeybee (*Apis mellifera*) visited *Detarium microcarpum* and *Maranthes polyandra* in abundance, which suggests the possibility of bee-keeping in the area.

Some of the camp staff collects honey but uses destructive burning to harvest the honey. They would also benefit from the introduction of bee-keeping.

8.2 Suggestions for further research

Mole provides an ideal opportunity for research on savanna ecology. Possible topics are:
- The effect of grazing on the structure and dynamics of the vegetation
- The effect of seasonal flooding on seasonal changes of species composition
- The succession on old village sites: Gbantala village, which was abandoned in December 1992 provides an ideal opportunity for long-term research.
- The ecology of *Borassus aethiopum* (see section 7.3.1)
- Phenology and ecology of *Vitellaria paradoxa*
- Phenology and pollination of savanna trees (eg. *Maranthes polyandra* shows adaptations typical of bat-pollination; Lock and Marshall 1975 and Lack 1976b)

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APPENDIX 1: VASCULAR PLANTS OF MOLE NATIONAL PARK

Old names are given in brackets
* LIFE-FORM: T=tree, S=shrub, H=herb, G=grass, C=climber, E=epiphyte, F=fern
** HABITAT: F=forest, R=riverine forest, M=forest margin/thicket, G=grassland, S=swamp, A=aquatic, W=weed/ruderal

	*	**
ACANTHACEAE		
Asystasia gangetica (L.) T. Anders.	H	FW
Barleria ruellioides T. Anders.	H	R
Blepharis maderaspatensis (L.) Heyne ex Roth	H	W
Dyschoriste perrottetii (Nees) O. Ktze.	H	R
Hygrophila senegalensis (Nees) T. Anders.	H	G
Justicia flava (Forssk.) Vahl	H	M
Justicia insularis T. Anders.	H	W
Lepidagathis alopecuroides (Vahl) R. Br. ex Griseb.	H	R
Lepidagathis anobrya Nees	H	G
Lepidagathis collina (Endl.) Milne-Redhead	H	G
Monechma ciliatum (Jacq.) Milne-Redhead	H	G
Monechma ndellense (Lindau) Miège & Heine	H	G
Nelsonia canescens (Lam.) Spreng	H	W
Phaulopsis ciliata (Willd.) Hepper (P. falcisepala)	H	R
Ruellia togoensis (Lindau) Heine	H	R
ADIANTACEAE		
Adiantum incisum Forssk.	F	F
Adiantum phillipense L.	F	F
Pityrogramma calomelanos (L.) Link	F	F
AGAVACEAE		
Sansevieria liberica Gér. & Labr.	H	FG
AMARANTHACEAE		
Achyranthes aspera L.	H	FW
Alternanthera pungens Kunth (A. repens)	H	W
Alternanthera sessilis (L.) R. Br. ex Roth	H	W
Amaranthus spinosus L.	H	W
Celosia trigyna L.	H	W
Cyathula achyranthoides (H. B. & K.) Moq.	H	FW
Pandiaka angustifolia (Vahl) Hepper (P. heudelotii)	H	WG
Pandiaka involucrata (Moq.) Hook.f.	H	G
AMARYLLIDACEAE		
Crinum distichum Herb.	H	G
Crinum glaucum A. Chev.	H	G
Pancratium tenuifolium Hochst. ex A. Rich (P. hirtum)	H	G
Pancratium trianthum Herb.	H	G
Scadoxus multiflorus (Martyn) Raf. (Haemanthus multiflorus)	H	GM
ANACARDIACEAE		
Haematostaphis barteri Hook.f.	T	M
Lannea acida A. Rich.	T	G
Lannea kerstingii Engl. & K. Krause	T	G
Lannea microcarpa Engl. & K. Krause	T	G
Ozoroa insignis Del. (Heeria insignis)	S	G
Ozoroa pulcherrima (Schweinf.) R. & A. Fernandes (Heeria pulcherrima)	S	G
Sclerocarya birrea (A. Rich.) Hochst.	T	G
ANNONACEAE		
Annona glauca var. glauca Schum. & Thonn.	S	G
Annona senegalensis Pers.	T	G
Hexalobus monopetalus (A. Rich.) Engl. & Diels	T	G
Mischogyne elliotiana (Engl. & Diels) Friis (Uvariastrum elliotianum)	T	R
Monodora tenuifolia Benth.	T	F
Uvaria chamae P. Beauv.	C	MR
Xylopia parviflora (A. Rich.) Benth.	T	R
APIACEAE (Labiatae)		
Steganotaenia araliacea Hochst.	T	G
APOCYNACEAE		
Ancylobotrys amoena Hua	C	M
Saba comorensis (Bojer) Pichon (S. florida)	C	M
Strophanthus sarmentosus DC.	C	F

ARACEAE		
Amorphophallus cf. flavovirens N.E. Br.	H	M
Amorphophallus dracontioides (Engl.) N.E. Br.	H	G
Anchomanes difformis (Bl.) Engl.	H	FM
Culcasia saxatilis A. Chev.	C	FR
Stylochiton hypogaeus Lepr.	H	G
Stylochiton lancifolius Kotschy & Peyr.	H	G
ARALIACEAE		
Cussonia arborea (C. barteri)	T	G
ARECACEAE (Palmae)		
Borassus aethiopum Mart.	T	G
Elaeis guineensis Jacq.	T	M
Raphia sudanica A. Chev.	T	R
ARISTOLOCHIACEAE		
Aristolochia albida Duchartre	C	G
ASCLEPIADACEAE		
Ectadiopsis oblongifolia (Meisn.) Schltr	H	G
Gongronema obscurum Bullock	H	G
Gymnema sylvestre (Retz.) Schultes	C	MR
Leptadenia hastata (Pers.) Decne.	C	G
Raphionacme keayii Bullock	H	G
Raphionacme vignei Bruce	H	G
Tacazzea apiculata Oliv.	C	R
ASTERACEAE (Compositae)		
Acanthospermum hispidum DC.	H	W
Adenostemma caffrum DC.	H	R
Aedesia baumannii O. Hoffm.	H	G
Ageratum conyzoides L.	H	W
Aspilia angustifolia Oliv. & Hiern	H	G
Aspilia bussei O. Hoffm. & Muschl.	H	G
Aspilia ciliata (Schum.) Morton (A. helianthoides)	H	G
Aspilia linearifolia Oliv. & Hiern	H	G
Bidens pilosa L.	H	W
Coreopsis borianiana Sch. Bip.	H	G
Dicoma sessiliflora Harv.	H	G
Echinops longifolius A. Rich.	H	G
Gutenbergia macrocephala Oliv. & Hiern	H	G
Melanthera elliptica O. Hoffm.	H	M
Mikania chenopodiifolia Willd. (M. cordata)	C	R
Pleiotaxis newtonii O. Hoffm.	H	G
Vernonia amygdalina Del.	S	R
Vernonia camporum A. Chev.	H	G
Vernonia guineensis Benth.	H	G
Vernonia nigritiana Oliv. & Hiern	H	G
Vernonia purpurea Sch. Bip. ex Walp.	H	G
BIGNONIACEAE		
Kigelia africana (Lam.) Benth.	T	GR
Markhamia tomentosa (Benth.) K. Schum. ex Engl.	T	M
Stereospermum kunthianum Cham.	T	G
BOMBACACEAE		
Adansonia digitata L.	T	MG
Bombax costatum Pellegr. & Vuillet	T	G
Ceiba pentandra (L.) Gaertn.	T	F
BORAGINACEAE		
Heliotropium indicum L.	H	W
Heliotropium strigosum Willd.	H	G
BURSERACEAE		
Boswellia dalzielii Hutch.	T	M
Dacryodes klaineana (Pierre) H.J. Lam	T	F
CAPPARACEAE		
Cadaba farinosa Forssk.	S	G
Cleome viscosa L.	H	W
Maerua angolensis DC.	S	G
Maerua oblongifolia (Forssk.) A. Rich.	H	G
Maerua pseudopetalosa (Courbonia virgata)	S	G
CARYOPHYLLACEAE		
Polycarpaea corymbosa (L.) Lam.	H	G
Polycarpaea eriantha Hochst. ex A. Rich.	H	G
Polycarpaea linearifolia (DC.) DC.	H	G

Polycarpaea tenuifolia (Willd.) DC.	H	G
CELASTRACEAE		
Apodostigma pallens (Hippocratea pallens)	C	M
Mayteuus senegalensis (Lam.) Exell	T	G
CERATOPHYLLACEAE		
Ceratophyllum demersum L.	H	A
CHRYSOBALANACEAE		
Parinari congensis F. Didr.	T	G
Parinari curatellifolia Planch. ex Benth.	T	G
Parinari polyandra Benth.	T	G
COCHLOSPERMACEAE		
Cochlospermum planchonii Hook.f. ex Planch.	S	G
Cochlospermum tinctorium A. Rich.	H	G
COMBRETACEAE		
Anogeissus leiocarpus (DC.) Guill. & Perr.	T	M
Combretum collinum Fresen. ssp. binderianum (Kotschy) Okafor (C. binderianum)	T	G
Combretum collinum Fresen. ssp. geitonophyllum (C. lamprocarpum)	T	G
Combretum collinum Fresen. ssp. hypopilinum (C. hypopilinum)	T	G
Combretum fragrans F. Hoffm. (C. ghasalense)	T	G
Combretum glutinosum Perr. ex DC.	T	G
Combretum molle G. Don	T	G
Combretum nigricans Lepr. ex Guill. & Perr.	T	M
Pteleopsis suberosa Engl. & Diels	T	G
Quisqualis indica L.	C	R
Terminalia avicennioides Guill. & Perr.	T	F
Terminalia glaucescens Planch. ex Benth.	T	G
Terminalia ivorensis A. Chev.	T	F
Terminalia laxiflora Engl.	T	G
Terminalia macroptera Guill. & Perr.	T	G
Terminalia mollis Laws.	T	G
COMMELINACEA		
Aneilema umbrosum var. umbrosum (Vahl) Kunth	H	F
COMMELINACEAE		
Aneilema lanceolatum Benth.	H	G
Aneilema paludosum A. Chev.	H	G
Aneilema setiferum A. Chev. var. pallidiciliatum J.K. Morton	H	G
Aneilema umbrosum (Vahl) Kunth	H	F
Commelina aspera Benth.	H	G
Commelina congesta C.B. Cl.	H	G
Commelina diffusa Burm.f.	H	RS
Commelina erecta L.	H	M
Commelina lagosensis C.B. Cl.	H	M
Commelina nigritana Benth.	H	G
Cyanotis angusta C.B. Cl.	H	G
Cyanotis lanata Benth.	H	G
Cyanotis longifolia Benth.	H	G
Murdannia simplex (Vahl) Brenan	H	G
CONNARACEAE		
Agelaea obliqua[1] (P. Beauv.) Baill.	C	F
Byrsocarpus coccineus Schum. & Thonn.	C	M
CONVOLVULACEAE		
Evolvulus alsinoides (L.) L.	H	G
Evolvulus nummularius (L.) L.	H	W
Ipomoea argentaurata Hallier f.	H	G
Ipomoea asarifolia (Desr.) Roem. & Schult.	H	G
Ipomoea heterotricha F. Didr.	C	G
Ipomoea involucrata P. Beauv.	C	F
Ipomoea mauritiana Jacq.	C	M
Lepistemon owariense (P. Beauv.) Hallier f.	C	R
Merremia hederacea (Burm.f.) Hallier f.	C	R
Merremia kentrocaulos (C.B. Cl.) Hallier f.	C	M
Merremia pinnata (Hochst. ex Choisy) Hallier f.	C	R
Stictocardia laxiflora	C	M
CUCURBITACEAE		
Cucumis melo L.	C	W
Mukia maderaspatana (L.) M.J. Roem. (Melothria maderaspatana)	C	G
Trochomeria macrocarpa (Sond.) Hook.f. (T. macroura)	C	G

[1] This species has been incuded in *A. pentagyna* agg. (Hawthorne 1993; FROGGIE).

CYPERACEAE		
Ascolepis capensis (Kunth) Ridley	G	G
Ascolepis dipsacoides (Schum.) J. Raynal	G	G
Ascolepis protea Welw.	G	G
Bulbostylis abortiva (Steud) C.B. Cl.	G	G
Bulbostylis coleotricha (A. Rich.) C.B. Cl.	G	G
Bulbostylis filamentosa (Vahl) C.B. Cl.	G	G
Bulbostylis metralis Cherm.	G	G
Bulbostylis pusilla (A. Rich.) C.B. Cl.	G	G
Bulbostylis scabricaulis Cherm.	G	G
Cyperus amabilis Vahl	G	G
Cyperus cuspidatus Kunth	G	G
Cyperus difformis L.	G	G
Cyperus dilatatus Schum. & Thonn.	G	G
Cyperus exaltatus Retz.	G	S
Cyperus halpan L. (C. haspan)	G	G
Cyperus karlschumannii C.B. Cl.	G	G
Cyperus podocarpus Boeck.	G	G
Cyperus pustulatus Vahl	G	G
Cyperus reduncus Hochst. ex Boeck.	G	G
Cyperus submicrolepis Kuek.	G	G
Cyperus tenuiculmis Boeck. var. schweinfurthianus (Boek.) Hopper	G	G
Cyperus tenuispica Steud.	G	G
Diplacrum africanum C.B. Cl.	G	G
Eleocharis setifolia (A. Rich.) J. Raynal	G	G
Fimbristylis alboviridis C.B. Cl.	G	G
Fimbristylis debilis Steud.	G	G
Fimbristylis dichotoma var. dichotoma (L.) Vahl	G	G
Fimbristylis dichotoma (L.) Vahl var. pluristriata (C.B. Cl.) Napper	G	G
Fimbristylis hispidula (Vahl) Kunth	G	G
Fimbristylis littoralis Gaud.	G	G
Fimbristylis ovata (Burm.f.) Kern	G	G
Fimbristylis pilosa Vahl	G	G
Fimbristylis scabrida Schumach.	G	G
Fuirena ciliaris (L.) Roxb.	G	G
Fuirena umbellata Rottb.	G	G
Kyllinga echinata Hooper	G	G
Kyllinga nigritana C.B. Cl.	G	G
Kyllinga sp. aff. odorata Vahl	G	G
Kyllinga tenuifolia Steud.	G	G
Lipocarpha albiceps Ridl.	G	G
Lipocarpha prieuriana Steud.	G	G
Lipocarpha sphacelata (Vahl) Kunth	G	G
Mariscus cylindristachyus Steud. (M. alternifolius)	G	M
Mariscus luridus C.B. Cl.	G	G
Mariscus squarrosus (L.) C.B. Cl.	G	G
Pycreus lanceolatus (Poir.) C.B. Cl.	G	G
Rhynchospora corymbosa (L.) Britt.	G	G
Rikliella kernii (Raym.) J. Raynal (Scirpus kernii)	G	G
Schoenoplectus senegalensis (Hochst. ex Steud.) Palla (Scirpus jacobii)	G	G
Scleria achtenii De Wild. (S. substriatoalveolata)	G	G
Scleria depressa (C.B. Cl.) Nelmes	G	SM
Scleria melanotricha Hochst. ex A. Rich.	G	G
Scleria naumanniana Boeck.	G	M
Scleria pergracilis (Nees) Kunth	G	G
Scleria sphaerocarpa (E.A. Rob.) Napper	G	G
DAVALLIACEAE		
Nephrolepis undulata (Afzel. ex Sw.) J. Sm.	F	F
DILLENIACEAE		
Tetracera alnifolia Willd.	C	F
DIOSCOREACEAE		
Dioscorea abyssinica Hochst. ex Kunth	C	M
Dioscorea bulbifera L.	C	M
Dioscorea dumetorum (Kunth) Pax	C	M
DIPTEROCARPACEAE		
Monotes kerstingii Gilg	T	G
DROSERACEAE		
Drosera indica L.	H	G

EBENACEAE		
Diospyros elliotii (Hiern) F. White	T	R
Diospyros mespiliformis Hochst. ex A. DC.	T	F
ERIOCAULACEAE		
Eriocaulon cf. mamfeense Meikle	H	A
Eriocaulon cinereum R. Br.	H	G
ERYTHROXYLACEAE		
Erythroxylum emarginatum Thonn.	S	F
EUPHORBIACEAE		
Alchornea cordifolia (Schum. & Thonn.) Muell. Arg.	T	FG
Antidesma venosum Tul.	T	R
Bridelia ferruginea Benth.	T	G
Bridelia scleroneura Muell. Arg.	T	G
Caperonia palustris (Linn.) St.-Hil.	H	G
Croton nigritanus Sc. Elliot	S	R
Croton pseudopulchellus Pax	S	M
Drypetes floribunda (Muell. Arg.) Hutch.	T	F
Euphorbia baga A. Chev.	H	G
Euphorbia convolvuloides Hochst. ex Benth.	H	WG
Euphorbia hirta L.	H	W
Euphorbia prostrata Ait.	H	W
Hymenocardia acida Tul.	T	G
Jatropha neriifolia Muell. Arg.	H	G
Phyllanthus amarus Schum. & Thonn.	H	W
Phyllanthus beillei Hutch.	S	M
Phyllanthus discoideus (Baill.) Muell. Arg.	T	F
Phyllanthus muellerianus (O. Ktze.) Exell	S	F
Phyllanthus reticulatus Poir.	S	R
Phyllanthus sp. aff. sublanatus	H	G
Phyllanthus sublanatus Schum. & Thonn.	H	G
Sapium dalzielii Hutch.	H	G
Sapium grahamii (Stapf) Prain	H	G
Securinega virosa (Roxb. ex Willd.) Baill.	S	M
Uapaca togoensis Pax	T	G
FABACEAE (Leguminosae)		
CAESALPINIOIDEAE		
Afzelia africana Sm.	T	G
Berlinia grandiflora (Vahl) Hutch. & Dalz.	T	R
Burkea africana Hook.	T	G
Cassia absus L.	H	W
Cassia mimosoides L.	H	G
Cassia obtusifolia L. (C. torta)	H	W
Cassia sieberiana DC.	H	R
Daniellia oliveri (Rolfe) Hutch. & Dalz.	T	G
Detarium microcarpum Guill. & Perr	T	G
Dialium guineense Willd.	T	F
Erythrophleum africanum (Welw. ex Benth.) Harms	T	G
Isoberlinia doka Craib & Stapf	T	G
Isoberlinia tomentosa (Harms) Craib & Stapf (I. dalzielii)	T	G
Piliostigma thonningii (Schum.) Milne-Redhead	T	G
Tamarindus indica L.	T	G
MIMOSOIDEAE		
Acacia dudgeoni Craib ex Holl.	T	G
Acacia gourmaensis A. Chev.	T	G
Acacia hockii De Wild.	T	G
Acacia polyacantha Willd. ssp. campylacantha (Hoechst. ex A. Rich.) Brenan	T	G
Acacia sieberiana DC.	T	G
Amblygonocarpus andongensis (Oliver) Exell & Torre	T	G
Dichrostachys cinerea (L.) Wight & Arn. (D. glomerata)	S	G
Entada abyssinica Steud. ex A. Rich.	T	G
Entada africana Guill. & Perr.	T	G
Mimosa pigra L.	S	R
Parkia biglobosa Don (P. clappertoniana)	T	G
Prosopis africana (Guill. & Perr.) Taub.	T	G
PAPILIONOIDEAE		
Abrus precatorius L.	C	R
Adenodolichos paniculatus (Hua) Hutch. & Dalz.	S	G
Aeschynomene indica L.	H	G
Aeschynomene kerstingii Harms	H	G

Alysicarpus glumaceus (Vahl) DC.	H	G
Alysicarpus ovalifolius (Schum. & Thonn.) J. Léonard	H	G
Alysicarpus rugosus (Willd.) DC.	H	G
Atylosia scarabaeoides (L.) Benth.	C	G
Crotalaria axillaris Ait.	S	M
Crotalaria calycina Schrank	H	G
Crotalaria confusa Hepper	H	G
Crotalaria goreensis Guill. & Perr.	H	G
Crotalaria leprieurii Guill. & Perr. (C. vogelii)	H	G
Crotalaria macrocalyx Benth.	H	G
Crotalaria microcarpa Hochst. ex Benth.	H	G
Crotalaria mortonii Hepper	H	G
Desmodium gangeticum var. gangeticum (L.) DC.	H	G
Desmodium hirtum Guill. & Perr.	H	G
Desmodium laxiflorum DC.	H	M
Desmodium ramosissimum G. Don	H	G
Desmodium salicifolium (Poir.) DC.	S	G
Desmodium velutinum (Willd.) DC.	S	M
Eriosema griseum Bak.	H	G
Eriosema pulcherrimum Taub.	H	G
Eriosema spec.	H	G
Flemingia faginea (Guill. & Perr.) Bak. (Moghania faginea)	S	R
Indigofera barteri Hutch. & Dalz.	H	G
Indigofera berhautiana Gillett	H	G
Indigofera bracteolata DC.	H	G
Indigofera conferta Gillett	H	G
Indigofera congolensis De Wild. & Th. Dur.	H	G
Indigofera dendroides Jacq.	H	G
Indigofera geminata Bak.	H	G
Indigofera hirsuta L.	H	W
Indigofera kerstingii Harms	H	G
Indigofera leprieurii Bak.f.	H	G
Indigofera macrocalyx Guill. & Perr.	H	G
Indigofera nigricans Vahl ex Pers.	H	G
Indigofera nigritana Hook.f.	H	R
Indigofera omissa Gillett	H	G
Indigofera oubanguiensis Tiss.	S	G
Indigofera paniculata Vahl ex Pers.	H	G
Indigofera stenophylla Guill. & Perr. var. ampla Sprague	H	G
Indigofera tetrasperma Vahl ex Pers.	H	G
Indigofera trialata A. Chev.	H	G
Indigofera trichopoda Lepr. ex Guill. & Perr.	H	G
Lonchocarpus cyanescens (Schum. & Thonn.) Benth.	C	M
Lonchocarpus laxiflorus Guill. & Perr.	T	G
Lonchocarpus sericeus (Poir.) H. B. & K.	T	G
Macrotyloma biflorum (Schum. & Thonn.) Hepper (Dolichos chrysanthus)	C	G
Melliniella micrantha Harms	H	G
Mucuna pruriens (L.) DC.	C	M
Pericopsis laxiflora (Benth. ex Bak.) van Meeuwen (Afrormosia laxiflora)	T	G
Pseudarthria hookeri Wight & Arn.	H	G
Psophocarpus palustris Desv.	C	R
Pterocarpus erinaceus Poir.	T	G
Pterocarpus lucens Lepr.	T	M
Pterocarpus santalinoides L'Hér. ex DC.	T	R
Rhynchosia densiflora (Roth) DC.	C	M
Rhynchosia minima (L.) DC.	C	G
Rhynchosia nyasica Bak.	S	G
Rhynchosia sublobata (Schum. & Thonn.) Meikle	C	G
Sphenostylis schweinfurthii Harms	H	G
Tephrosia elegans Schum.	H	G
Tephrosia letestui Tisserant	H	G
Tephrosia mossiensis A. Chev.	H	G
Tephrosia pedicellata Bak.	H	G
Tephrosia platycarpa Guill. & Perr. (T. flexuosa)	H	G
Teramnus labialis (L.f.) Spreng.	C	G
Uraria picta (Jacq.) DC.	H	G
Vigna ambacensis Welw. ex Bak. (V. pubigera)	C	G
Vigna filicaulis Hepper	C	S
Vigna racemosa (G. Don.) Hutch & Dalz.	C	G

Vigna reticulata Hook.f.	C	G
Xeroderris stuhlmannii (Taub.) Mendoca & E. P. Sousa (Ostryoderris stuhlmannii)	T	G
Zornia glochidiata Reichb. ex DC.	H	G
FLACOURTIACEAE		
Dissomeria crenata Hook.f. ex Benth.	T	R
Flacourtia flavescens Willd.	T	M
Oncoba spinosa Forssk.	T	M
GENTIANACEAE		
Canscora diffusa (Vahl) R. Br. ex Roem. & Schult.	H	R
GUTTIFERAE		
Garcinia afzelii Engl.	T	F
Garcinia ovalifolia Oliv.	T	R
Psorospermum corymbiferum Hochr.	S	G
HIPPOCRATEACEAE (CELASTRACEAE)		
Salacia leptoclada Tul. (S. baumannii)	C	F
Salacia togoica Loes.	C	F
HYDROPHYLLACEAE		
Hydrolea macrosepala A. W. Bennett	H	G
HYPOXIDACEAE		
Curculigo pilosa (Schum. & Thonn.) Engl.	H	G
ICACINACEAE		
Icacina oliviformis (Poiret) Raynal (I. senegalensis)	S	G
IRIDACEAE		
Gladiolus gregarius Welw. ex Bak.	H	G
Gladiolus klattianus Hutch.	H	G
LAMIACEAE (Labiatae)		
Aeolanthus pubescens Benth.	H	G
Haumaniastrum caeruleum (Oliv.) J. K. Morton	H	G
Hoslundia opposita Vahl	S	M
Hyptis lanceolata Poir.	H	G
Hyptis spicigera Lam.	H	G
Hyptis suaveolens Poit.	H	W
Leucas martinicensis (Jacq.) R. Br.	H	W
Ocimum canum Sims	H	W
Orthosiphon rubicundus (D. Don) Benth.	H	G
Platostoma africanum P. Beauv.	H	G
Solenostemon latifolius (Hochst. ex Benth.) J. K. Morton	H	G
Tinnea barteri Guerke	S	G
LAURACEAE		
Cassytha filiformis L.	H	M
LEMNACEAE		
Lemna perpusilla Torrey (L. paucicostata)	H	A
LENTIBULARIACEAE		
Utricularia subulata L.	H	G
LILIACEAE		
Aloe buettneri A. Berger	H	G
Asparagus flagellaris (Kunth) Bak.	H	G
Chlorophytum aureum Engl.	H	M
Chlorophytum blepharophyllum Schweinf. ex Bak.	H	M
Chlorophytum pusillum Schweinf. ex Bak.	H	MG
Chlorophytum stenopetalum Bak.	H	M
Chlorophytum togoense Engl.	H	M
Eriospermum abyssinicum Bak.	H	G
Gloriosa simplex L.	H	G
Scilla sudanica A. Chev.	H	G
Urgenia altissima (L.f.) Bak.	H	G
LOGANIACEAE		
Anthocleista vogelii Planch.	T	R
Strychnos innocua Del.	T	G
Strychnos nigritana Bak.	C	M
Strychnos spinosa Lam.	T	G
Usteria guineensis Willd.	C	F
LOMARIOPSIDACEAE		
Bolbitis acrostichoides (Afzel. ex Sw.) Ching	F	F
LORANTHACEAE		
Englerina lecardii (Engl.) Balle	S	G
Tapinanthus belvisii (DC.) Danser	S	G
Tapinanthus dodoneifolius (DC.) Danser	S	G

LYCOPODIACEAE		
Lycopodium cernuum L.	H	F
LYTHRACEAE		
Ammannia auriculata Willd.	H	G
Ammannia baccifera L.	H	S
Ammannia prieureana Guill. & Perr.	H	S
Rotala tenella (Guill. & Perr.) Hiern	H	GS
Rotala welwitschii Exell (R. decussata)	H	G
MALPIGHIACEAE		
Flabellaria paniculata Cav.	C	F
Rhinopterys angustifolia Sprague	S	G
MALVACEAE		
Abutilon ramosum (Cav.) Guill. & Perr	S	M
Gossypium hirsutum L.	S	W
Hibiscus articulatus Hochst. ex A. Rich.	H	G
Hibiscus asper Hook.f.	H	S
Hibiscus gourmania Hutch. & Dalz.	H	G
Hibiscus scotellii Bak.f.	H	M
Sida acuta Burm.f.	H	W
Sida alba L.	H	G
Sida cordifolia L.	H	W
Sida linifolia Juss. ex Cav.	H	G
Sida rhombifolia L.	H	W
Sida urens L.	H	M
Wissadula rostrata (Schum. & Thonn.) Hook.f. (W. amplissima)	S	M
MARANTACEAE		
Marantochloa purpurea (Ridl.) Milne-Redh.	H	F
Thalia welwitschii Ridl.	H	GR
MARSILEACEAE		
Marsilea spec.	F	G
MELASTOMATACEAE		
Dissotis elliotii Gilg var. setosior Keay & Brenan	H	R
Heterotis rotundifolia (Sm.) Jac.-Fél. (Dissotis rotundifolia)	H	F
MELIACEAE		
Khaya senegalensis (Desv.) A. Juss.	T	M
Pseudocedrela kotschyi (Schweinf.) Harms	T	G
Trichilia emetica (T. roka) ssp. suberosa Vahl J. Wilde	T	G
MENISPERMACEAE		
Cissampelos mucronata A. Rich.	C	G
Triclisia subcordata Oliv.	C	F
MOLLUGINACEAE		
Mollugo nudicaulis Lam.	H	W
MORACEAE		
Antiaris toxicaria Lesch. (A. africana)	T	F
Ficus abutilifolia (Miq.) Miq.	T	M
Ficus asperifolia Miq.	S	R
Ficus congensis Engl.	T	F
Ficus glumosa Delile	T	M
Ficus gnaphalocarpa (Miq.) Steud. ex A. Rich.	T	G
Ficus ingens (Miq.) Miq.	T	G
Ficus platyphylla Delile	T	G
Ficus sur Forssk. (F. capensis)	T	FG
Ficus tessellata Warb.	T	F
Ficus thonningii Blume	T	M
MYRTACEAE		
Syzygium guineense (Willd.) DC.	T	R
NYCTAGINACEAE		
Boerhavia coccinea Mill.	H	W
Boerhavia diffusa L.	H	W
Boerhavia erecta L.	H	W
NYMPHAEACEAE		
Nymphaea lotus L.	H	A
Nymphaea micrantha Guill. & Perr.	H	G
OCHNACEAE		
Campylospermum flavum (Schum. & Thonn. ex Stapf) Farron (Ouratea flava)	S	F
Campylospermum glaberrimum (P. Beauv.) Farron (Ouratea glaberrima)	S	F
Lophira lanceolata van Tiegh. ex Keay	T	G
Ochna afzelii R. Br. ex Oliv.	T	M
Ochna schweinfurthiana F. Hoffm.	T	G

OLACACEAE		
Olax subscorpioidea Oliv.	T	F
Ximenia americana L.	T	GR
OLEACEAE		
Jasminum kerstingii Gilg & Schellenb.	H	G
Linociera nilotica Oliv.	T	R
ONAGRACEAE		
Ludwigia erecta (L.) Hara (Jussiaea erecta)	H	G
Ludwigia hyssopifolia (G. Don.) Exell (Jussiaea linifolia)	H	G
Ludwigia octovalvis (Jacq.) Raven (Jussiaea suffruticosa)	H	S
Ludwigia perennis L. (Jussiaea perennis)	H	G
Ludwigia stenorraphe (Brenan) Hara (Jussiaea stenorraphe)	H	G
OPHIOGLOSSACEAE		
Ophioglossum costatum R. Br.	F	G
Ophioglossum gomezianum A. Braun	F	G
OPILIACEAE		
Opilia amentacea Roxb. (O. celtidifolia)	C	M
ORCHIDACEAE		
Calyptrochilum christyanum (Rchb.f.) Summerh.	H	FG
Eulophia cristata (Sw.) Steud.	H	G
Eulophia cucullata (Sw.) Steud.	H	G
Eulophia juncifolia Summerh.	H	G
Nervilia kotschyi (Rchb.f.) Schltr.	H	G
OXALIDACEAE		
Biophytum petersianum Klotzsch	H	G
PANDANACEAE		
Pandanus candelabrum P. Beauv.	T	R
PASSIFLORACEAE		
Adenia cissampeloides (Planch. ex Benth.) Harms	C	F
PEDALIACEAE		
Sesamum radiatum Schum. & Thonn.	H	W
POACEAE (Gramineae)		
Acroceras amplectens Stapf	G	G
Acroceras zizanioides (Kunth) Dandy	G	G
Andropogon ascinodis C.B. Cl.	G	G
Andropogon canaliculatus Schumach.	G	G
Andropogon fastigiatus Sw.	G	G
Andropogon gayanus Kunth var. bisquamulatus (Hochst.) Hack.	G	G
Andropogon gayanus Kunth var. gayanus	G	G
Andropogon gayanus Kunth var. squamulatus (Hochst) Stapf	G	G
Andropogon perligulatus Stapf	G	G
Andropogon pseudapricus Stapf	G	G
Andropogon schirensis	G	G
Andropogon tectorum Schumach. & Thonn.	G	G
Aristida kerstingii Pilger	G	G
Beckeropsis uniseta (Nees) K. Schum.	G	G
Brachiaria brachylopha Stapf	G	G
Brachiaria distichophylla (Trin.) Stapf	G	M
Brachiaria jubata (Fig. & De Not.) Stapf	G	G
Brachiaria lata (Schumach.) C.E. Hubbard	G	W
Brachiaria stigmatisata (Mez) Stapf	G	G
Brachyachne obtusiflora (Benth.) C.E. Hubbard	G	G
Cenchrus biflorus Roxb.	G	W
Cenchrus ciliaris L.	G	G
Chasmopodium caudatum (Hack.) Stapf	G	G
Chloris pilosa Schumach.	G	G
Chloris robusta Stapf	G	R
Chrysochloa hindsii C.E. Hubbard	G	G
Ctenium canescens Benth.	G	G
Ctenium elegans Kunth (C. virgata)	G	G
Ctenium newtonii Hack.	G	G
Cymbopogon giganteus Chiov.	G	G
Dactyloctenium aegyptium (L.) P. Beauv.	G	W
Digitaria argillacea (Hitchc. & Chase) Fern. (D. lecardii)	G	W
Digitaria ciliaris (Retz.) Koel.	G	W
Digitaria delicatula Stapf	G	W
Digitaria gayana (Kunth) Stapf ex A. Chev.	G	W
Digitaria leptorhachis (Pilger) Stapf	G	W
Digitaria longiflora (Retz.) Pers.	G	W

Echinochloa colonum (L.) Link (E. colona)	G	S
Echinochloa pyramidalis (Lam.) Hitchc. & Chase	G	G
Echinochloa stagnina (Retz.) P. Beauv.	G	G
Eleusine indica (L.) Gaertn.	G	W
Elytrophorus spicatus (Willd.) A. Camus	G	G
Eragrostis aspera (Jacq.) Nees	G	G
Eragrostis atrovirens (Desf.) Trin. ex Steud.	G	G
Eragrostis ciliaris (L.) R. Br.	G	W
Eragrostis gangetica (Roxb.) Steud.	G	W
Eragrostis namaquensis Schrad var. diplachnoides (Steud.) W.D. Clayton	G	R
Eragrostis tenella (L.) P. Beauv. ex Roem & Schult.	G	W
Eragrostis tremula Hochst. & Steud.	G	W
Eragrostis turgida (Schumach.) De Wild.	G	G
Euclasta condylotricha (Hochst. ex Steud.) Stapf	G	W
Hackelochloa granularis (L.) O. Ktze.	G	W
Heteropogon contortus (L.) P. Beauv.	G	G
Hyparrhenia glabriuscula (Hochst. ex A. Rich.) Anderss. ex Stapf	G	G
Hyparrhenia involucrata Stapf	G	G
Hyparrhenia rufa (Nees) Stapf	G	G
Hyparrhenia smithiana (Hook.f.) Stapf	G	G
Hyparrhenia subplumosa Stapf	G	G
Hyperthelia dissoluta (Nees ex Steud.) W.D. Clayton	G	G
Imperata cylindrica (L.) Raeuschel	G	G
Ischaemum amethystinum J.-P. Lebrun	G	G
Leersia hexandra Sw.	G	G
Leptochloa caerulescens Steud.	G	S
Loudetia arundinacea (Hochst. ex A. Rich.) Steud.	G	G
Loudetia flavida (Stapf) C.E. Hubbard	G	G
Loudetia hordeiformis (Stapf) C.E. Hubbard	G	G
Loudetia simplex (Nees) C.E. Hubbard	G	G
Loudetia togoensis (Pilger) C.E. Hubbard	G	G
Loudetiopsis kerstingii (Pilger) Conert	G	G
Loudetiopsis scaettae (A. Camus) W.D. Clayton	G	G
Loudetiopsis thoroldii (C.E. Hubbard) Phipps	G	G
Microchloa indica (L.f.) P. Beauv.	G	G
Microchloa kunthii Desv.	G	G
Monocymbium ceresiiforme (Nees) Stapf	G	G
Oropetium aristatum (Stapf) Pilger	G	G
Oryza barthii A. Chev.	G	G
Oxytenanthera abyssinica (A. Rich.) Munro	S	M
Panicum afzelii Sw.	G	G
Panicum fluviicola Steud.	G	G
Panicum pansum Rendle	G	G
Panicum phragmitoides Stapf	G	G
Paspalum polystachyum R. Br.	G	G
Paspalum scrobiculatum L. (P. orbiculare, polyst. comm.)	G	G
Pennisetum pedicellatum Trin.	G	R
Pennisetum polystachion (L.) Schult.	G	G
Pennisetum subangustum (Schumach.) Stapf & C.E. Hubbard	G	G
Perotis patens Gandoger	G	G
Phragmites karka (Retz.) Trin. ex Steud.	G	G
Rhytachne furtiva W.D. Clayton	G	G
Rhytachne triaristata (Steud.) Stapf	G	G
Rottboellia cochinchinensis (Lour.) W.D. Clayton (R. exaltata)	G	WG
Sacciolepis africana C.E. Hubbard & Snowden	G	G
Schizachyrium brevifolium (Sw.) Nees ex Buese	G	G
Schizachyrium exile (Hochst.) Pilger	G	G
Schizachyrium nodulosum (Hack.) Stapf	G	G
Schizachyrium platyphyllum (Franch.) Stapf	G	G
Schizachyrium ruderale W.D. Clayton	G	G
Schizachyrium rupestre (K. Schum.) Stapf	G	M
Schizachyrium sanguineum (Retz.) Alston	G	G
Schizachyrium schweinfurthii (Hack.) Stapf	G	G
Schoenefeldia gracilis Kunth	G	W
Setaria barbata (Lam.) Kunth	G	F
Setaria gracilipes C.E. Hubbard	G	M
Setaria longiseta P. Beauv.	G	M
Setaria pallide-fusca (Schumach.) Stapf & C.E. Hubbard	G	W
Sorghum arundinaceum (Desv.) Stapf	G	W

Sporobolus festivus Hochst. ex A. Rich.	G	G
Sporobolus paniculatus (Trin.) Dur. & Schinz	G	G
Sporobolus pyramidalis P. Beauv.	G	G
Sporobolus subglobosus A. Chev.	G	G
Tripogon minimus (A. Rich.) Hochst. ex Steud.	G	G
Vetiveria nigritana (Benth.) Stapf	G	R
PODOSTEMACEAE		
Tristicha trifaria (Bory ex Willd.) Spreng	H	G
POLYGALACEAE		
Polygala arenaria Willd.	H	G
Polygala atacorensis Jacq.-Fél.	H	G
Polygala micrantha Guill. & Perr.	H	G
Securidaca longepedunculata Fres.	T	G
POLYGONACEAE		
Polygonum salicifolium Brouss. ex Willd.	H	G
Polygonum senegalense Meisn.	H	SA
PONTEDERIACEAE		
Eichhornia natans (P. Beauv.) Solms-Laub.	H	G
Heteranthera callifolia Rchb. ex Kunth	H	G
PROTEACEAE		
Protea occidentalis Beard (P. angolensis)	T	G
RANUNCULACEAE		
Clematis hirsuta Guill. & Perr.	C	M
RHAMNACEAE		
Ziziphus abyssinica Hochst. ex A. Rich.	T	G
Ziziphus mauritiana Lam.	T	G
Ziziphus mucronata Willd.	T	R
RUBIACEAE		
Breonadia salicina (Vahl) Happer & Wood (Adina microcephala)	T	R
Canthium acutiflorum Hiern	T	M
Canthium multiflorum (Schum. & Thonn.) Hiern	C	M
Chassalia kolly (Schumach.) Hepper	S	F
Cremaspora triflora (Thonn.) K. Schum.	C	F
Crossopteryx febrifuga (Afzel. ex G. Don) Benth.	T	G
Fadogia agrestis Schweinf. ex Hiern	H	G
Fadogia andersonii Robyns	H	G
Feretia apodanthera Del.	S	M
Gardenia aqualla Stapf & Hutch.	S	G
Gardenia erubescens Stapf & Hutch.	S	G
Gardenia sokotensis Hutch.	S	M
Gardenia ternifolia Schum. & Thonn.	S	G
Hymenodictyon floribundum (Steud. & Hochst.) B.L. Robinson	S	M
Ixora brachypoda DC.	T	R
Keetia venosa (Cantium venosum)	C	M
Kohautia genius (S. Bowd.) Mabberley (K. senegalensis)	H	G
Mitragyna inermis (Willd.) O. Ktze.	T	S
Morelia senegalensis A. Rich. ex DC.	S	R
Mussaenda elegans Schum. & Thonn.	C	F
Nauclea latifolia Sm.	T	G
Neorosea chevalieri (Tricalysia chevalieri)	T	M
Oldenlandia corymbosa L.	H	W
Oldenlandia herbacea (L.) Roxb.	H	W
Pavetta crassipes K. Schum.	S	G
Polysphaeria arbuscula Hook.f.	S	R
Pouchetia africana A. Rich. ex DC.	S	M
Psychotria calva Hiern	S	M
Psychotria vogeliana Benth.	S	R
Psydrax horizontale (Canthium horizontale)	C	F
Rytigynia senegalensis Blume	S	R
Sabicea brevipes Wernham	C	M
Spermacoce filifolia Perr. & Lepr. ex DC. (Borreria filifolia)	H	G
Spermacoce hepperana Verdc. (Borreria compressa)	H	G
Spermacoce octodon (Hepper). Hakki (Borreria octodon)	H	G
Spermacoce radiata (DC.) Sieber ex Hiern (Borreria radiata)	H	G
Spermacoce ruelliae DC. (Borreria scabra)	H	G
Spermacoce stachydea (DC.) Hutch. & Dalz. (Borreria stachydea)	H	G
Tarenna spec.	T	M
Tricalysia okelensis Hiern	S	R
Vangueriopsis nigerica Robyns	T	M

Vangueriopsis spinosa (Schum. & Thonn.) Hepper	T	M
RUTACEAE		
Afraegle paniculata (Schum. & Thonn.) Engl.	T	R
Zanthoxylum xanthoxyloides (Lam.) Zepernick & Timler (Fagara zanthoxyloides)	T	F
SANTALACEAE		
Thesium viride A.W. Hill	H	G
SAPINDACEAE		
Allophylus cobbe (L.) Raeuschel (A. africanus, A. spicatus)	S	M
Aphania senegalensis (Juss. ex Poir.) Radlk.	T	M
Blighia sapida C. Koenig	T	M
Cardiospermum halicacabum L.	C	M
Lecaniodiscus cupanioides Planch. ex Benth.	T	M
Lepisanthes senegalensis (Poir.) Lennhouts (Aphania senegalensis)	T	M
Paullinia pinnata L.	C	M
Zanha golungensis Hiern	T	M
SAPOTACEAE		
Malacantha alnifolia (Bak.) Pierre	T	FG
Manilkara multinervis (Bak.) Dubard	T	F
Mimusops kummel Bruce ex A. DC.	T	R
Vincentella passargei (Engl.) Aubrév.	T	R
Vitellaria paradoxa C.F. Gaertner (Butyrospermum paradoxum)	T	MS
SCROPHULARIACEAE		
Alectra sessiliflora (Vahl) O. Ktze. var. senegalensis (Benth.) Hepper	H	G
Bacopa hamiltoniana (Benth.) Wettst.	H	G
Dopatrium longidens Skan	H	G
Dopatrium macranthum Oliv.	H	G
Ilysanthes gracilis Skan	H	G
Ilysanthes schweinfurthii Engl.	H	G
Lindernia debilis Skan	H	G
Lindernia diffusa (L.) Wettst.	H	G
Micrargeria barteri Skan	H	G
Scoparia dulcis L.	H	G
Sopubia parviflora Engl.	H	G
Sopubia ramosa (Hochst.) Hochst.	H	G
Striga asiatica (L.) O. Ktze.	H	G
Striga aspera (Willd.) Benth.	H	G
Striga brachycalyx Skan	H	G
Striga forbesii Benth.	H	G
Striga linearifolia (Schum. & Thonn.) Hepper	H	G
Striga passargei Engl.	H	G
Torenia thouarsii (Cham. & Schlechtend.) O. Ktze.	H	G
SELAGINELLACEAE		
Selaginella buchholzii Hieron.	H	G
SIMAROUBACEAE		
Quassia undulata (Guill. & Perr.) D. Dietr. (Hannoa undulata)	T	G
SMILACACEAE		
Smilax kraussiana Meisn.	C	F
SOLANACEAE		
Physalis angulata L.	H	W
Schwenckia americana L.	H	W
Solanum dasyphyllum Schum. & Thonn.	H	W
SPHENOCLEACEAE		
Sphenoclea zeylanica Gaertn.	H	G
STERCULIACEAE		
Cola laurifolia Mast.	T	R
Cola millenii K. Schum.	T	F
Melochia corchorifolia L.	H	G
Sterculia setigera Del.	T	G
Waltheria indica L. (W. americana)	H	GR
TACCACEAE		
Tacca leontopetaloides (L.) O. Ktze. (T. involucrata)	H	MR
THELYPTERIDACEAE		
Christella microbasis (Bak.) Holttum (Thelypteris microbasis)	H	R
THYMELAEACEAE		
Gnidia kraussiana Meisn. (Lasiosiphon kraussianus)	H	G
Synaptolepis retusa Oliv.	H	G

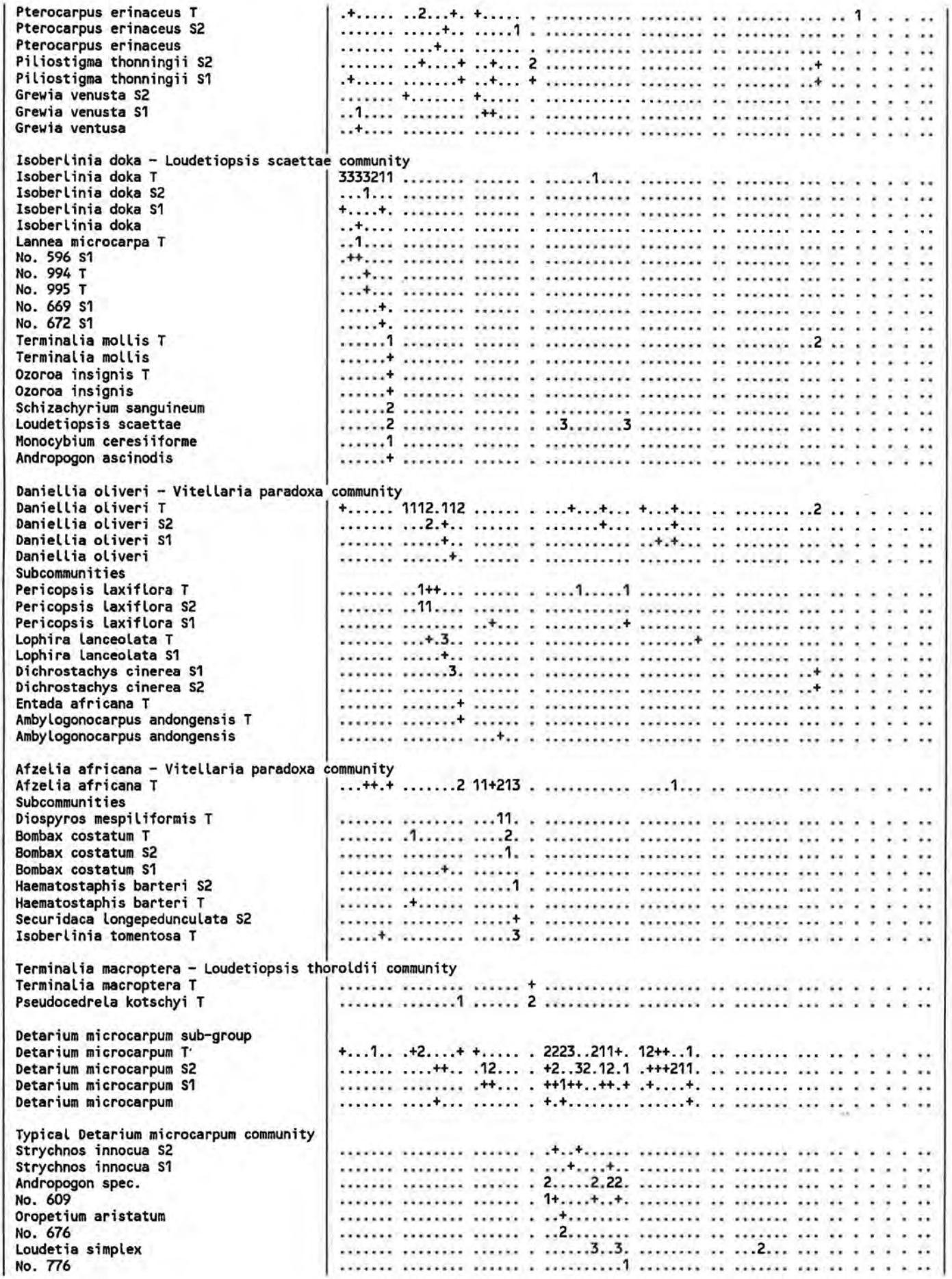
TILIACEAE		
Corchorus aestuans L.	H	G
Corchorus fascicularis Lam.	H	R
Corchorus tridens L.	H	W
Grewia cissoides Hutch. & Dalz.	S	G
Grewia lasiodiscus K. Schum.	S	G
Grewia venusta Fresen. (G. mollis)	T	G
Grewia villosa Willd.	C	M
Triumfetta lepidota K. Schum.	S	G
Triumfetta pentandra A. Rich.	S	G
Triumfetta tomentosa Boj.	S	M
TURNERACEAE		
Wormskioldia pilosa (Willd.) Schweinf. ex Urban	H	G
ULMACEAE		
Celtis integrifolia Lam.	T	R
Trema orientalis (L.) Bl. (T. guineensis)	T	F
URTICACEAE		
Laportea aestuans (L.) Chew (Fleurya aestuans)	H	M
VERBENACEAE		
Clerodendrum capitatum (Willd.) Schum. & Thonn.	C	F
Lantana rhodesiensis Moldenke	H	G
Lippia multiflora Moldenke	H	G
Vitex chrysocarpa Planch. ex Benth.	T	R
Vitex doniana Sweet	T	G
Vitex simplicifolia Oliv.	S	G
VITACEAE		
Ampelocissus bombycina (Bak.) Planch.	C	M
Ampelocissus grantii (Bak.) Planch.	C	M
Ampelocissus leonensis (Hook.f.) Planch.	C	G
Ampelocissus multistriata (Bak.) Planch.	C	M
Cissus aralioides Welw. ex Bak.	C	M
Cissus arguta Hook.f.	C	M
Cissus cornifolia (Bak.) Planch.	C	G
Cissus palmatifida (Bak.) Planch.	C	G
Cissus populnea Guill. & Perr.	C	M
Cyphostemma adenocaule (Steud. ex A. Rich.) Descoings (Cissus adenocaulis)	C	M
Cyphostemma cymosum (Cissus cymosa)	C	M
Cyphostemma flavicans (Bak.) Descoings (Cissus flavicans)	H	G
Cyphostemma jatrophoides (Welw. ex Bak.) Descoings (Cissus jatrophoides)	H	G
XYRIDACEAE		
Xyris decipiens N.E. Br.	H	M
Xyris rubella Malme	H	G
ZINGIBERACEAE		
Aframomum baumannii K. Schum.	H	M
Costus afer Ker-Gawl.	H	F
Kaempferia aethiopica (Solms.-Laub.) Benth.	H	M
ZYGOPHYLLACEAE		
Balanites aegyptiaca (L.) Del.	T	G

APPENDIX 2: RELEVE LOCATIONS

Relevé no.	Date	Location	Latitude	Longitude	Altitude (m)
49	09.11.1992	Plain c. 1 km NE of Jang Camp	09°27'66N	02°10'25W	-
50	10.11.1992	Plain c. 1 km North of Grupe Camp	09°14'96N	02°12'33W	-
51	10.11.1992	Plain c. 1 km NE of Kabampe Camp	09°13'25N	02°01'83W	-
52	11.11.1992	Plain c. 500 m N of Seriseeni Camp	09°36'13N	01°36'83W	220
53	11.11.1992	Boval c. 1.5 km N of Seriseeni C.	09°36'25N	01°36'50W	220
54	11.11.1992	Boval c. 1.5 km N of Seriseeni C.	09°36'25N	01°36'50W	220
55	12.11.1992	Plateau c. 6 km NNE of Lovi Camp	09°28'09N	01°58'34W	220
56	12.11.1992	Plateau c. 5.5 km NNE of Lovi Camp	09°27'65N	01°58'59W	220
57	13.11.1992	Summit c. 3.5 km N of Kananto Camp	09°16'50N	02°00'00W	280
58	13.11.1992	N Slope c. 1.3 km N of Kananto Camp	09°15'48N	01°59'96W	240
59	13.11.1992	Valley c. 700 m N of Kananto Camp	09°14'96N	02°00'50W	200
60	14.11.1992	Plain c. 2 km E of Brugbani Camp	09°21'12N	01°51'21W	90
61	14.11.1992	NE Slope c. 2.5 km NE of Brugbani	09°21'63N	01°51'13W	70
62	14.11.1992	NE Slope c. 2.5 km NE of Brugbani	09°21'65N	01°51'15W	75
63	14.11.1992	Depression c. 4.5 km NE of Brugbani	09°21'89N	01°50'89W	90
64	14.11.1992	Plain c. 4.6 km NNW of Brugbani C.	09°23'44N	01°53'39W	170
65	14.11.1992	Plain c. 4.6 km NNW of Brugbani C.	09°23'44N	01°53'39W	170
66	14.11.1992	Plain c. 4.6 km NNW of Brugbani C.	09°23'50N	01°53'24W	150
67	14.11.1992	Plain c. 4.6 km NNW of Brugbani C.	09°23'50N	01°53'24W	150
68	14.11.1992	Plain c. 1 km NNE of Brugbani Camp	09°21'02N	01°52'29W	130
69	14.11.1992	Plain c. 1 km NNE of Brugbani Camp	09°21'02N	01°52'29W	130
70	14.11.1992	Plain c. .5.2 km NE of Samole Camp	09°18'45N	01°51'46W	120
71	11.12.1992	Depression W of Dam near Mole Motel	09°15'58N	01°51'48W	70
72	12.12.1992	Valley c. 4.5 km NE of Brugbani C.	09°22'14N	01°50'14W	60
73	12.12.1992	Plain c. 4.5 km NE of Brugbani Camp	09°22'12N	01°50'20W	70
74	12.12.1992	Plain c. 4.5 km NE of Brugbani Camp	09°22'20N	01°50'20W	70
75	12.12.1992	Depression c. 4 km NNE of Brugbani	09°22'83N	01°51'20W	80
76	12.12.1992	Near road down Steep Hill	09°24'28N	01°53'50W	110
77	12.12.1992	Near road down Steep Hill	09°24'27N	01°53'50W	120
78	13.12.1992	Plateau c. 4.6 km NNE of Kananto C.	09°17'51N	01°59'87W	300
79	13.12.1992	Escarpment c. 4.6 km NNE of Kananto	09°17'51N	01°59'92W	270
80	13.12.1992	Plain c. 4.2 km N of Kananto Camp	09°17'38N	02°00'11W	240
81	13.12.1992	S Slope c. 1.5 km NE of Kananto C.	09°15'48N	01°59'99W	180
82	15.12.1992	Plateau c. 7.5 km E of Belepong C	09°58'23N	01°38'73W	370
83	15.12.1992	Escarpment c. 6 km ENE of Belepong	09°58'15N	01°39'05W	280
84	15.12.1992	Plateau c. 6 km NE of Belepong Camp	09°58'19N	01°39'18W	230
85	15.12.1992	Plain c. 6 km NE of Belepong Camp	09°58'06N	01°39'36W	200
86	15.12.1992	Plain c. 5.5 km NE of Belepong Camp	09°58'45N	01°40'18W	220
87	15.12.1992	Plateau c. 2 km NE of Belepong Camp	09°58'37N	01°42'15W	160
88	16.12.1992	Plain c. 1 Km NE of Kuboma Camp	09°12'71N	02°07'11W	260
120	20.02.1993	Plateau c. 3 km NE of Gbantala Camp	09°50'70N	01°44'47W	200
121	20.02.1993	Plateau c. 3 km NE of Gbantala Camp	09°47'40N	01°44'40W	180
122	20.02.1993	Plateau c. 1 km E of Gbanwele Camp	09°41'88N	01°52'14W	290
123	21.02.1993	NE Slope c. 3 km ESE of Konkori C.	09°36'84N	01°45'63W	300
124	21.02.1993	NE Slope c. 3.6 km SE of Konkori C.	09°36'63N	01°45'77W	320
125	21.02.1993	NE Slope c. 3.2 km SE of Konkori C.	09°35'99N	01°46'31W	320
126	21.02.1993	SW Slope c. 2 km ESE of Konkori C.	09°37'18N	01°46'42W	300
127	21.02.1993	Edge of Scarp c 1.5km ESE of Konko.	09°37'25N	01°46'57W	290
128	21.02.1993	Plain c. 4.3 km ESE of Konkori Camp	09°40'34N	01°50'42W	240
129	22.02.1993	Plain c. 1.5 km WSW of old Ducie C.	09°44'39N	01°56'02W	280
130	22.02.1993	Plain c. 0.7 km SE of Sogsiama Camp	09°43'31N	02°03'34W	220
131	23.02.1993	Plain c. 0.7 km NE of Buge Village	09°38'46N	01°54'22W	180
132	23.02.1993	Plain c. 4.8 km NNE of Lovi Camp	09°27'29N	01°58'59W	220
133	26.02.1993	Plain c. 3 km SSW of Polzen Camp	09°49'13N	01°31'00W	300
134	27.02.1993	Plain c. 1.3 km NNE of Bawena Camp	09°33'92N	01°40'72W	360
135	27.02.1993	Plain c. 5 km SE of Kwomwoghlugu C.	09°24'05N	01°47'09W	240
136	01.03.1993	Plain c. 1.5 km NNE of Lovi Camp	09°24'95N	01°58'83W	120
137	10.03.1993	S Slope c. 5 km WNW of Nyanga Camp	09°33'78N	01°59'13W	120
138	10.03.1993	SW slope c. 11 km WNW of Nyanga C.	09°36'02N	02°02'34W	160
139	10.03.1993	S slope c. 10.5 km WNW of Nyanga C.	09°36'04N	02°02'21W	170
140	10.03.1993	S slope c. 10.3 km WNW of Nyanga C.	09°35'97N	02°02'10W	180

APPENDIX 3: VEGETATION TABLE

Column	111111 111122 2 22222223333 33333344 44 4444445 555 55 5 5 5 5 66 1234567 89012345 678901 2 34567890123 45678901 23 4567890 123 45 6 7 8 9 01
Releve number	1 1 11 1 111 11 1 111 1 111 11 1 355375 85236348 343832 3 88522272877 32252257 88 6665666 857 76 7 7 6 6 73
	2106970 02110598 900377 8 16809685276 48452360 54 9754684 793 41 2 5 2 3 13
Species number	32 112 11 2111 11 112 1 111 1 12 11 21 1 1 9058570 89067072 882089 8 14077659154 17028558 79 6356376 731 66 8 7 0 6 66
Slope (degree)	1 11 1 3 1 11 2 1 000550 50000005 000580 3 00505050055 30500500 00 0000000 000 00 5 0 5 0 00
Soil depth (Shallow/Medium/Deep)	D DSSD MMDD S SS M SSSSSS SSSS M S S SSSSSSS D M D M DM
Rock outcrops/Surface stoniness *	000033 01000000 132434 0 13212212244 01300120 15 0000134 000 00 0 0 0 0 00
Drainage *	M WMMW IWMMWI M WWIMIM P MIIM PMMPMM P MMMM MM PPPPPPP MM PI I P M PP
Tree height (m)	2 11111 11 1211 11 1 1 1 1 1111 11 111 122 1 2 1 1 02445 62880002 972488 1 58087425153 44803099 67 812 37 7 0 2
Tree cover (%)	6366241 32231533 321236 5 22261 2612 45614312 277 34 7 6 1 0550500 00505500 555500 0 50005 55005 00020000 55 550 50 0 5 5
Herb cover (%)	1 111 1 1 1 67 546 87 7 0 5 776 7 567 7 77 77 0008644 866 40 6 0 0 79
	50 050 00 5 0 0 055 0 050 0 05 50 0000000 000 00 1 0 0 0 00
Date (month, year)	011011 11001011 000100 0 11100010111 00010011 11 1111111 111 11 1 1 1 1 10 211321 21221212 332232 3 22122222222 22212211 22 1111111 212 21 2 2 1 1 22
	999999 99999999 999999 9 99999999999 99999999 99 9999999 999 99 9 9 9 9 99
	322322 22332322 333233 3 22233323222 33323322 22 2222222 222 22 2 2 2 2 23
B(urnt), D(ry undergrowth)	B BD D BB B B BBBDBB B DB BBBDBDDD BBB BB BD B D D D
Grasses and Spermacoce agg. of savanna woodland communities and Anogeissus forest	
Andropogon tectorum	..3..3. 41....3. ...3.. . .3.....2.2 ..... .3 ..... 4+. .. . .
Andropogon gayanus var. bisquamulatus	.+..... .3..+.1. ....+..... ...1..1. .. ..
Spermacoce radiata	....+.. ....+...+.+1+ .....1 1+ ....1 +. . . . . ..
Spermacoce filifolia	.++.... ....1... ....+. .. ..
Burkea africana - Terminalia avicennioides community group	
Burkea africana T	2++..1+ .+...2.2 222..2 2 1..21.2312. 233+2.+. .. ..
Burkea africana S2	+..... ....2... . .....11.+ ....
Burkea africana S1	.... 1 .....+. ....
Burkea africanaH	....+. ....
Terminalia avicennioides T	2+..... 2+..1... ....+. . ...1..+1.+. 1+211.+. .. ..
Terminalia avicennioides S2	+..... ..2++... .....+ . .+.....+.. 11.+...2 .. ..
Terminalia avicennioides S1	....+.+.. ....+..... +.....1 .. ..
Terminalia avicennioides	....++ .. ..
Annona senegalensis T	....1.. ....
Annona senegalensis S2	....+ ....
Annona senegalensis S1	....+.. ++1... . ....1+..... ..+..... .. ..
Annona senegalensis	..+.... .+..... ....+. ...+.... .. ..
Gardenia aqualla S2	....1....+ ....+. . ... +.. .. . .
Gardenia aqualla S1	1..... ...++... ....1..... 1+..+..+ .. ..
Gardenia aqualla	....+... ....+ .. ..
Gardenia ternifolia S2	..... +..... ....+.+.. ....
Gardenia ternifolia S1	.++.... ....++.+ ..1+.... .. ..
Gardenia ternifolia	.+..... ....
Lannea acida T	.+1+.1+ .+..+..+ ....+. . ...+..... ....
Lannea acida S2	....+.. ....1. . ...+.....+ .. ..
Lannea acida S1	....+.. ....
Combretum species group	
Combretum fragrans T	.+..... ....
Combretum fragrans S2	...+... ....2... . ...+.... .. ..
Combretum fragrans S1	....1... . .....+ ...+.... .. ..
Combretum cf. fragrans T	....+... ....+ .. ..
Combretum cf. fragrans S2	1..... ....+. . ++..1...+.. .....+ .+ ....
Combretum cf. fragrans S1	....2..... ....
Combretum sp. S2	....1..... 1+.... + ...+... ..+..+.. .. ..
Combretum sp. T	....2.. .. ..
No. 977Combretum sp. S2	.... 1..... .. ..
No. 777Combretum sp. S1	....++ ....
No. 633/4Combretum sp. S1	..... .+..... ....
No. 633/4Combretum sp. T	..... .+..... ....
Vitellaria paradoxa sub-group	
Vitellaria paradoxa ssp paradoxa T	+.12+11 2.12+.+1 .12+.. 1 ....1..... +..... .+ ..... 2.. .. . .
Vitellaria paradoxa ssp paradoxa S2	...2... +.22.... 112... 2 .....+. ..1+.... .1 ....
Vitellaria paradoxa ssp paradoxa S1	....+++..+ +.+... . .....+.++ +..... .. ..
Vitellaria paradoxa ssp paradoxa	.....+. .+..+... ....+...+ .. ..


Pterocarpus erinaceus T
Pterocarpus erinaceus S2
Pterocarpus erinaceus
Piliostigma thonningii S2
Piliostigma thonningii S1
Grewia venusta S2
Grewia venusta S1
Grewia ventusa
Isoberlinia doka - Loudetiopsis scaettae community
Isoberlinia doka T
Isoberlinia doka S2
Isoberlinia doka S1
Isoberlinia doka
Lannea microcarpa T
No. 596 S1
No. 994 T
No. 995 T
No. 669 S1
No. 672 S1
Terminalia mollis T
Terminalia mollis
Ozoroa insignis T
Ozoroa insignis
Schizachyrium sanguineum
Loudetiopsis scaettae
Monocybium ceresiiforme
Andropogon ascinodis
Daniellia oliveri - Vitellaria paradoxa community
Daniellia oliveri T
Daniellia oliveri S2
Daniellia oliveri S1
Daniellia oliveri
Subcommunities
Pericopsis laxiflora T
Pericopsis laxiflora S2
Pericopsis laxiflora S1
Lophira lanceolata T
Lophira lanceolata S1
Dichrostachys cinerea S1
Dichrostachys cinerea S2
Entada africana T
Ambylogonocarpus andongensis T
Ambylogonocarpus andongensis
Afzelia africana - Vitellaria paradoxa community
Afzelia africana T
Subcommunities
Diospyros mespiliformis T
Bombax costatum T
Bombax costatum S2
Bombax costatum S1
Haematostaphis barteri S2
Haematostaphis barteri T
Securidaca longepedunculata S2
Isoberlinia tomentosa T
Terminalia macroptera - Loudetiopsis thoroldii community
Terminalia macroptera T
Pseudocedrela kotschyi T
Detarium microcarpum sub-group
Detarium microcarpum T
Detarium microcarpum S2
Detarium microcarpum S1
Detarium microcarpum
Typical Detarium microcarpum community
Strychnos innocua S2
Strychnos innocua S1
Andropogon spec.
No. 609
Oropetium aristatum
No. 676
Loudetia simplex
No. 776

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Erythrophleum africanum - Detarium microcarpum community
Erythrophleum africanum T      ....... ........ ...... . .......... 32223212 .. ....... ... .. . . . . ..
Erythrophleum africanum S2     ....... ........ ...... . .......... ....1... .. ....... ... .. . . . . ..
Erythrophleum africanum S1     .....+. ........ ...... . .......... ...++..+ .. ....... ... .. . . . . ..
Erythrophleum africanum        ....... ........ ...... . ..+....... ........ .. ....... ... .. . . . . ..
Combretum molle S2             ....... ........ ...... . .......... .+...... .. ....... ... .. . . . . ..
Combretum molle S1             ....... ........ ...... . .......... .......+ .. ....... ... .. . . . . ..
Combretum molle                ....... ........ ...... . .......... .......+ .. ....... ... .. . . . . ..
Monotes kerstingii T           ......1 ........ ...... . .......... .....+.. .. ....... ... .. . . . . ..
Monotes kerstingii S2          ...+... ........ ...... . .......... ........ .. ....... ... .. . . . . ..
Monotes kerstingii S1          ....... ........ ...... . .......... .....+.. .. ....... ... .. . . . . ..

Companions (Burkea - Terminalia community group)
  Not in Afzelia community
Ximenia americana S2           .+..... ....+... ...... . .....+.+... ........ .. ....... ... .. . . . . ..
Ximenia americana S1           +...... ........ ...... 1 ......++... ........ .. ....... ... .. . . . . ..
No. 631                        .+..... .+...... ...... . ..+....... ...+..+. .. ....... ... .. . . . + . .
Cochlospermum planchonii S1    ....... ........ ...... . ..+....... ...+.... .. ....... ... .. . . . . ..
Cochlospermum planchonii       ......+ +....... ...... . +++.......+ ...+.... .+ ....... ... .. . . . . ..
No. 651                        .....+. ....+... ...... . ..+....... ........ .. ....... ... .. . . . + . ..
No. 594                        .1..... ....1... ...... . .......... ...2.... .. ....... ... .. . . . . ..
Teramnus labialis              .+..... .+...... ...... . .......... ...+.... .. ....... ... .. . . . . ..
Ctenium newtonii               ......+ ....1... ...... . ......1... ...1.... .. ....... ... .. . . . . ..
  Not in Isoberlinia community
Parkia biglobosa T             ....... ........ ...... . .......2... ..1..1.. .. ....... ... .. . . . . ..
Parkia biglobosa S1            ....... ........ ...... . .......+... ........ .. ....... ... .. . . . . ..
No. 953 S2                     ....... .....+.. ..+..+ . .......... +...+... .. ....... ... .. . . . . ..
Maytenus senegalensis S2       ....... ....+... ...... . .......... .......+ .. ....... ... .. . . . . ..
Maytenus senegalensis S1       ....... ........ ...+.. 1 .......... ........ .. ....... ... .. . . . . ..

Acacia gourmaensi - Acacia dudgeoni community
Acacia gourmaensis T           ......+ ........ ...... . .......... ........ 11 ....... ... .. . . . . ..
Acacia gourmaensis S2          ....... ........ .+.... . .......... ........ 22 ....... ... .. . . . . ..
Acacia gourmaensis S1          ....... ........ ...... . .......... ........ ++ ....... ... .. . . . . ..
Acacia gourmaensis             ....... ........ ...... . .......... ........ ++ ....... ... .. . . . . ..
Acacia dudgeoni T              ......+ ........ ...... . .......... ........ +. ....... ... .. . . . . ..
Acacia dudgeoni S2             ....... ........ ...... . .......... ........ ++ ....... ... .. . . . . ..
Acacia dudgeoni S1             ....... ........ ...... . .......... ........ ++ ....... ... .. . . . . ..
No. 802                        ....... ........ ...... . .......... ........ 4. ....... ... .. . . . . ..

Species of savanna woodland and boval communities
Pandiaca angustifolia          .++.1+. ....+... ...1.. . +.+...+.1++ ...+..++ .. +.+..++ +.. .. . . . . ..
Lepidagathis anobrya           .+....+ ....+... ...... . ..+....... ...+.... .. +.+..11 ... .. . . . . ..
Hyparrhenia subplumosa         .31.212 ....2.3. ...... . ......1... ...3..42 .2 ....+.1 ... .. . . . . ..

Boval vegetation
No. 638                        ....... ........ ...... . .......... ........ .. 222.323 ... .. . . . . ..
No. R65                        ....... ........ ...... . .......... ........ .. .++.2.. ... .. . . . . ..
Andropogon pseudapricus        ..1.... ........ ...... . .......... ........ .. +....1. ... .. . . . . ..
No. 727                        ....... ........ ...... . .......... ........ .. +....1. ... .. . . . . ..
Loudetiopsis kerstingii        ....2.. ........ ...... . 31......1.. ......1. .. 5553..1 ... .. . . . . ..
Panicum afzelii                ....... ........ ...... . .......... ........ .. ...1... ... .. . . . . ..
No. 647                        ....... ........ ...... . .......... ........ .. ...+... ... .. . . . . ..
No. 723                        ....... ........ ...... . .......... ........ .. .....1+ ... .. . . . . ..
No. 726                        ....... ........ ...... . .......... ........ .. .....+. ... .. . . . . ..

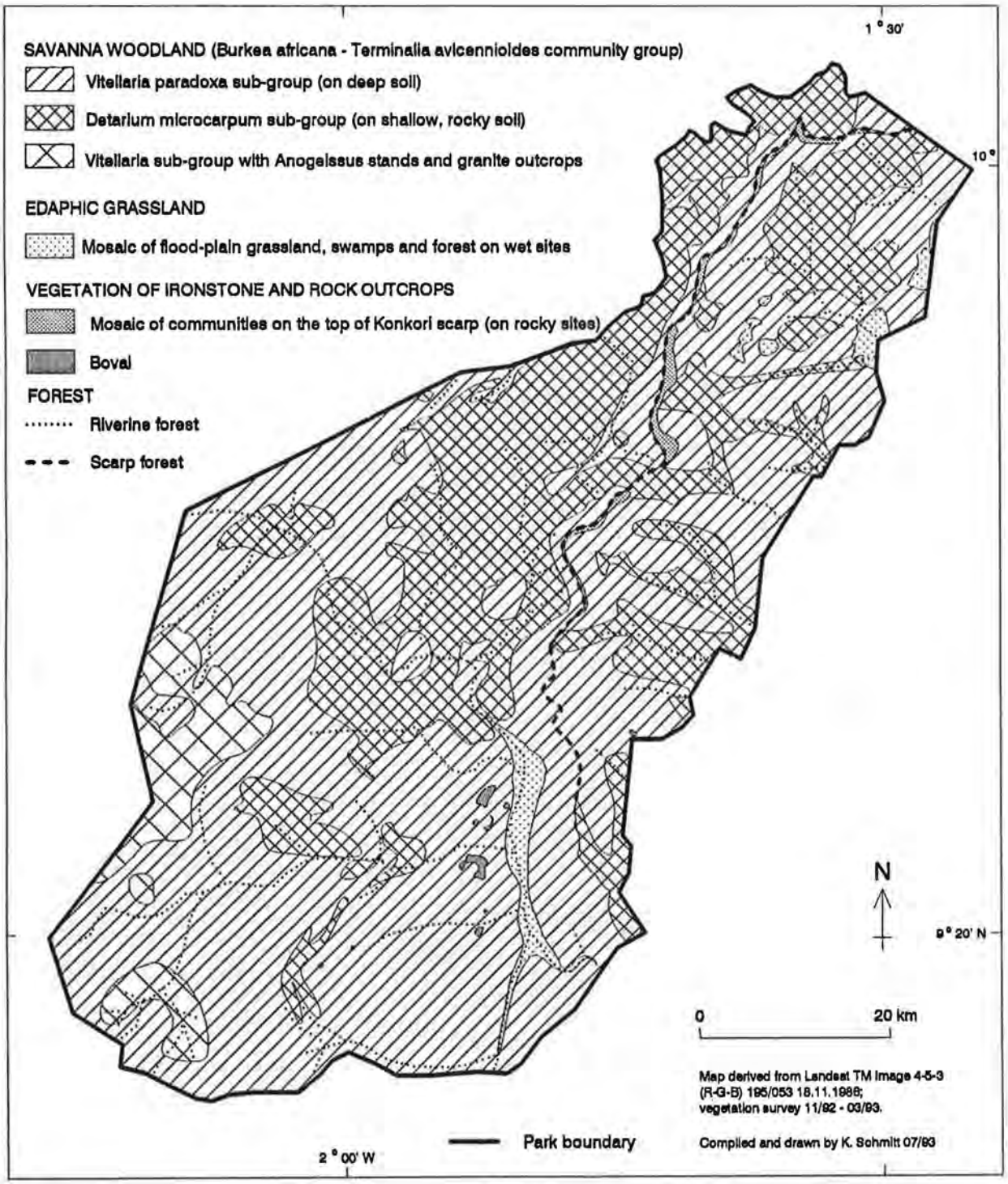
Riverine forests
Anogeissus leiocarpus community
Anogeissus leiocarpus T        .....+. ........ ....+. . .......... ........ .. ....... 234 .. . . . . ..
Anogeissus leiocarpus S2       ....... ........ ...... . .......... ........ +. ....... .1+ .. . . . . ..
Anogeissus leiocarpus          ....... ........ ...... . .......... ........ .. ....... .+. .. . . . . ..
Ceiba pentandra T              ....... ........ ...... . .......... ........ .. ....... .2. .. . . . . ..
Pterocarpus santalinoides T    ....... ........ ...... . .......... ........ .. ....... .+. .. . . . . ..
Lonchocarpus sericeus T        ....... ........ ...... . .......... ........ .. ....... .+. .. . . . . ..
Ficus sur S1                   ....... ........ ...... . .......... ........ .. ....... .+. .. . . . . ..
Ficus sur                      ....... ........ ...... . .......... ........ .. ....... .+. .. . . . . ..
Cassia sieberiana T            ....... ........ ...... . .......... ........ .. ....... .+. .. . . . . ..
Desmodium velutinum S1         ....... ........ ...... . .......... ........ .. ....... .+. .. . . . . ..
Desmodium velutinum            ....... ........ ...... . .......... ........ .. ....... .1. .. . . . . ..
No. 681                        ....... ........ ...... . .......... ........ .. ....... .3. .. . . . . ..
Paullinia pinnata              ....... ........ ...... . .......... ........ .. ....... .1. .. + . . . ..
Voacanga africana              ....... ........ ...... . .......... ........ .. ....... .+. .. . . . . ..

Mitragyna inermis community
Mitragyna inermis T            ....... ........ ...... . .......... ........ .. ....... ... .3 . . . . ..
Mitragyna inermis S2           ....... ........ ...... . .......... ........ .. ....... ... 3. . . . . ..
Mitragyna inermis              ....... ........ ...... . .......... ........ .. ....... ... 1. . . . . ..
Ziziphus mauritiana S2         ....... ........ ...... . .......... ........ +. ....... ... 1. . . . . ..
Ziziphus mauritiana            ....... ........ ...... . .......... ........ .. ....... ... +. . . . . ..
Paspalum spec.                 ....... ........ ...... . .......... ........ .. ....... ... .3 . . . . ..
No. R73                        ....... ........ ...... . .......... ........ .. ....... ..3 3. . . . . ..
Sporobolus pyramidalis         ....... ........ ...... . .......... ........ .. ....... ..1 +. . . . . ..
```

754 - Pterocarpus erinaceus community	
No. 754 T	.... 4 . . . ..
No. 754 S2	.... + ...
No. 754 S1	.... + + ...
No. 754	.... + + ...
No. 755	.... + ...
No. 756	.... + ...
Cisampelos mucronata	.... + ...
764 - Khaya senegalensis community	
No. 764 T	.... 3 . . ..
Khaya senegalensis T	.... 1 . . ..
Vitex doniana T	....+..... .... 2 . . ..
Vitex doniana S1	..+.... ....
Campylospermum flavum S1	.... + ...
Scleria depressa	.... 2 . . ..
Acroceras zizanioides	.... 2 . . ..
Marantochloa purpurea S1	.... 1 . . ..
Marantochloa purpurea	.... + ...
Aneilema umbrosum var umbrosum	.... + ...
Costus afer	.... + ...
Nelsonia canescens	.... + ...
Heterotis rotundifolia	.... + ...
Abrus precatoris	.... + ...
Ipomoea involucrata	.... + ...
Flood-plain grassland and swamps	
Andropogon gayanus - Terminalia laxiflora community	
Andropogon gayanus	.... .2 . . 5 . ..
Terminalia laxiflora T	....+. .. . . 2 . ..
Terminalia laxiflora S1	....+..... ....
Bridelia ferruginea S1	.... + . ..
Alysicarpus rugosus	.... + . ..
Stylosanthes barteri	.... + . ..
Allophylus cobbe	.... + . ..
Schizachyrium spec. community	
Schizachyrium spec.	.... 4 ..
No. 713	.... + ..
No. 714	.... 3 ..
No. 715	.... + ..
No. 716	.... + ..
No. 717	.... + ..
Swamps	
No. 741Cyperus	.... + . . 4.
No. 742Poaceae	.... 2.
Paspalum scorbiculatum	....+ .. . . . . 1.
No. 744	.... 2.
Ipomoea asarifolia	....+. .. . . . . +.
Kyllinga 967	2
No. 968	3
No. 969	2
No. 970	2

* Releve 0 from Hall and Jenik (1968), releves 990 - 994 from Houston (1974).
** Rock outcrops/Surface stoniness: 0: <1%, 1: 1-10%, 2: 10-25%, 3: 25-50%, 4: 50-75%, 5: 75-100%
Drainage: P = poor, I = imperfect, M = moderately well, W = well

Acacia sieberiana S1 (130:1); Amaranthaceae (49:1); Andropogon fastigiatus (49:+, 58:1); Andropogon schirensis (51+, 60:2); Antiaris toxicaria (59:+); Aspilia linearifolia (51:+, 70:+); Beckeropsis uniseta (58:+, 60:+); Cassia mimosoides (50:+); Cassia obtusifolia (59:+); Cenchrus ciliaris (81:+); Combretum sp. (55:+); Commelinaceae (75:+); Cymbopogon giganteus (87:+); Cyperaceae (50:+); Desmodium gangeticum var gangeticum (59:+); Desmodium ramosissimum (55:+); Dichrostachys cinerea (49:+, 73:+, 76:+); Dioscorea dumetorum (59:+); Echinops longifolius (60:+, 70:+); Erythroxylum emarginatum T (78:1); Fabaceae (49:+); Ficus platyphylla T (134:+); Fimbristylis ovata (51:1); Grewia villosa (49:+); Hibiscus asper (49:+, 56:+, 86:+); Mariscus cylindristachyus (59:+); Monechma ciliatum (49:+, 70:+, 73:1, 74:1, 85:+, 86:+); No. 581 (49:+); No. 582 (49:+); No. 596 (50:+); No. 597 (50:+); No. 600 (50:+); No. 602 (50:+); No. 609 (58:+); No. 612 (79:1, 57:+); No. 614 (51:+); No. 615 (51:1); No. 616 (51:+); No. 620 (51:+); No. 621 (51:+, 60:+); No. 622 (51:+); No. 624 (51:+); No. 627 (52:+); No. 628 (55:+, 56:+); No. 629 (52:+); No. 630 (52:+); No. 632 (52:+); No. 641 (53:+); No. 642 (53:+); No. 648 (54:+); No. 649 (54:+); No. 650 (55:+); No. 653 (55:+); No. 664 (56:+); No. 665 (56:+); No. 666 (56:+); No. 668 (57:1); No. 669 (57:1); No. 670 (57:+); No. 671 (57:+); No. 674 (58:1); No. 680^S2 (58:+); No. 682 (59:1); No. 689 (58:+); No. 693 (60:1); No. 694 (60:+); No. 695 (60:+); No. 697 (60:+); No. 698 (60:+); No. 698^T (60:+); No. 702 (61:2); No. 703 (61:1); No. 704 (61:+); No. 706 (62:+); No. 709 (62:+); No. 730 (70:3); No. 732 (70:1); No. 753^S1 (72:+); No. 753Cola (72:+); No. 760/1 (73:+); No. 766 (75:+); No. 778 (77:+); No. 779 (77:+); No. 780 (77:+); No. 783 (79:+); No. 784 (79:+, 83:+); No. 785^S1 (79:+); No. 786^S2 (79:+); No. 788^S1 (81:+); No. 788Kaputaputa (81:+); No. 801^S2 (84:+); No. 804 (86:2); No. 946^S2 (121:+); No. 952^S2 (126:+); No. Ficus954 S2 (126:+, 127:+); No. Ficus954 T (126:+); No. 971 (133:+); No. 972 (133:+); No. R78 (78:+); No. R80 (80:+); No. R83 (83:+); Pandiaka angustifolia (51+, 52:1); Panicum spec. (50:+, 86:+); Poaceae spec. (49:+, 86:+, 87:1); Pseudocedrela kotschyi (49:+); Quassia undulata S1 (130:+); Rottboelia cochinchinensis (59:+); Sansevieria liberica (51:+, 50:+); Setaria megaphylla (59:+); Solanum spec. (59:+); Sterile herb (133:+); Strychnos spinosa S1 (134:+); Tanteborase (83:+); Trichilia emetica ssp suberosa (50:+); Triumfetta spec. (59:+); Wissadula rostrata (50:+).


1 ° 30'
10 °
9 ° 20' N
2 ° 00' W
SAVANNA WOODLAND (Burkea africana - Terminalia avicennioides community group)
Vitellaria paradoxa sub-group (on deep soil)
Detarium microcarpum sub-group (on shallow, rocky soil)
Vitellaria sub-group with Anogeissus stands and granite outcrops
EDAPHIC GRASSLAND
Mosaic of flood-plain grassland, swamps and forest on wet sites
VEGETATION OF IRONSTONE AND ROCK OUTCROPS
Mosaic of communities on the top of Konkori scarp (on rocky sites)
Boval
FOREST
Riverine forest
Scarp forest
N
0
20 km
Map derived from Landsat TM image 4-5-3
(R-G-B) 195/053 18.11.1988;
vegetation survey 11/92 - 03/93.
Park boundary
Compiled and drawn by K. Schmitt 07/93