LAND UNIT SURVEY OF THE TAI REGION, SOUTH-WEST COTE D'IVOIRE

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CONTENTS

PREFACE

The Land Unit Survey Taï (LUST) has been conducted as part of the research programme 'Analysis and design of land-use systems in the Taï region, Côte d'Ivoire', of the Agricultural University, Wageningen, the Netherlands (AUW), and of the Tropenbos programme. Both programmes operate in Côte d'Ivoire within the framework of the programme 'Ecosystèmes forestiers et systèmes de production' of the Ministry of Scientific Research in Côte d'Ivoire. The study was financed by the Tropenbos Foundation.

The survey was conducted during the period July 1988 through June 1989, by A. de Rouw, vegetation scientist (Agricultural University/Tropenbos), and H.C. Vellema, physical geographer/soil scientist (MAB-Unesco associate expert). Both scientists had gained experience in earlier research and survey activities in the Taï region. The field team included K.B. Timmerman, student physical geography/soil science, Universities of Utrecht and Wageningen, the Netherlands, Henri Gnesio Teke and Pierre Glebeo Polé, who helped identifying plants, and two assistants from the field station of the 'Institut Ecologique Tropical', Yvonne Paki Djéa and Jean Bolé Grédé.
The third author of this report, W.A. Blokhuis, soil scientist, AUW, Wageningen, visited the area twice and advised on the subjects geology, geomorphology, soils and land units. He also edited the final text.

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Dr. M.A. Mulders and Mr. K.O. Pavlicek, AUW, and their students produced the SPOT false colour imagery and assisted the survey team with the interpretation. Together with the students G.J. van Veen and M. Pijpers they accompanied the survey team in the field.
Mr. H. van Reuler, AUW, and Centre Néerlandais, Abidjan, head of the project 'Soil Survey and Land Evaluation' in the Taï reserach programme, advised on various aspects of the survey, notably on soil investigations.
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identified particularly difficult plant species.
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SUMMARY

The Taï National Park (330.000 hectares) in south-west Côte d'Ivoire is the last remaining extensive area of undisturbed tropical forest in West-Africa. In the zone surrounding the park the population has increased rapidly during the last three decades, mainly through immigration. In this period considerable areas of primary forest have been transformed into tree crop plantations, mainly cocoa. In the agricultural zone around the Park little forest is left, and this has caused pressure on the National Reserve. Research in the region, directed to both nature conservation and economic development, has been conducted by ORSTOM (Organisation de Recherche Scientifique et Technique pour le développement en coopération), MAB-Unesco (Guillaumet et al., 1984) and the Agricultural University of Wageningen, the Netherlands. At the present time Wageningen University is engaged in a multidisciplinary research programme entitled 'Analysis and design of land use systems in the Taï region, Côte d'Ivoire'. This research focusses on sustainable and productive use of forest land, shifting cultivation areas and tree crop plantations.
In order to serve the goals of this programme an inventory of the available natural resources was made by means of a Land Unit Survey, with a reporting scale of 1:100,000. In a Land Unit Survey the environment is studied as a fully integrated entity. The survey aims at providing a framework in which the results of earlier, ongoing and future agricultural research can be accomodated, and at producing a geographic inventory that enables an extrapolation of research data obtained in experimental fields.
The field investigations were carried out in the period June 1988 to June 1989. The field team consisted of a vegetation scientist, a physical geographer/soil scientist, a botanist, a graduate student in physical geography/soil science, and two field assistants. The project was financed by the Tropenbos Foundation.
A Land Unit map, scale 1:100,000, was prepared of an area of 87,300 hectares, situated on the western side of the National Park and covering both the agricultural zone and a forested bufferzone aligning the protected area (Fig. 1). The main villages in the area are Taï and Para.

The use of aerial photographs and other remote sensing imagery is essential to land unit mapping. The procedure that we followed was strongly determined by the availability of this remote sensing imagery, and by the nature of the terrain and its vegetative cover. SPOT imagery of 1988 (false-colour, scale 1:50,000) gave a good insight into actual land use. Differences between forest and agricultural zone came out clearly, and different cropping systems could be distinguished. Half-way through the project period aerial photographs of 1956 (scale 1:50,000) became available to us. On the photographs landforms could be identified as well as land use patterns, and so the land use of 1956 could be mapped. Field orientation, however, was, in general, hardly better than on SPOT images, and so most observations had to be made along

traverses following a chosen compass bearing. The field data were processed in a data base computer programme.

The study area has a monsoon-type, tropical climate, an Aw-type in the classification of Köppen. The average annual temperature is 26°C, and the diurnal and seasonal variations are small. The mean annual rainfall increases from about 1800 mm in the north to about 2000 mm in the south. The rainfall has a seasonal distribution pattern. There is a rainy season from March through October, with a relatively drier interlude with higher solar radiation in July and August. The dry season is from November till March; in the north it is slightly longer than in the south.

The geology of south-west Côte d'Ivoire is dominated by granites and associated metamorphic rocks of the Precambrian Basement Complex. The northern part of the study area is underlain by migmatites that are similar to gneiss, whereas in the southern part the lithology is more varied, including gneisses, schists and granites, with changes and transitions over short distances. Major faults run northeast-southwest, and rock formations of different lithology stretch in the same general direction. Rock outcrops are rare, occurring on the few inselberg-type crests, incidentally on other crest and upper slope sites, and in riverbeds. Saprolite (weathering rock) is exposed in deeply incised ravines, in a few road cuts and in the subsoil of some of the reference profiles.

Over 80% of the study area is part of a dissected peneplain with remnants of a Tertiary ironstone capping. At present these form the uplands, an undulating to rolling landscape, characterised by the toposequence: crest, upper slope, middle slope, lower slope and valley bottom. The difference in height between crest and nearest valley bottom is generally between 20 and 40 m over slope lengths of 500 to 700 m. In part of the uplands some of the crests appear as inselbergs. The inselberg areas form separate land units with a different ecology and a different land use potential. A steep-sided hill in the south-western part of the study area rises prominently above the plain. An alluvial landscape stretches along the Cavally river and the lower reaches of its tributaries. Most of the study area is situated between 100 and 240 meters above sea level.

The entire survey area belongs to the catchment of the Cavally river, the main tributaries of which are the Nsé, the Audrénisrou, the Gô and the Méno. Especially west of the Audrénisrou fault the direction of the rivers and small streams is related to the structural and tectonic pattern that runs northeast to southwest. The first-order tributaries form a semi-dendritic drainage pattern that may have formed as a result of a new erosion cycle, that is active at present.

Upland soils have been assigned to catenas or catena variants. A catena is the soil pattern along a toposequence; it is a special type of soil association. Different rock types have different catenas and the differences between catenas are most clearly expressed in the soils of crest and upper slope. In contrast, those of middle and lower slope, and especially of valley bottoms, are much more alike.

Catenas were described for soils that have developed on migmatite, granite, granite-gneiss and on the steep-sided hills, and catena variants for soils from schists and soils on inselbergs. The upland-alluvial transition zone is characterized by a soil association. The soil pattern of the alluvial plains of the Cavally river and the lower reaches of its main tributaries is that of a soil complex. The major soil forming processes in the area are: 'in situ ' weathering of rock with formation of sesquioxides and clay, and loss of bases and silica; clay migration vertically and laterally; gleying; formation of plinthite and hardening of plinthite into laterite (ironstone). Many soils are gravelly, containing either lateritic gravel derived from ironstone capping, or quartz gravel derived from quartz veins in the rock, or both.

In the field soils were studied by augering and in soil profiles. Some 300 augerings were described. Nineteen soil profiles were described and sampled. Soil samples from 17 profile pits were analysed on percentage stones and gravel (fraction >2 mm), particle-size composition of the fine earth (fraction <2mm), pH, organic carbon, and exchange properties. The various upland profiles have much in common. Most textures are sandy loam and sandy clay loam, with clay percentages often increasing with depth. The soils are very acid (pH in the surface soil between 6.4 and 4.2) and the base saturation is usually low. The soils have low-activity clays. As organic carbon percentages are often high, a substantial part of the exchange capacity of the soil is due to organic matter. Aluminium saturation of the cation exchange complex is often high, especially in the subsurface and subsoil, with percentages between 50 and 95. There is a close relationship between pH and Al-saturation: with pH<4.8, Al-saturation is usually above 50%, and there is a risk of aluminium toxicity. This risk is present in nearly all soils that have been investigated. The analytical data and the corresponding field data do not give a clear relationship between soil properties and the main soil forming factors in the region: parent material, relief and climate.

The soils have been classified according to three international systems: Soil Taxonomy (Soil Survey Staff, 1975), the system of FAO (FAO/Unesco, 1974) and the French system (CPCS, 1967). Most upland soils are Kandiudults and Kandihumults according to the latest revison of Soil Taxonomy (Soil Survey Staff, 1990), but Hapludox and Humitropepts also occur. Soils on alluvium and some of the lower slope soils are Troporthents. In the revised FAO-system (FAO, 1988) most upland soils are Ferralsols, and some are Cambisols. Regosols are found in alluvial plains and on some of the lower slopes. In the

French system most soils belong to the 'Classe des Sols Ferrallitiques' and the 'Sous-classe des Sols Ferrallitiques fortement désaturés en (B)'. 'Sous-classes' include 'typique', 'humifère' and 'appauvri'.

Three classification systems for vegetation have been used previously in the Taï area, by Mangenot (1955), by Guillaumet (1967) and by the Development and Resources Corporation (1967). In the framework of the Land Unit survey a classification system was required with units indicative of important ecological factors such as climate, geology and soil. In the system that we developed plant communities were the classification units. Communities are characterised by their full species composition, and named after two prominent species. In some communities a distinction was made between characteristic and differentiating species. Sampling was done by making 'relevées' in which all plant species and their relative abundance were described. In all 253 complete 'relevées' were studied. In order to arrive at a classification both the 'relevées' and the species were clustered by the TWINSPAN computer programme.
The ordination programme DECORANA was used for organising data on species abundance alone, with environmental interpretation as a subsequent, independent step.

Ultimately the following communities were defined:
* 6 communities (A through F) in mature forest of uplands;
* 2 communities (G, H) in upland areas with inselberg crests;
* 1 community (L) in the group of steep-sided hills;
* 2 communities (J,K) in alluvial plains;
* 3 communities (I, II and III) in secondary forest;
* 2 communities (IV and V) in plantation undergrowth.

An important ecological phenomenon is the apparent interchangeability of edaphic and climatic humidity. Some indicator species groups could be defined in this respect.
The Oubi classification of forests has been compared with our classification. We distinguished four rainfall/vegetation zones for the Land Unit classification, the Oubi had three zones. Some of the boundaries between zones were nearly the same. Oubi consider Millettia rhodantha ('Ferreclao') an indicator plant for places favourable for agriculture.

By comparing aerial photographs of 1956 and SPOT imagery of 1988, it became clear to what extent land use had changed over the last thirty years. Major changes resulted from the opening up of the land by timber extraction roads, the establishment of the National Park and bufferzone, and massive cocoa planting by immigrant farmers. On the Land Use map the situation of 1956 has been combined with that of 1988.

Land use is different between ethnic groups. The indigenous population, belonging to the Oubi, Guéré and Krou, cultivate one crop of upland rice on cleared forest land, then let the field return to forest. Some farmers plant cocoa and coffee with the rice crop. Immigrants - Baolé from Côte d'Ivoire, Mossi from Burkina Faso, and Malinese - grow mainly cocoa, and some food crops. Rice is grown in a system of shifting cultivation utilising mainly secondary forest, whereas the cultivation of coffee and cocoa requires 'fresh forest' (i.e. primary forest). Shifting cultivation cycles are normally about 20 years, but in land unit AU - that has better soils and more available moisture - cycles never exceed 6 years.

The Land Use map (Appendix 10) shows that there has been, over the last thirty years, a distinct increase of land used for agriculture - mainly for tree crops - and a decrease in the area covered by primary forest. There has also been an increase of cocoa and coffee plantations at the expense of land that was used for shifting cultivation. In a case study of land use near the village Sakré, the land occupation history is shown in detail (Fig. 15).
A special investigation has been made of over 1400 fields of cocoa in the area south of Poulé-oula (Figs. 14 and 16). The cocoa fields were classified in three categories (good, average, poor) on aspects of health, on shape of the tree, and on size in relation to age. Land unit Usg1 had much poor cocoa, whereas land units UI2 and H had the largest percentages of good cocoa fields.

Land Units have a characteristic combination of landform, soil and vegetation. The Land Unit map shows that there is more variation in the southern part than in the northern part of the survey area. Of the 18 land units distinguished, 12 were of uplands and 6 of other landforms. The legend of the Land Unit map is strongly related to landform. It has a distinct hierarchy, with major geomorphic units on the highest level of abstraction: uplands (U), uplands with inselbergs (UI), alluvial landscape (A) and upland-alluvium association (AU). In the uplands there are three more levels of abstraction: four rainfall/vegetation zones on the second level, lithology on the third, and drainage density and slope on the fourth level.

The main results of the land unit survey have been given in a final chapter: discussion, conclusions and recommendations. The main recommendations are:

* In order to protect the Taï National Park relevant land utilization types must be developed and implemented for both the agricultural zone (annual and perennial crops) and the bufferzone (timber and other forest products).
* Land use should be more in line with the ecology of the site.
* More detailed soil and vegetation investigations are required in land units that lack uniformity and that have, at the same time, development potential.
* Similar Land Unit surveys, or an extension of the present one, are recommended for other zones surrounding the National Park, especially where land is scarce and, consequently, there is a need for a better use of land

resources. In such areas the agricultural zone is easily extended into the protected area.

Finally, present and proposed research activities in the Taï area are reviewed. Data of agricultural experiments, together with the natural resources investigation of the Land Unit Survey Taï could form the basis for a comprehensive physical land evaluation of the area.

1. INTRODUCTION

1.1. Short history

The closed evergreen forest of south-west Côte d'Ivoire remained largely uninhabited for many years. The few inhabitants lived along rivers and in villages that often changed location. Hunting, fishing and shifting cultivation were practiced for subsistence. In the colonial period the French government stimulated permanent settling along the only road, that ran north-south from Guiglo to Djiroutou and was built between 1937 and 1940. Agriculture did not change much in the following decennia, and both shifting cultivation and timber extraction remained on a small scale (Bos, 1964; Guillaumet, 1967). All activities were concentrated along the road, leaving the centre of the forest land devoid of people. This land use pattern can be clearly observed on aerial photographs of 1956.

In 1965 the Government of Côte d'Ivoire decided to promote the development of the south-west. More timber was to be extracted and large agro-industrial plantations were projected. Transport of products was planned through the newly built harbour San Pedro and energy was to be produced by a hydro-electric plant near Buyo. Still more important for the development of the region was the encouragement given to local farmers to produce cash crops, especially cocoa. As the region was considered underpopulated, immigration was also encouraged (Guillaumet et al., 1984). Attracted by local conditions such as an abundance of forest, many immigrants, usually from savannah regions, settled in this area and started tree crop plantations. Presently people from drier regions, Burkinabé, Malinese and Baoulé largely outnumber the native forest people Oubi, Guéré and Krou.

Migration was not always planned and spontaneous immigration was enforced by a shortage of land in other parts of Côte d'Ivoire, and indirectly by poor climatic conditions in the Sahel. The Ivorian immigrants arrived first, in the sixties. They were mainly Baoulé from the centre of the country. The influx of non-Ivorian immigrants followed in the seventies. They were mainly Burkinabe, very often re-migrating within Côte d'Ivoire (Lena et al., 1977; Ruf, 1984). At the onset of the eighties immigration by Ivorians had stopped but non-Ivorian immigration was still in full swing. In the demographic survey of the Taï 'sous-prefecture'*) in 1971 a population density of 3.3 persons per square kilometer was calculated. The indigenous population made up for about 80% (Schwartz and Capot-Rey, 1971). In 1985 the population had increased to 13 persons per square kilometer, 22% of which were indigenous**).

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* local admnistrative department

** data kindly provided by the 'sous-prefect' of Taï, in 1985

In the same period expanding logging activities provided roads along which the immigrants could penetrate easily into the interior.

In 1972 the Government took an important step to protect the forests and their environment by establishing the Taï National Park. This national reserve of 330,000 hectares is the last remaining extensive area of undisturbed tropical rain forest in West-Africa.
A bufferzone ('zone tampon') was delineated in 1977 around most of the Park. The status of this 66,000 ha peripheral zone was defined as 'partial faunal reserve'. Since then minor modifications of the bounderies took place. At present the bufferzone covers an area of about 90,000 hectares.
At least three factors are responsible for the growing scarcity of forest in the area between the National Park and the Liberian border: a population increase mainly through immigration; the transformation of forest into tree crop plantations; and the scarcity of such forest as most forest land is protected in the National Park.

1.2. Aims of the project

At the present time both nature conservation and economic development are important issues in Côte d'Ivoire, and so it is not surprising that next to the National Park, the agricultural area is also being studied, the latter from both an agricultural and a socio-economic point of view. In the MAB/UNESCO pilot research project 'Projet Taï' (1975-1984) several scientists from different disciplines participated, and a wealth of information was gathered (Guillaumet et al., 1984). Most of the research activities were concentrated in the western part of the Park.

The Agricultural University of Wageningen (AUW) has conducted research in Côte d'Ivoire since 1954, in collaboration with the 'Office des Recherches Scientifiques et Techniques Outre-Mer' (ORSTOM), a French organisation based in Paris. A 'Centre Néerlandais' was established at the research site of ORSTOM at Adiopodoumé, near Abidjan. The Centre Néerlandais gave the opportunity to young scientists from various departments of the AUW to participate in agricultural research in Côte d'Ivoire; it also enabled students from Wageningen to spend some time at various research institutes in Côte d'Ivoire as part of their MSc-studies.

Since 1981 the activities of the Agricultural University have largely been concentrated in the multidisciplinary research programme 'Analysis and design of land use systems in the Taï region, Côte d'Ivoire'. Within the framework of one of the sub-programmes (projects), viz. Soil Survey and Land Evaluation, a Land Unit Survey was conducted of an area of some 90,000 hectares, including the agricultural zone between the National Park of Taï and the Cavally

river; the buffer zone along the western boundary of the Park; and parts of the National Park itself (Fig. 1).
The Land Unit Survey, with a reporting scale of 1:100,000, aims at providing a framework in which the results of earlier, ongoing and future agricultural research can be accomodated, and at producing an ecological inventory that would allow a proper extrapolation of research data.

1.3. Location of the study area

The study area is located in south-western Côte d'Ivoire (5°57'-5°30' N latitude and 7°30'-7°14' W longitude) in the western part of the Taï National Park; the villages Taï and Para are the most important centres (Fig. 1). The size of the mapped area is about 87,000 ha.
The northern boundary is the northern limit of the available SPOT coverage. The southern boundary is the southern limit of topographical map sheet Taï 4a. In the north the western boundary is the limit of the topographical map sheet Taï 4c; further south it is the Cavally river, that marks the boundary between Côte d'Ivoire and Liberia. As the survey was more or less confined to the agricultural zone and the bufferzone, the eastern limit coincides roughly with the western boundary of the National Park. It is plotted where, on the basis of aerial photo interpretation, a different land unit can be expected towards east. In the north-east, a part of the Park where research has been conducted, is included. In the south-eastern corner the boundaries are those of the map sheet Taï 4a.

From an administrative point of view, most of the area is part of the 'sous-prefecture' Taï. South of the village Zriglo it belongs to the 'sous-prefecture' Grabo.

The road Guiglo-Tabou is the only main road which crosses the study area. Though it is a so-called all-weather road, it can occasionally cause difficulties on the traject south of Sakré. Several wood logging tracks, that are at present mainly used by the traders that buy cocoa, open up the areas east and west of the main road. In the agricultural zone there are many farmers' footpaths. The Guiglo-Tabou road provides the only crossing for the Nsé, the Audrénisrou and the Gô rivers. The Méno can be crossed south-east of Para. The Cavally and part of the Méno rivers are navigable by canoe if the water is high enough.

2. THE LAND UNIT SURVEY: CONCEPT, PROCEDURE AND METHODS

2.1. Introduction

A Land Unit Survey is an efficient means to provide an inventory of the natural resources of an area. The mapping units (Land Units) have, conceptually, a characteristic combination of land form, hydrology, soils and vegetation; land use may also differ characteristically between land units.
The methodology is in part based on that of the 'land systems survey' (Christian and Stewart, 1968) developed in Australia for small-scale land inventories. It has been developed at the ITC, Enschede, the Netherlands, by the Land Ecology Group of the Department of Land Resource Survey and Rural Development (Zonneveld, 1979). The methodology of a Land Unit survey is comparable to that of a resources inventory as described by Touber et al. (1989), and to land use and land ecological surveys (Küchler and Zonneveld, 1988). Soil inventories in a Land Unit survey follow the physiographic approach that was developed at the Agricultural University and the Soil Survey Institute, both at Wageningen, the Netherlands. A Land Unit Survey is normally executed by a team of scientists of the various disciplines involved: geology/geomorphology, soil science, vegetation science.
The use of aerial photographs and other remote sensing imagery is the core of the research in land unit mapping because of the reconnaissance nature of most of the surveys. Field work is limited to investigations in sample areas and along carefully selected traverses. During this field work preliminary mapping units obtained from the analysis of aerial photographs and satellite pictures are 'translated' into land units. If there is a good correlation between photographic features and terrain characteristics, the field knowledge from sample locations can be extrapolated to the entire survey area.
The legend of a Land Unit map has a distinct hierarchy. The highest level is usually defined by the landform, i.e. by the geomorphology of the terrain, a feature that is largely determined by lithology, geological structure and geological history. Soils and hydrology are strongly related to land forms, whereas they have a distinct impact on the natural vegetation.
Within the accuracy of the chosen map scale a Land Unit has a certain uniformity as far as land characteristics and land use potential are concerned. This implies that a Land Unit Map can be interpreted in terms of a suitability rating for different land use and management systems. Land evaluation is an important practical application of the results of a Land Unit Survey.

2.2. Procedure of the Land Unit Survey of the Taï region

The Land Unit Survey Taï (LUST) took place in the period June 1988 to June 1989. The field team consisted of a vegetation scientist, a physical geographer/soil scientist, a botanist, a graduate student in physical geography/ soil science, and two field assistants.

The 'Institut Géographique de la Côte d'Ivoire' (IGCI) was requested to produce aerial photographs on a scale 1:50,000. Unfortunately, and due to circumstances beyond our control, the IGCI could not comply with the request. As an alternative SPOT (Système Probatoire d'Observation de la Terre) imagery was used. False colour SPOT images were produced by the National Aerospace Laboratory in the Netherlands on a 1:50,000 scale (the techniques used are described in Appendix 1). These were available to the field team in September 1988. Later in 1988 aerial photographs, dating from 1956, on a scale of 1:50,000, could be studied at the IGCI offices in Abidjan. At the end of the main period of field survey these photographs were purchased, and could be used in the field.

The time schedule of the survey procedure is outlined in Table 1; the separate items of the procedure are discussed below.

Step 1: 1 1/2 month; study of reference material
During this period emphasis was given to the study of reference material such as literature, topographical, geological and other thematic maps and other sources of information. This study continued during the subsequent steps of the survey procedure. The MAB Technical Note no. 15 (Guillaumet et al., 1984), Guillaumet (1967) and Development and Resources Corporation (DRC) (1967) were of great value. Available topographic maps were at a scale of 1:50,000 (sheets Taï no. 4a and 4c, 1966) and at a scale of 1:200,000 (sheet Taï, 1967). The thematic maps were usually small-scale maps covering south-west Côte d'Ivoire. The results of previous field studies carried out by members of the survey team (De Rouw, ...; Vellema, in prep.) were adopted for use in the Land Unit survey; these included about 500 observation points with soil and site descriptions, and 100 relevees of vegetation.

Step 2: 2 1/2 months; interpretation of SPOT images and field correlation
SPOT false colour images became available at the beginning of this period. The SPOT tapes had been processed in a way that gave maximum differentiation in the agricultural zone, which meant that there was a lack of detail in the forest zone. A rough classification of the area was then made on the basis of colour, textural and spatial patterns on the images.
In the field observations were made at places that were recognizable on the satellite images, and along traverses that were cut from these points on compass bearing. Special attention was paid to differences in vegetation and

in crops in order to detect the correlation between the colours of the images and these land characteristics. It was found that differences in vegetation and land use did show up well on SPOT imagery, but that landforms could not be identified.
The conclusion of the field correlation study was that the SPOT images could be used for differentiating between various land use systems, but that they did not supply sufficient information for land units to be defined. For this information aerial photographs were required.

Step 3: 5 months; aerial photo interpretation and field work
In the beginning of this period ~~we had for the first time access to~~ aerial photographs of 1956 (NB-29-XI, nos. 114-249), covering the entire study area. Although the quality of these aerial photographs was not optimal and their age advanced, they appeared to be useful as a basis for the Land Unit Survey. In fact, without these photographs the Land Unit survey would have been impossible.

Step 4: 3 months; processing and classification of data, map compilation and report writing
Both soil and vegetation data were processed by computer programmes (see Appendix 5 for the programmes used in the vegetation survey). The legend of the Land Unit map was obtained by correlation of these data with the observations on landforms (Appendix 11).
The land use map of 1956, based on aerial photographic interpretation, and the land use map of 1988, based on interpretatiuon of SPOT images and on field work, were combined into one map (Appendix 10).

Table 1 Time schedule of the survey

Step and period of time
Step I, 1½ months

Sources of information
* reference material
* data of earlier field investigations

Suitability (+) and limitations (-) of sources of information
* general impression of study area

Office activities
* study of reference material
* interpretation of topographic and thematic maps
* adaption of data of preceding field work

Step and period of time
Step II, 2½ months

Sources of information
* SPOT false colour images 1:50,000 (1988)

Suitability (+) and limitations (-) of sources of information

+ the major roads Taï-Sakré-Para, major rivers, villages, large 'campements' and some drainage patterns visible
+ differences between primary forest, secondary forest and agricultural land visible
+ differences in land use pattern visible
+ delineation of some land units
- few orientation points
- differences between crops not visible
- in general no land units can be distinguished

Office activities

* continuation of Step I
* interpretation of SPOT-images

Field activities

* observations at places recognizable on the SPOT-images
* field correlation of the colours and colour patterns on the SPOT-images

Results

* map of land use (1988)

Step and period of time
Step III, 5 months

Sources of information

* aerial photographs 1:50,000 (1956)
* second generation SPOT-images

Suitability (+) and limitations (-) of sources of information

+ the major road Taï-Sakré-Para, major rivers, villages, 'campements', drainage patterns and landforms visible
+ some patterns of vegetation visible in primary forest
- no recent orientation points (villages, roads, agricultural land)
+ greater contrast between colours
- same limitations first generation as SPOT

Office activities

* interpretation of aerial photographs
* correlation with SPOT
* input of field data

Field activities

* observations along roads and paths and along cut traverses

Results

* aerial photo interpretation map
* map of land use of 1956

Step and period of time
Step IV, 3 months

Sources of information

* data of field work

Suitability (+) and limitations (-) of sources of information

+ correlation between field data and remote sensing imagery in some areas
- no correlation between field data and remote sensing imagery in most areas with a complex land use pattern
- vegetation table not available during field work

Office activities
* classification and processing of data
* study of correlation between various landscape aspects
* map preparation
* reporting

Results
* land use map of 1956 and of 1988 integrated
* land units map
* draft report

2.3. Methods used in the Land Unit survey

2.3.1. Aerial photo interpretation

Aerial photographs were studied at the IGCI office during the beginning of step III, but field use of these photographs was restricted to the last months of this period. Both photo interpretation and field work could have been more efficient if the aerial photographs would have been available to office and field use from the beginning of the Land Unit survey.
Photo interpretation began with the delineation of the main landforms. Landforms were differentiated on the basis of relief and on density of drainage pattern. Major vegetation boundaries were added. These photo-interpretation units corresponded well to terrain features, but the correlation with soil associations - mainly catenas - and with vegetation units was poor. This led to a more or less continuous process of adaptation of the photo-interpretation during the final stage of the fieldwork and during the map compilation stage. Some of the photo interpretation units appeared to be far from uniform; in order to characterise these units and sometimes subdivide them, additional field observation points were required (see section 2.3.3.).
Land use patterns could be recognized on the aerial photographs, and so the land use of 1956 was drafted (Appendix 10).

2.3.2. Interpretation of SPOT images

Some of the colours on the SPOT images were clearly related to terrain features: large roads and villages usually showed up white to light green, rivers dark blue, food crops and young secondary vegetation rose to light brown, coffee and cocoa blue and light red, and bamboo red to orange (Timmerman, 1989). However, the correlations were not always clear. The same crops showed different colours at different locations, probably due to variations in condition of the crops, in management, in degree of weed infestation. In other instances different crops showed similar colours at different locations. Another difficulty in the interpretation of SPOT images was the small size of many of the fields. Fields are often far from homogeneous; there is much intercropping, and tree crops, annual crops and vegetables produce an irregular pattern in

one and the same (small) field.
Little detail could be observed in the forest area. This was due to the method of processing the SPOT tapes - that was geared towards maximum contrast in the agricultural zone - and the presence of haze in the forest zone.

The SPOT tapes were processed again after completion of the correlation study of step 2 (Appendix 1). On these images some of the differences in land use and vegetation were better expressed. However, since the field team had gradually become acquainted with the earlier SPOT imagery and, moreover, the new products became available only towards the end of the field survey, not much use was made of these later SPOT images.

2.3.3. Fieldwork

Fieldwork consisted of SPOT terrain correlation studies (mainly in step 2) and investigations of site characteristics (geology, landform, soils, vegetation and land use; mainly in step 3). Altogether the field work took 3 months.
Orientation in the field was a problem throughout the survey. On the SPOT images only the major road Zagne-Tabou was visible; none of the smaller tracks showed up. Major rivers and villages and some of the smaller rivers could be detected, but many small settlements and most of the smaller drainageways could not be identified.
In general the aerial photographs of 1956 provided better orientation in the field than the SPOT images did, notwithstanding the fact that land use and the sites of minor roads and of some villages had changed since 1956. In the forest zone field orientation from aerial photographs is bound to be a problem, regardless of the age of air photo cover, as drainage channels, foot-paths and minor relief differences are obscured by the closed canopy of trees. Similar problems arose when using the 1:50,000 topographic maps which is not surprising since these maps were largely derived from the aerial photographs of 1956.
Because of the uncertainty of orientation all field observations were done along lines, starting from a point that could be identified on the SPOT image or on an aerial photograph. In the forest, observations had to be made along traverses following a chosen compass bearing; the relatively open understorey of the forest made it relatively easy to cut lines. Cutting of traverses was, however, almost impossible in parts of the agricultural zone, where thickets and secondary forest were almost inaccessible. Consequently, in the agricultural zone, timber extraction roads and farmers' foot paths in the direction desired were used.

The field assistants and labourers cut the lines and fixed poles every 50 meters along these lines. At each pole the direction and inclination towards the next pole were measured. Bifurcations, crossings of rivers and other conspicuous terrain features were noted, as well as land use and vegetation: primary forest, age of forest fallow, type and condition of crops, age of plantation, cropping patterns and owner of the field. The team covered 2 to 5 kilometers a day along roads and paths, about 500 meters through secondary forest and thicket, and 1 to 1.5 kilometers in primary forest. The lines of observation are shown in Fig. 2.

The survey team subsequently made observations along these lines, particularly along toposequences (catenas) that were crossed by the cut lines. For the catena observations additional lines were cut from crest to valley bottom. The survey team covered between 2 and 5 kilometers a day.
Information on a consistent set of land characteristics - geology, physiography, hydrology, soil and vegetation - was collected at about 300 observation points. The time-consuming extensive vegetation relevees were restricted to 150 of these points. The data on soils from augerings were supplemented by the description and sampling of 12 profile pits. Some of the profile pits used in an earlier survey (Vellema, in prep.) have been included. Profile descriptions and analytical data of soil samples are in Appendix 9.
Between periods of field work the field data were processed in a data base computer programme.

3. CLIMATE

The climate in West-Africa is determined by its tropical location and by the seasonal north-south movements of two air masses with distinctly different moisture conditions. The frontal separation between these two air masses is known as the Inter Tropical Convergence Zone (ITCZ), which is a front or belt of instability and rain that follows the apparent migration of the sun. As the sun moves northward, warm moist air is drawn inland by south-west monsoonal winds bringing rain. As the solar cycle reverses and the front moves south over the ocean, the north-east trade winds prevail, bringing relatively dry weather (DRC, 1967). During a few days to a few weeks in the dry season the Harmattan brings dry and dusty air from the Sahara desert.

The study area has an Aw climate according to the classification of Köppen (1931): a tropical rainy climate with a main temperature in the coldest month > 18°C and a distinct dry season. The average annual temperature is around 26°C with little variation from year to year. Diurnal changes in temperature are small, except for the period that the Harmattan wind blows when the nights can be cold and fog may occur in the morning hours. During this period the humidity, which is normally high, drops distinctly.

Data on rainfall were available from meteorological stations at Zagné (30 km north of the study area), Taï and Grabo (75 km south of the study area); they are presented in Table 2. The study area has a mean annual rainfall that increases from about 1800 mm in the north to about 2000 mm in the south and variation in annual rainfall between years is high.

Table 2 Average monthly and annual rainfall in mm measured or calculated over the period 1951-1980 (sligthly modified after ANAM, 1987)

Station	Latitude	Longitude	J	F	M	A	M	J	J	A	S	O	N	D	year
Zagné	6°16'	7°29'	18	73	134	163	199	240	159	155	274	225	94	36	1770
Taï	5°52'	7°27'	24	61	156	182	220	266	153	143	269	237	116	47	1874
Grabo	4°55'	7°29'	54	56	128	157	281	401	152	110	250	219	174	108	2110

Based on the seasonal rainfall distribution, ANAM (1987) distinguished three climatic zones for Côte d'Ivoire: northern, central and southern. The study area is situated in the transition zone between the central and the southern climatic zone (Table 3), but is nearest the central zone.
The rainfall data supplied by ANAM (1987) allow a distinction of four seasons in the Taï area. There is a relatively long rainy season from March through June, with a maximum towards the end of this period; this maximum is most clearly expressed in the south; a shorter rainy season is concentrated in September and October. The dry season is from November through February,

but it is to be noted that there are only three dry months (December, January and February) in Taï and Zagné, and two (January and February) in Grabo. In Grabo August is relatively dry, in Zagné and Taï both July and August. More important than the lower rainfall in midsummer is the higher solar radiation as compared with the two rainy seasons (Monteny, 1983).

Table 3 Seasonal rainfall distribution (ANAM, 1987)

Central climatic zone

* 4 months of little rainfall (< 100 mm) Nov, Dec, Jan, Feb
* 6 months of variable rainfall (100-250 mm) Mar, Apr, May, Jul, Aug, Oct
* 2 months of heavy rainfall (150-350 mm) Jun, Sep

Southern climatic zone

* 4 months of little rainfall (<100 mm) Dec, Jan, Feb, Aug
* 5 months of moderate rainfall (100-150 mm) Mar, Apr, Sep, Oct, Nov
* 3 months of heavy rainfall (150-650 mm) May, Jun, Jul

Rainstorms occur especially at the onset of the long rainy season; they are intensive and very local. The rainstorms often result in rain splash, soil compaction and sheet or gully erosion.

Rainfall and rainfall distribution determine the vegetation growth and crop production through the moisture availability in the soil. A prolongued period of little or no rain has a major effect on plant growth. Large fluctuations in the dates that mark the beginning of the rainy season strongly affect the growth of agricultural crops and natural plant communities (DRC, 1967), especially in soils with low waterholding capacity like sandy, gravelly or shallow soils.

In the south there is more variation in the actual sowing dates than in the north, and this reflects the higher rainfall and more regular rainfall distribution in the south as compared to the north of the study area.

has been published by the Bureau de Recherches Géologiques et Minières (BRGM) in 1973 on a scale of 1:500,000. It is based on surveys by A. Papon, R. Lemarchand and co-workers in the period 1962 - 1970.
The survey team of the Development and Resources Corporation

4. GEOLOGY

The most accurate and recent geological map of SW Côte d'Ivoire ~~was produced by Papon (1973) at a scale 1:500,000~~. The same geological information is also supplied as overprints on 1:200,000 topographical maps. ~~DRC (1967)~~ prepared a generalised geological map of south-west Côte d'Ivoire from information accumulated during soil investigations. ~~The 1:500,000 geological map published by the Bureau de Recherches Géologiques et Minières (1973) is based on surveys by Papon and Lemarchand.~~
The original reporting scale of the geological surveys was 1:50,000. The topographical sheets Taï 4a and 4c, covering our study area, were mapped by Bos (1964). Fig. 3 gives a simplified version of this map.
The following is based on the above mentioned studies and on our own observations during the Land Unit Survey.

The underlying geology of most of SW Côte d'Ivoire belongs to the Precambrian Basement Complex that consists of granites and associated metamorphic rocks, mainly of gneissic character. The formations belong to two different systems, the 'Libérien', of Archean age (3000-2300 million YBP) and the 'Eburnéen', of Proterozoic age (2300-1500 million YBP) (Tagini, 1972). Each of these eras is characterised by a main orogenic event, the Liberian orogenesis (2750-2500 million YBP) and the Eburnean orogenesis (2090-1830 million YBP). Especially the latter has been of significant importance for the present geology and geomorphology of Côte d'Ivoire; after the Eburnean orogenesis only minor and local geological events took place.

The south-west of Côte d'Ivoire is characterised by a rectilinear structure of parallel bands of either Liberian or Eburnean formations, that have a northeast-southwest orientation. The major part of our study area is covered by the migmatites of the Liberian formation. In the south there is an alternation of Liberian and Eburnean formations.
Bos (1964) recognised two major faults in the area of our survey, those of the Audrénisrou and of the Gô (Fig. 3). They are both in a northeast/southwest direction. Smaller faults occur in a direction perpendicular to this, northwest/southeast. These are of a later date. Tectonic activity has thus cleaved the region into several compartments.

Migmatite is a rock of mixed composition resulting from the introduction of material with a more or less granitic character into a pre-existing metamorphic rock. It is characterized by lithological differences over short distances due to different intensities of metamorphism and granitization.
Bos (1964) divided the migmatites into homogeneous and heterogeneous migmatites. The latter, occurring northwest of the major fault of the Audrénisrou, are more granitic than the homogeneous migmatites, and they contain hardly any mica. Granitic inclusions are frequent and, on a larger

scale of mapping, these could probably have been separated from the more gneissic migmatites. The homogeneous migmatites are very similar to gneisses and contain much mica.
In the southern part of the study area the lithology is more varied; there is often an alternation of granites, gneisses and schists. Amphibolites, phyllites and quartzites are also found, and there are many transitions.

Rock outcrops are rare in the study area. They occur on the few inselberg-like crests, in riverbeds - especially those of the major rivers - and on some crests and upper slopes. Saprolite - weathered rock that has retained its rock structure - is exposed in deeply incised ravines and in some road-cuts; saprolite fragments occur frequently in the subsoil of reference profiles (Appendix 9).

There is a lack of concensus between the geologists on interpretation and delineation of the geological formations. The geological map of DRC (1967) differs from that of Papon mainly in names given to the various formations. Thus, most of the areas mapped as migmatities by Papon were considered to be gneiss by the pedologists of the DRC team. In the south the differences in interpretation and delineation are even larger than in the northern and central parts of the survey area. Although the survey of Bos (1964) was used as a basis for the map of Papon (BRGM, 1973), the differences between the two are striking. South of Nigré, Papon distinguished tuffs and sandstones and classified these rocks as volcanic or volcano-sedimentary. Bos, on the other hand, interpreted these formations as schists-quartzites and gneisses, and DRC (1967) as gneisses only. Between these formations and the village Nigré, Bos distinguished an extensive band of gneisses whereas Papon classified these rocks as migmatites.

It is evident from the discrepancies in geologic mapping in southwestern Côte d'Ivoire that there are great difficulties in interpretation (e.g. migmatites versus gneiss), related in part to gradual transitions in lithology that, moreover, are difficult to map because of the scarcity of exposures. During our survey we found distinct relations between soils and underlying geology mainly in the usually small areas where the underlying rock differed distinctly from that of the surroundings, e.g. granites in the mainly migmatite/gneiss area in the northern part. However, the granitic landforms and soils were usually too small to appear on the 1:100,000 Land Unit Map.

In the legend of the Land Unit Map (Appendix 11) the lithology is a differentiating characteristic on the third level of generalization; for the uplands it is simplified to migmatite, gneiss, granite and schist. This classification of the lithology is based on the interpretation of the surveys discussed above and on our own investigations of the relations between lithology, landforms and soils. In the legend the dominant rock types within a land unit are given; other rock types, not mentioned in the legend, are often present as inclusions (in decreasing order of coverage if there is more than one rock type in the area of the land unit), but this does not necessarily imply that the other formations are completely excluded. The lithological class is called an association if the different formations can be identified and if they occur in a more or less regular pattern. In a complex, on the other hand, the rock types can still be identified, but there is, apparently, no pattern in the way they occur over the area. In the latter case the differences at short distance are very pronounced and frequent.

For an understanding of the present landforms the development of extensive peneplains on the Precambrian basement is of importance. Uplifting of the surface, followed by erosion and dissection has probably occurred several times during Tertiary, and two levels can be distinguished at the surface of the present landscape. The most extensive, and lowest, level is at the present crests of the uplands. The ironstone cappings and lateritic gravel of the crests are considered to be the remnants of extensive ironstone sheets that covered the peneplain and that probably developed during dryer periods in the geological history (Tagini, 1972); the last dry period probably occurred around 30,000 YBP (Collinet et al., 1984). Whether or not remnants of Tertiary palaeosols occur on flattopped crests can no longer be ascertained. The ironstone cappings, being resistant to erosion, have had a strong influence on the development of the relief.
The earlier, and higher, level of planation is perhaps represented by land unit H, consisting of steep-sided hills. These rise to some 300 meter altitude and have flattish tops with remnants of an ironstone crust.

5. GEOMORPHOLOGY

5.1 Introduction

Over 80% of the study area consists of a dissected peneplain with remnants of an ironstone capping on the now highest terrain positions, the crests. Such a landscape can be adequately described by a typical toposequence or catena: a succession along the slope of sites with a characteristic combination of soil parent material, drainage condition, soil and vegetation. Although in principle these land characteristics form a continuum, it is practical to distinguish five sites on the catena, viz. the crest, the upper slope, the middle slope, the lower slope and the valley bottom (in francophone West-Africa known as 'bas-fonds'). Different catenas develop over rocks that differ in lithology, in structure or in texture.

In order to relate data on climate, geology, geomorphology, soils and vegetation to Land Units, to be discussed in Chapter 9, the legend of the Land Unit map (Appendix 11) is introduced in the chapter on geomorphology. Major geomorphic units appear on the highest level of abstraction in this legend, that of the 'major geomorphic unit'. These include Uplands (U), covering most of the dissected peneplain, steep-sided hills (H) and an alluvial landscape (A). Two landscapes occur as associations of geomorphic units. One is an association of uplands and low inselbergs (UI), where some of the crest positions have the characteristics of small domed inselbergs (bornhardts) or boulder inselbergs (tors) (Thomas, 1974). The other is an association of low uplands and alluvial bottom lands (AU). The numerous small valley bottoms in the uplands area can not be mapped individually on a scale of 1:100,000; they are part of geomorphic unit U rather than of A or AU.

On the second level of the Land Unit Map legend, four rainfall/vegetation zones are recognised within the uplands. Vegetation appears to be strongly related to a north-south rainfall gradient and has a greater ecological significance than, e.g. lithology that in certain Land Unit surveys of climatically uniform areas would appear on this level of the legend. Lithology is the differentiating characteristic on the third level of the Land Unit map, as has been discussed in Chapter 4.

Drainage density and physiography (slope classes) appear as differentiating characteristics on the fourth (and lowest) level of the Land Unit Map. These two characteristics usually occur related: stronger dissection is normally accompanied by steeper slopes, whereas weakly to moderately dissected areas are undulating. Drainage density is the total length of drainage channels over a given surface area; it may be expressed as km/km, or as cm/cm on the scale of the map. We established the drainage density from aerial photographs and

topographic maps, both having a scale 1:50,000. Physiography was described in five slope classes, from almost flat (< 2%) to steep (> 30%).
Most of the study area is situated between 100 and 240 meters above sea level (topographical maps 1:50,000, sheets Taï 4a and 4c; 1966). Land unit H rises towards 300 m.

5.2 The major geomorphic units

Uplands (U)
The uplands show a consistent differentiation into slope-related elements as described under 6.1. The major part of the landscape is moderately dissected (0,4-0,6 km/km^2) and has an undulating to rolling relief. It is often difficult to separate different geological formations; these are not distinct in landform, and if they are, the limited visibility in this forest- and bush-covered area may leave it unnoticed. However, in some cases the lithology has a clear imprint on the landform: the area where granite is dominant (Usgl) has an undulating relief, whereas the areas with a complex geology (Utc3, Usc3) have a more rolling relief.
Some areas near the Cavally river have steeper slopes and are more strongly dissected than areas further away from the river (Unm3 and Utm3, as compared to Unm2 and Utm2). The stronger rate of dissection may be due to the shorter distance to the Cavally river, the local erosion level.
Unm2 is the largest land unit in the survey area. The underlying geology is mainly migmatite, but small granitic inclusions, with a different catena of soils, occur.
In the undulating to rolling, moderately dissected uplands, the distance between successive crests is about 1000 to 1500 metres and the difference in elevation between crest and valley bottom is about 15 to 40 metres. The crests are flat-topped or have a convex cross-sectional profile. Over their length they have slope gradients of 0 to 5%. The valley sides have a convex upper slope, merging into a straight or concave middle slope that passes either concave or steeply convex into the valley bottom. The majority of the slope gradients ranges between 2 and 15%.
The valleys are characteristically level on cross-section, with ill-defined drainage channels; their longitudinal profile shows slopes of less than 2 percent (Van der Gaag, 1989). Some narrower sections of the 'bas-fonds' have distinct stream channels. Downstream the 'bas-fonds' merge with minor river floodplains. Some of these are broad enough te be mapped as alluvial landscape (A1).
In the northern part of the study area (land unit Unm2), deep gullies (locally known as 'ravines') have dissected some of the lower slopes (Vellema, in preparation). These gullies seem to have been formed by undercutting through retrogressive erosion (Zeeman, 1989), probably as a result of recent lowering of the local base level of erosion. Elsewhere these 'ravines' occur sparsely.

However, it is not clear whether they are not present, or whether they have remained unnoticed. Thus, field traverses do not cover the entire survey area, and ravines cannot be identified on aerial photographs or on SPOT false colour images.

Association of uplands and small inselbergs (UI)
In part of the uplands some of the highest landscape positions have the characteristics of small (or incipient) inselbergs. They occur in two rainfall/ vegetation zones and have been allocated to land units UI1 and UI2, respectively. Both are associations of uplands and small inselbergs.

In land unit UI1, in the northeastern part and entirely within the National Park, some of the crest sites have the appearance of small domed inselbergs (bornhardts). These crests have a convex profile, a circular plan, and a smooth, rock-paved surface. [(Photo 7)] They differ from other crest sites in being asymmetrical with some steep slopes. The middle and lower slopes are not different from those below non-inselberg crests and upper slopes. There is a characteristic natural vegetation of small trees in an open canopy. [(Photo 8)]
Relief - the difference in elevation between crest and nearest valley bottom - is in the order of 20 to 40 metres, and this refers to both inselberg and non-inselberg catena's.
The area mapped as UI1 stretches NNE to SSW; it occurs east of, and runs parallel to, the major geological fault in which the Audrénisrou and Gô rivers flow (Fig. 3).
Rock is exposed on the summit of the inselbergs and there are some rock boulders on the slopes. The rock type is a gneiss with banded areas of dark minerals alternating with quartz veins. It is probably the same migmatite that underlies the entire northern and central part of the survey area. Thomas (1974, page 166) made the observation that domed inselbergs are commonly found among strongly foliated and banded metamorphic rocks of the Precambrian shields.

There are two occurrences of land unit UI2. The northern one is in the same NNE-SSW direction as land unit UI1, and the domed inselbergs have the same morphology. However, the relief is lower and inselberg-crests occur less frequently than in UI1. The southern occurrence has the same domed inselbergs, but there are also some boulder inselbergs (tors). The lithology of the latter does not seem to be different from that of the rock-paved inselberg surfaces of the bornhardts.
Tors capping crest sites in a part of the National Park east of Para and across the Bono river were found to consist of granitic core stones. Granitic crests also occur scattered in the large migmatite upland areas (see above), but these crests do not normally have the characteristics of tors.

Steep-sided hill (H)
In the SW part of the study area two steep-sided hills are situated adjacent to the Cavally. The northern NE-SW oriented hill is by far the highest point in the survey area. The crest is small in extent and elongated and the very steep slopes have gradients up to 70%. The hills are surrounded by small footslopes.

Alluvial landscape (A)
The alluvial landscape consists of the floodplains of the Cavally river (A2) and of the smaller floodplains along the lower courses of the Audrénisrou, Méno and Nsé rivers, that are major tributaries to the Cavally (A1). Both consist of two physiographic units: natural levees along the stream flow channels, and undifferentiated low-lying areas with an irregular mesorelief further away from the river. The scale of the Land Unit map does not enable these physiographic units to be mapped separately.

Association of low uplands and alluvial landscape (AU)
Two areas have been mapped as an association of low uplands and river floodplain.
The larger of these areas includes parts of the floodplains of the Cavally, the Audrénisrou and the Gô rivers.

5.3. Hydrology

[(Photo 9)

The study area belongs to the catchment of the Cavally river, which forms the border with Liberia. The major rivers that drain the area are the Nsé, the Audrénisrou, the Gô and the Méno. The Cavally's fall is about 50 to 60 cm per km, that of the Méno 100 cm per km; the fall is irregular as there are rapids in the rivers.
Monthly discharge records of the Cavally, the Nsé and the Audrénisrou are presented in Table 4. It is obvious that the discharge is strongly related to the climatic season.
The floodplains of the major rivers are subject to seasonal flooding. The small inland valley swamps are waterlogged during the entire rainy season; in the dry season many of the small streambeds are nearly dry, but others remain swampy throughout the year, probably due to lateral flow of groundwater (Van der Gaag, 1989).
There are abrupt changes in the direction of the drainageways. Bos (1964) states that especially west of the Audrenisrou fault the direction of the rivers and small streams is strongly related to the structural and tectonic direction that runs NNE to SSW; this is clearly shown in the courses of the Gô and Audrénisrou rivers. In our opinion, this applies to the major part of the area.

The drainage pattern is predominantly subparallel/rectangular. Some areas have a remarkably wide, parallel pattern, especially west of the Audrenisrou in land unit Unm2, and west of the Méno in land unit Utz3.
The first order tributaries that form the upstream drainage pattern, have no preferential orientation; the drainage pattern is semi-dendritic (Fritsch, 1980). This pattern may have formed as a result of a new erosion cycle (Collinet et al., 1984).Drainage density has been used for the characterization of the land units (section 5.1).

Table 4 Average monthly discharge of rivers Cavally, Nsé and Audrénisrou measured in m^3/sec (Collinet et al., 1984).

River	Cavally	Nzé	Audrénisrou
Station	Taï	Taï	Tiéouléoula
Drainage area (in km^2)	13,750	1,240	106
January	68	9.0	0.157
February	40	5.6	0.144
March	67	13.8	0.309
April	75	7.9	0.640
May	107	12.8	1.45
June	216	37.1	2.88
July	248	44.9	1.23
August	259	35.0	1.37
September	517	86.6	3.07
October	622	97.5	2.93
November	301	37.3	1.69
December	160	15.0	0.586
Mean annual discharge	224	33.7	1.39
Number of years	10	10	8

6. SOILS

6.1. Former studies on soils of the area

Several surveys and other investigations have been carried out to study the soils in south-west Côte d'Ivoire (Leneuf, 1956; Riou, 1960; 1963; Development and Resources Corporation (DRC), 1967; Perraux, 1971; Fritsch, 1980, 1982).

The Development and Resources Corporation (DRC, 1967) made an inventory of the natural resources and the development potential of south-west Côte d'Ivoire, with emphasis on soils and forests. A comprehensive description of the soils, supplemented with data from laboratory investigations, and a soil map at a scale 1:200,000 were published. The DRC soil mapping units are associations of soil series. Twenty-two soil associations were described, many of which were soil catenas or groups of soil catenas. Next to the cartographic representation, each soil association has also been shown as a block diagram. Three associations cover our survey area (Appendix 6):

K = Daobli-Baolé-Koléa association, clayey and loamy soils of the undulating to rolling gneiss uplands;

I = Saoua-Bédoulé-Daolé association, clayey and loamy soils of the undulating to rolling gneiss uplands;

P = Naurou-Niagui-Kroon association, loamy and clayey soils of the undulating to rolling granite uplands.

We will refer to these soil associations and the composing soil series in more detail in relation to our own investigations (section 8.4). The soil series of the DRC report were not assigned to higher levls of a taxonomic soil classification system. Van Kekem (1984) translated the legend of the DRC report into French and established a correlation with the FAO/Unesco soil classification (FAO/Unesco, 1974).

Parraux (1971) studied the soils of Côte d'Ivoire and presented a soil map on a scale 1:500,000. He recognised three mapping units in our study area, viz.:

1. 'Sols ferrallitiques ; remanié; modal; sur granites; fortement désaturé' (upland soils);
2. 'Sols ferrallitiques; remanié; modal; sur schistes; fortement désaturé ' (upland soils);
3. 'Sols peu évolués/sols hydromorphes minéraux' (alluvial soils).

The large area covered by 'sols ferrallitiques' has been differentiated according to parent rock, either granite or schist.
An important difference between the soil maps of DRC and Parraux is the interpretation of migmatites as recognised and mapped by Papon (1973). DRC has interpreted these as gneisses, Parraux as granites. Both interpretations are,

at least to some extent, correct: migmatite is, by definition, a rock of mixed composition. In the Taï region most of the migmatites tend towards a gneiss, a minority towards granite. Often the granitic and gneissic migmatites alternate over short distances. The lack of a precise characterisation of the parent rock makes it difficult to identify soil parent materials. To this can be added the lack of rock outcrops in the area.

Within the framework of the MAB/Unesco project on the Taï area (Guillaumet et al., 1984) Fritsch (1980) made a detailed survey of 1600 hectares in the National Park, at a scale of 1:15,000. He produced a landform map - in which he distinguished six types of interfluves - and a soil map. The soil map gives a good illustration of the way soils change along a toposequence from crest to valley bottom. In the small area surveyed by Fritsch no differentiation based on parent rock was made; the underlying geology was, apparently, uniform.
Fraters (1986) made a comprehensive desk study of one particular transect in the survey area of Fritsch. Collinet et al. (1984) gave a summary of the work of Fritsch; they recognised four major soils in the catena: crest and upper slope, midslope, lower slope, valley bottom.

Vellema (in prep.) made a physiographic soil survey at a scale of 1:50,000 covering 20,000 hectares in the Taï area. Vellem's survey included Fritsch's study area and he distinguished between two main landscapes: uplands and alluvial plains. The various soils along the typical catena - basically the same as those recognised by Fritsch - were described. Mapping units were soils of crests, valley sides and valley bottoms, respectively; the valley bottoms were subdivided on drainage density and slope. No systematic differences in parent rock were found. Some of the results of Vellema's study have been incorporated in the present report.

6.2 General features of the soils

6.2.1 Soils of the uplands

The soils of the uplands belong to a number of typical catenas that are strongly related to the parent rock. A catena is an association of soils developed from one kind of parent rock, but differing in characteristics due to differences in relief and drainage. Within each catena the soils can be differentiated according to position on the slope. Most upland catenas can be characterised by five catenary positions: crest, upper slope, middle slope, lower slope and valley bottom ('bas-fonds'). Soils on crest, upper and middle slope have usually developed 'in situ' and these sites are subject to soil erosion. Lower slope soils are developed in colluvial material that has been eroded from the higher positions, but on steep and convex lower slopes, the soil may be residual. Valley bottom soils have developed in a mixture of colluvial and alluvial material. In a downstream direction the valley bottom lands change gradually into alluvial plains, and the parent materials grade from colluvio/alluvial into alluvial. In the upper parts of the valley bottoms the rivers are incising, and the valley bottom soils are residual with a shallow colluvio/alluvial veneer.

Some soil forming processes are prominent in the entire uplands area. They are described in the following, under the headings a through f.

(a) Soils developed 'in situ' in the Taï area are old; soil formation started after dissection of the Tertiary peneplain, that, over considerable distances, was covered by ironstone sheets or ironstone gravel. The present soils are strongly weathered, depleted of bases and have high contents of sesquioxides - mainly of iron and aluminium - and quartz by relative accumulation. The silt (2-50μm) fraction is small; silt-size weatherable minerals have produced clays, sesquioxides and soluble compounds. The latter were subsequently leached from the soil system. Many upland soils have a considerable amount of ironstone gravel or quartz gravel, or both. The ironstone gravel is derived from the physical disintegration of the ironstone sheets and subsequent partial transportation of the ironstone fragments, whereas the quartz gravel and angular fragments of quartz are weathering residues from granitic, migmatitic and gneissic rocks. The remnants of ironstone sheets and the ironstone gravel are still subject to weathering today; they may be an important source of iron for the formation of plinthite in subsoils (see c. below).

(b) The clay contents of soils that have formed 'in situ' increase with depth. Several mechanisms may be active here: downward migration of clay in suspension; downslope migration of suspended clay laterally over the surface and in the surface soil; selective transportation by termites that bring relatively clay-rich material to the surface, where it fans out over the surface when the termite mounds disintegrate. The latter process has been described for comparable soils in Sierra Leone by Dijkerman et al. (19..).

(c) In soil profiles or sections thereof that are subject to water saturation by groundwater, or by water stagnating over an impermeable layer, a reducing soil environment is created, at least during the rainy season. In the dry season, when the groundwater level sinks, and stagnating water is absent, there will be an oxidising environment. The alternation of reducing and oxidising conditions has a strong influence on the behaviour of iron in the soil. Iron is mobile as ferrous iron under reducing conditions, and particularly in the presence of organic matter, whereas it is immobile as ferric iron in

an oxidizing environment. Due to hysteresis in the speed of the ferric-ferrous transition, iron oxides may then accumulate in pores and on ped surfaces, forming reddish-brown mottles. The surrounding matrix of the soil, gradually depleted of iron, will assume a pale, greyish to greenish colour. Some of the iron may be lost from the soil and discharged towards rivers.
This process, generally known as 'gleying' is active in valley bottom soils and in soils of the alluvial plains, where subsoils are greyish due to permanent reducing conditions, whereas both reddish-brown and greyish mottles occur in the zone where the watertable fluctuates. The combination of reddish-brown and greyish mottles is sometimes described as 'redox mottling'. There is stronger segregation of ferric iron in lower slope soils than in valley bottom soils since lower-slope positions may receive iron compounds from higher-lying sites. The permanently reduced zone - continuously below the groundwater level - may be much deeper there.

In tropical climates the gleying process may be very intensive and the mottles with iron accumulation have a distinct red colour. Most of the ferric iron in these mottles is haematite (α-Fe_2O_3), and such mottles may harden irreversibly upon periodic or continuous drying. The soil material is known as plinthite. Soil Taxonomy (1975) defines plinthite as an iron-rich, humus-poor mixture of clay with quartz and other diluents, that commonly occurs as dark red mottles. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on exposure to drying. This may occur when surface soil is lost due to erosion, or when the soil dries out to greater depths, e.g. as a result of deforestation.
It is interesting to note that in the Taï area plinthite formation is not restricted to lower slope soils, but is also found in the subsoils of middle slope and even upper slope and crest positions. This unusual occurrence of plinthite is presumably due to water saturation at some depth for part of the year in combination with a lateral flow of water containing ferrous iron over an impermeable layer or horizon. Reddish plinthite mottles, especially when somewhat hardened, can be easily confused in the field with weathered pea-iron gravel and with iron-indurated saprolite fragments. We have, therefore, described reddish mottles as plinthite only if accompanied by pale, greyish-coloured mottles.
The more common occurrence of plinthite is in lower slope positions that have a fluctuating water table and receive ferrous iron from higher-lying sites. We must assume that temporarily water-saturated conditions on crest and upperslope sites induce hydromorphic weathering of the ironstone gravel that abounds there. Ferrous iron is formed and is transported towards lower positions, notably - but not exclusively - the lower slopes.

Some of the recently or subrecently formed plinthite in the Taï catenas will eventually harden into ironstone. Such 'recent ironstone' can be found as a hardpan or as ironstone gravel in some of the middle and lower slope soils, e.g in the walls of steeply incised drainage channels ('ravines'), as described by Zeeman (1989). The Tertiary ironstone sheets which covered the original peneplain (see a.) have probably formed in a similar manner, with hardening taking place concurrently with a change to drier climatic conditions accompanied by dissection of the landscape. Several such dry phases may have occurred, and original pediplain levels in West Africa can now be related to different periods of ironstone crusting (Collinet et al., 1984).

(d) Different rocks weather into different soil materials. This is most evident on crests and upper slopes where soils have developed 'in situ', that is: directly in the weathering rock material (saprolite). In the study of catenas in the Taï region we have, therefore, focussed our attention on the characteristics of crest and upper slope soils. Most of the reference profiles are on these highest positions of the catena.
As a rule-of-thumb, dark-coloured rocks are rich in weatherable minerals; they produce clay-rich soils, that are reddish-brown to red due to the presence of much finely divided ferric iron. Plinthite (see above) in such soils may form a continuous phase, and hardening of plinthite will then produce continuous ironstone pans or surface cappings. Schists, phyllites, amphiboles and dolerites in the Taï region are rich in weatherable minerals.
Granitic rocks have little weatherable minerals. These rocks weather into sandy or loamy soil material with little ferric iron and much quartz gravel and stones. The soils are light yellowish brown. Plinthite may occur in the form of mottles that will produce some ironstone gravel on hardening, but continuous ironstone sheets or hardpans are rare in granitic regions.
Migmatite rocks produce reddish clayey soils or yellowish-brown loamy soils, depending on their composition. Quartz fragments and fine quartz gravel are often present; the quartz derives from veins in the original rock. The composition of migmatite may change over short distances and this may not be reflected in the properties of the soils, and even when it is, such soil differences cannot usually be mapped on the 1:100,000 scale of the Land Unit map.

(e) The ironstone cappings of crest sites, and the lateritic gravel on the surface or at shallow depth in crest and upper slope soils, are probably the remnants of extensive ironstone sheeting in earlier geologic periods (see Chapter 4). However, catenas differ in respect of the quantity of ironstone in their upper members. The catena developed over granite (see below) features very little ironstone gravel on crests and upper slopes, whereas the migmatite catena or the schist variant have much lateritic gravel on similar positions. The original Tertiary or Pleistocene ironstone capping was probably not uniform but dependent on the rock type over which it developed.

(f) Soils in a catena are strongly related, each soil receives compounds from soils in higher positions, and loses compounds to soils in lower positions. Soil forming processes differ in nature and in intensity with position on the slope. The major processes are:

* lateral movement of water with suspended matter (clay-size minerals) and soluble compounds, including ferrous iron;
* erosion at higher positions and sedimentation on lower slope sites and in the valley bottom;
* variation of soil depth with position on the slope.

The specific characteristics of the Taï catenas are most clearly expressed on crest and upper slope sites; in the lower catena-positions, with their partly colluviated soil material, soils are more alike among catenas.

6.2.2 Soils of the alluvial plains, and of the upland-alluvium transition zone

All upland soils can be placed in a catena or a catena variant. In alluvial plains, however, the catena concept does not work: the relationships between adjoining soils are of a different nature, and the soil pattern can be described either as a soil association or as a soil complex, following the definitions in the Soil Survey Manual (Soil Survey Staff, 1951). Soil association and soil complex are soil mapping units. A soil association is a group of defined and named taxonomic soil units, regularly geographically associated in a defined proportional pattern. The catena, defined earlier, is a specific form of a soil association. The soil complex is a soil association, the taxonomic members of which cannot be mapped individually even in a detailed soil survey.
The process of 'gleying', described above, is characteristic for the alluvial soils.

6.3 Description of the soils

Migmatite catena: brownish or reddish clayey soils, with ironstone gravel; on migmatite

The migmatite catena covers most of the survey area, in the northern part almost exclusively. It is characteristic for land units Unm2, Unm3, Upm2, Utm2 and Utm3 and it covers parts of other land units that have a complex underlying geology.

The soils of crest and upper slope contain much ironstone gravel, up to 80% of the soil volume in some sections of the profile, such as the surface and subsurface soil. The ironstone gravel is rounded, 4 to 8 mm across. The gravelly layer begins at the surface or at shallow depth (usually within 20 cm); the thickness of the gravelly layer is normally more than 50 cm, and often more than 100 cm. Quartz gravel (fine gritty gravel and angular fragments up to about 5 cm diameter) is usually present in smaller quantities; larger fragmnts of quartz occur incidentally. The other soil characteristics can be summarized as follows:
The surface soil (A horizon) is a dark brown (7.5YR3/3) sandy loam to sandy clay. The subsurface soil (B horizon) is strong brown (7.5YR5/6), but colours may be redder (5YR5/6; 2.5YR5/6) or more yellow (10YR5/6); textures are sandy clay to clay, and the clay percentage generally increases with depth. Fine mica flakes may occur, especially in soils in the southern part of the survey area. In the subsoil (BC and C horizons) red mottles occur in a number of profiles; these are either plinthite mottles or saprolite fragments. The soils are well drained.
Reference profiles are 2, 6, 8, 10, 13, 15 and 19.
The crest and upper slope soils correspond to the Daobli series of association K, or the Bédoulé series of association I of the DRC classification (DRC, 1967); see also Appendix 6.

In a downslope direction the soils get less gravelly, and the gravelly layer gets thinner. There is also an increasing thickness of the gravelfree surface soil (as a result of colluviation). In midslope soils the gravelly soil layer is between 10 and 100 cm thick, in lower slope soils there is little ironstone gravel.

The midslope soils have a dark brown to dark yellowish brown (10YR3-4/3-4) A horizon, with a sandy loam to sandy clay texture. The B horizon is dark yellowish brown (10YR4/6), with depth grading into strong brown (7.5YR4/6). Textures are sandy clay loam to clay; clay percentages increase with depth. Mottles of plinthite occur in the lower B horizon or in the subsoil.
The midslope soils are well to moderately well drained.
Reference profiles are 1, 3 and 5. The midslope soils correspond to the Saoua series of association K in the DRC classification.

The lower slope soils have a dark grayish brown (10YR4/2) A horizon, with a loamy sand to sandy loam texture. The B horizon is dark yellowish brown (10YR4/6) to brownish yellow (10YR6/6); textures are sandy loam, with depth grading into sandy clay. Plinthite mottling is common in the lower B horizon or in the subsoil. Some of the plinthite has hardened, especially on the steeper, convex slopes, where part of the overlying soil cover has been eroded, and where the plinthite appears within 70 cm depth. The lower slope soils are moderately well drained, but the lower parts of concave slopes are imperfectly

drained.
Reference profiles are 4, 7 and 16.
The soils correspond to the Baolé and Daolé series of the DRC classification; these series cover the upper and the lower parts, respectively, of what we have called the lower slope.

The valley bottom soils of this catena have much in common with those of the other catenas. They are therefore described as one group, following the description of the hill catena.

In the migmatite catena the crests and upper slopes occupy 30-50% of the surface area, the middle slopes 20-30%, the lower slopes 25-30%, and the valley bottoms about 15%. A similar relative coverage is found in the other catenas.

(Photo 15)

Schist variant: reddish clayey soils, with or without ironstone gravel

The composition and texture of migmatite is generally similar to that of gneiss, but it may tend towards granite at one side, and to schist and sometimes phyllite at the other. The schistose layers in the migmatite are often so small that typical schist-derived soils cannot be identified, but in other cases the intrusions are of sufficient extent to produce a specific soil. Such schist-derived soils seem to form inclusions in other catenas, and only when the inclusion is at a crest or upper slope site, are schist-derived soils to be expected. This is also shown in the block diagram of association P in the DRC report. We have, therefore, characterised the schist-derived soils by crest and upper slope soils only, and we define these as a variant (of the migmatite catena) rather than as a separate catena.

The soils on crest and upper slope differ from those in comparable positions of the migmatite catena in having less ironstone gravel and quartz fragments, and containing much mica. The A horizon is a dark brown to dark yellowish brown (7.5 and 10YR3-4/4) sandy clay loam to clay. The B horizon is red to yellowish red (2.5 and 5YR5/6-8), sometimes strong brown (7.5YR5/6), and has a clayey texture. Plinthite mottles and saprolite are often found within 120 cm depth, and they give the soil a multicoloured appearance. The soils are well-drained.
Reference profiles are 14 and 18.
The soils correspond to the Terreagui series in association P of the DRC classification.

Granite catena: yellowish-brown loamy soils with quartz gravel

The soils that have developed over granitic rock form a catena that is distinct from the migmatite catena in all positions on the slope. The granite catena is dominant in land unit Usgl, and it occurs as an associated catena or an

inclusion in a number of other land units.
The soils differ from those of the migmatite catena in being coarser-textured, yellowish-brown rather than reddish-coloured, and they have little ironstone gravel but much angular gravel and larger fragments of quartz. The catena corresponds to association P of the DRC classification, except for the Terreagui series.

The crest and upper slope soils have a dark brown (10YR3/2) A horizon with a sandy loam texture. The B horizon is dark yellowish brown (10YR4/6) to yellowish brown (10YR5/6), or strong brown (7.5YR4/6); textures range from sandy loam to sandy clay, but loamy textures are most common. Between depths of 50 and 100 cm there is much quartz gravel; the surface soil and subsoil contain are less gravelly. The soils are well drained.
The crest and upper slope soils correspond to the Niagui series of the DRC classification.
Reference profile is 17.

The middle slope soils are similar to those of crest and upper slope, but the quartz gravel occurs mainly below 100 cm depth, and there is some iron mottling in the subsoil. The soils are moderately well drained.
They correspond to the Kroon series of the DRC classification.

The lower slope soils have a very thin, very dark grayish brown to dark brown (10YR3/2-3) A horizon with a sandy loam texture. Textures in the B horizon grade with depth from sandy loam through sandy clay loam to sandy clay. Red (2.5YR5/8) mottles and quartz gravel occur mainly in the subsoil (B horizon). The soils are moderately well drained.
They correspond to the Naurou series of the DRC classification.

Granite-gneiss catena: yellowish brown loamy soils, with little ironstone gravel

The granite-gneiss catena differs from the migmatite catena mainly in the virtual absence of ironstone gravel. There is much resemblance to the soils of the granite catena, but the soils have less quartz fragments and more plinthite; the latter occurs even in crest and upper slope soils. This catena is found together with the migmatite catena and the schist variant in land unit Utx2, and occasionally in some other land units.

The crest and upper slope soils have a dark brown (10YR3/3) A horizon with a loamy sand to sandy loam texture. The B horizon is yellowish brown (10YR5/6) or dark yellowish brown (10YR4/6), and grades into strong brown (7.5YR4-5/6) with depth; textures grade with depth from sandy loam or sandy clay loam to sandy clay. Plinthite may occur at depths below 100 cm. The soils are well drained.
Reference profile is 12.

The middle slope soils differ from the crest and upper slope soils in having a B horizon that is yellowish red (5YR4/6) below 50 cm. The B horizon contains plinthite that in some profiles has recently hardened into ironstone gravel. The soils are moderately well drained.

The lower slope soils are finer textured than the soils on higher slope positions.

Inselberg variant: shallow soils over acid to intermediate igneous rock

Some of the crest and upper slope sites of the migmatite catena have the characteristics of small domed inselbergs (bornhardts) or boulder inselbergs (tors). The occurrence of these inselberg variants is restricted to a few areas that have been mapped as 'association of uplands and small inselbergs' on the land unit map. In land unit UI1 only bornhardts occur, in land unit UI2 both bornhardts and tors are found.
The middle and lower slopes below the inselberg crests are not different from those below the crests of the migmatite catena.
The inselbergs proper have shallow, skelettal soils, or there is merely bare rock, the latter consisting of migmatite/gneiss.

Hill catena

The hill catena is developed over steep-sided hills formed from amphibolite or dolerite. They occur on two locations near the Cavally river. The hill catena is characteristic for land unit H. The soils on crest and valley sides are shallow and skelettal sandy loams to clay loams; ironstone gravel and larger fragments of ironstone are at the surface. The footslope soils that surround the hills are deep, reddish-brown (5YR4/4) to dusky red (2.5YR3/2) slightly gravelly sandy clays and clays. These soils are well drained.

Soils of the valley bottoms in the upland areas

The valley bottom soils are the lowest members of the catenas described above and they have many common characteristics, regardless of the catena to which they belong. They have developed in colluvio/alluvial parent materials overlying saprolite that has weathered 'in situ' under waterlogged conditions.
All these soils are hydromorphic, ground water tables are high, and redox mottling begins at shallow depth. There is considerable variation in soil colour and in textures, the latter ranging from sand to sandy clay loam. Quartz gravel is often found. These soils are poorly to very poorly drained. They cover about 15% of the uplands.

Soils of the upland-alluvium association

In the transitional zone from upland to the alluvial plain of the Cavally, and

to the alluvial plains of the lower reaches of some of its tributaries, there is a pattern of low uplands, lower slope members of upland catenas, and river floodplains. The soils form, geographically, an association that coincides with land unit AU.
Reference profiles are 9 and 11.

Soils of the alluvial complex

The alluvial plains of the Cavally river and the lower reaches of the Nsé, the Audrénisrou and the Méno, have a complex pattern of soils that differ in texture, in depth to ground water table and in other, related, features. Part of these alluvial soils occur in an intricate pattern with the spurs of the uplands, and this soil landscape has been described above as upland-alluvium association.
Most clearly expressed in the alluvial complex are the soils of the natural levees, adjacent to the rivers. They have a very thin, dark brown (10YR3/3) surface soil, with textures that vary from loamy sand to sandy clay loam. The subsurface soil has similar textures, and a yellowish brown to brownish yellow (10YR5-6/6) colour. Redox mottling begins within 10 cm depth. The soils are moderately well to poorly drained.
Soils of the alluvial complex are characteristic for land units A1 and A2.

6.4 Analytical data from soil samples

6.4.1 Introduction

Samples from most of the reference profiles mentioned in section 6.3 were analysed on particle-size distribution, pH, organic carbon and exchange properties. Profiles 1 to 5, inclusive and profile 7 were analysed in the ORSTOM-laboratory, Adiopodoumé. These profiles are from the northern part of the survey area, and also served as reference profiles in another survey (Vellema, in preparation). When the ORSTOM laboratory closed in 1989 the samples from the other reference profiles were sent for analysis to the Department of Soil Science and Plant Nutrition of the Agricultural University, Wageningen. Most of the analytical methods used in both laboratories were the same. The methods are described in Appendix 8. The analytical data are given in Appendix 9, together with the corresponding soil profile descriptions.
The analytical data are discussed separately for each laboratory not only because systematic differences may occur, but also because of a different siting of the reference profiles in the catena. The soils analysed at Adiopodoumé are from one land unit, Unm2, and they occupy upper slope, middle slope and lower slope positions of the migmatite catena. There is no profile on a crest site. Of the 11 soils analysed in the Wageningen laboratory, however, 7 of the ten upland profiles occupy crest/upper slope positions, whereas two are on a

lower slope, and one on a middle slope. One profile is on alluvial parent material. The 11 reference profiles represent 8 different land units.

6.4.2 Data from the Wageningen laboratory: profiles 8, and 10 to 19, inclusive

Coarse fragments

The coarse fragments (particles > 2mm of the whole soil, or 'stones and gravel') in the Taï soils consist of ironstone and quartz gravel. The ironstone fragments (lateritic or pea-iron gravel) is usually derived from the Tertiary ironstone capping. However, in the subsoil of some profiles there may be ironstone gravel derived from actual plinthite that has recently hardened. Quartz gravel occurs as angular fragments. These are derived from quarz veins in the original Basement Complex rock. In soils developed on granitic rock most of the gravel is quartz (see the field description of profile 17), whilst in soils on basic and intermediate rock types most of it is ironstone. The semi-quantitative field observations (e.g. slightly gravelly, gravelly, very gravelly) correspond well with the laboratory data. Most of the saprolite fragments have probably been analysed as part of the fine earth fraction, since the weathered rock is mostly soft and earthy. Some, however, may have hardened due to precipitation of ferric iron, and these saprolite pockets - which in fact have become ironstone fragments - could have become part of the 'stones and gravel' fraction after grinding and seeving of the soil sample.

Most of the soils on crest and upper slope sites have high contents of ironstone gravel in the surface and subsurface soils, but the upper 5 to 10 cm may be free of gravel. The subsoils have less gravel. There are two exceptions: profile 18, developed over schist, has very little gravel, except for a very thin surface horizon, and profile 12, developed over granitic gneiss has gravelfree upper horizons, overlying a very gravelly subsoil.

The two profiles on middle slope positions (nrs. 14 and 17) have a gravelfree surface soil of variable thickness, and are very gravelly at depth. Profile 16, on a lower slope, has little gravel, but a very gravelly subsoil (the field description shows the latter to be largely quartz). The profile on alluvium (nr. 11) is free of gravel.

Particle-size distribution of the fine earth (fraction < 2mm)

Crest site soils have 12 to 34% clay, 3 to 13% silt, and 54 to 79% sand. The soil textural classes according to the U.S.D.A.-classification are sandy loam and sandy clay loam. Relationships with assumed parent rock are not clear, except perhaps for profile 18, developed on schist, that has relatively high contents of silt and clay, and a low content of sand. The lower slope profile, nr. 16, is sandy. It is not uncommon to find sandy lower slope soils in a catena with clayey upper catenary members.

In some soils there is a marked increase of clay percentage with depth: nrs. 10, 14, 17, 18 and 19. These soils have kandic diagnostic horizons in the U.S.D.A. classification system (Soil Survey Staff, 1975).

pH

Values for pH-H_2O are higher than those for pH-KCl, and this shows that cation exchange capacity of these soils exceeds the anion exchange capacity. pH-H_2O in most soils is between 4.4. and 6.4, with subsurface and subsoils having the lowest values. The soils appear to be strongly leached and very acid. pH is a good indicator of the degree of saturation of the exchange complex with aluminium and bases (see below).

Organic carbon

The surface samples, usually taken from the upper 2 or 3 centimeters, are high in organic matter, between 1.7 and 7.3%, mostly between 2 and 4%. In many soils the contents of organic carbon remain high with increasing depth, often around 1%. The lowest contents of organic carbon are in profile 11, developed in alluvial parent material, and in profile 16 , on a lower slope site. Both are sandy soils.

The high organic matter content in the soils of the Taï region, that have clays with a low active surface, is of great value in retaining plant nutrients.

Exchange properties

Exchangeable cations were measured in an unbuffered 0.1 M barium chloride extract. The data represent the exchange properties of the soils under field conditions. The aluminium saturation of the cation exchange complex has been calculated as percentage of the sum of cations, a quantity that more or less equals the effective cation exchange capacity or ECEC.

Exchangeable bases were also determined after leaching the soil with 1M ammonium acetate, buffered at pH7. The amount of ammonium retained by the soil is considered to be the cation exchange capacity of the fine earth at pH7, or CEC7. The ECEC is defined as sum of bases extracted with 1 M NH_4OAc,pH7, plus aluminium extracted by 1M KCl. The method that we used, extraction by 0.1 M $BaCl_2$, should give the same results. Pratt and Bair (1961) investigated various extractants on acid soils and they found that, except for soils containing very little aluminium, barium and potassium chlorides in normal, unbuffered solutions extracted the same amount of aluminium from any one soil.

The CEC and the ECEC were also calculated for the clay fraction, assuming that all exchange sites of the soil are on clay-size mineral particles. In this calculation the contribution of organic matter to CEC and ECEC has been neglected. The error made can be high in soils such as those in the Taï area that have low-activity clays and contain high amounts of organic matter. We have therefore omitted the calculation of CEC-clay and ECEC-clay in samples with over 1.0% organic carbon. The calculated values have been used for classifying the soils and could, for this purpose, have been restricted to the B horizons.

In strongly leached soils all bases are retained on exchange sites, and extraction by an unbuffered barium chloride solution and a buffered

ammonium acetate solution should give the same results. In most samples this appears to be the case.
Exchangeable calcium and magnesium are highest in the upper centimeters of the soil, where Ca usually is the dominant ion. With depth Ca and Mg decrease and Al increases. Exchangeable sodium is negligible, potassium is low, whereas calcium and magnesium occupy most of the exchange sites in the surface soil Exchangeable manganese is always low; it never exceeds 0.2 cmol(+) per kg, and is usually below 0.1. Exchangeable aluminium is strongly dominant in the subsurface soil and subsoil of most profiles.

Odell et al. (1974) found high exchangeable aluminium in soils in Sierra Leone that had developed from granite, schist and gneiss of the Basement Complex. Soils having 2 to 6 cmol(+) per kg of exchangeable aluminium had low productivity due to one or more of several factors. Firstly, large amounts of exchangeable aluminium in soils increase their 'unavailable' water content - water that is held against 15 bars (1500 kPa). Secondly, clayey soils with 3 cmol(+) per kg, or more, of exchangeable aluminium in the surface were found to be difficult to cultivate when wet, whereas they became very hard upon severe drying. Thirdly, aluminium toxicity to crops may occur when the ratio exchangeable Ca+Mg/ exchangeable Ca+Mg+Al drops below 0.1, or when pH-H_2O is below 4.8. Finally, high exchangeable aluminium causes phosphate fixation.
Coleman and Thomas (1967) showed that exchangeable aluminium rather than exchangeable hydrogen, is the dominant cation associated with soil acidity. Useful indicators of soil acidity are exchangeable aluminium values, Ca+Mg/Ca+Mg+Al ratios, and percentage aluminium saturation of the ECEC. Since aluminium is precipitated at a pH of about 5.5. to 6.0, soils are essentially base-saturated at such pH levels (Sanchez, 1976). Examples of pH - aluminium saturation relationships are given by Kamprath (1973) and Sanchez (1976).

The pH-aluminium saturation relationship in 11 Taï region soils is given in Fig. 6. At pH values over 5.0 aluminium saturation seldom exceeds 30%, and at values above 5.5 it is negligible. If the pH drops below 5.0, aluminium saturation increases rapidly. A saturation percentage of 50 can be considered critical for soil-plant relationships, and this is reached when pH drops below 4.8. Odell et al. (1974) found aluminium toxicity at such pH levels.
Most surface soils have over 50 % exchangeable aluminium. This implies that in most soils of the Taï region there is a risk of aluminium toxicity when cropped without liming to increase both the soil pH and the percentage exchangeable calcium. Some soils show a different pattern. In profile 11 aluminium saturation varies with depth, and this may reflect the vertically heterogeneous, alluvial, parent material. Profile 17 has a negligible amount of bases and, consequently, aluminium saturation is above 90% in most of the soil. But the most notable exception is profile 13 that has virtually no exchangeable aluminium. It differs strongly from profile 12 that occurs in the

same land unit (Utx2), occupies the same position in the catena, whereas the sites of both soils have a similar ecology: (disturbed) primary forest. However, both profiles belong to the same subgroup in Soil Taxonomy (Soil Survey Staff, 1975), and to the same soil unit in the FAO-Unesco classification system (FAO, 1988).

L 1990

ORSTOM

6.4.3 Data from the O.R.S.T.O.M.-laboratory: profiles 1 to 5, inclusive, and 7

Coarse fragments

Soils on lower slope positions (profiles 4 and 7) have very few coarse fragments, whereas soils on upper and middle slopes have large contents of gravel. Most of the gravel consists of rounded ironstone fragments. Some of the ironstone gravel in the subsoil of a few profiles may be recently hardened plinthite. Small amounts of quartz gravel are very common.

Particle-size distribution of the fine earth

All six profiles have low percentages of silt, between 5 and 16, usually below 10, with about equal quantities of fine silt (2-20 μm) and coarse silt (20-50 μm). Clay percentages are between 10 and 42, and there is generally a marked increase of clay content with depth. Total sand percentages are between 45 and 84. The coarse sand fraction (200-2000 μm) is usually much larger than the fine fraction (50-200 μm). Lowest clay and highest sand percentages are found in profile 7, on a lower slope position. The textural composition of this soil is similar to that of the lower slope reference profile 16, in land unit Usy2. However, profile 14, also from a lower slope site, has a particle-size distribution similar to that of soils from higher catena positions.

pH

Upper surface soils have pH-H_2O values between 4.6 and 6.3, in lower surface soils the pH is 4.2 to 5.0, and below 20 cm depth between 4.2 and 4.9. Except for some relatively high pH values at the surface (5.3; 5.5; 6.3), there is little variation with depth and between soils. The pH-KCl is 0.1 to 1.2 units lower than the pH-H_2O.

Organic carbon

The upper surface samples (0 to 2/10 cm) have organic carbon percentages between 1.0 and 2.6, the lower surface samples between 0.7 and 1.6, and below 20 cm depth organic carbon is between 0.4 and 0.8%. In some of the profiles analysed in the Wageningen laboratory much higher organic carbon has been found. Most of the Wageningen profiles are from sites with higher rainfall than the sites of the ORSTOM-profiles, and this may explain their higher contents of organic carbon.

Exchange properties

Exchangeable bases were measured after leaching with 1 M ammonium acetate

of pH 7. Exchangeable aluminium was measured in a 1 M KCl extract. Ezxchangeable bases are low, but Ca and Mg are relatively high in some of the upper surface samples. Base saturation decreases rapidly with depth, whilst aluminium saturation increases - the same observation was made in the reference profiles analysed in the Wageningen laboratory. Al-saturation - pH relationships are given in Fig. 7. The observations are in line with those from the profiles in land unit Unm2.
The ECEC of the fine earth fraction is 3 or less, and often below 2 cmol(+) per kg. The ECEC calculated for the clay fraction (in samples with organic carbon 0.1% or less) is usually between 3 and 6, but higher values are found in profile 7.

6.4.4 Conclusions

The analytical data and the corresponding field data do not give a clear relationship between soil properties and the main differentiating soil forming factors in the region: parent material, relief and climate.
It has been assumed that the geology of the area is most clearly expressed in soils on crest sites (see section 2.3.3), but this is not confirmed in the field observations and analytical data of most crest profiles. The one notable exception is profile 18, developed on schist, that stands more or less apart on account of its soil texture. The lack of correspondence between soil and parent rock can be understood from the geology, that, although conforming over large areas to the term 'migmatite' or 'gneiss', is highly variable over short distances where the lithology may vary between gneiss, granite, schist and phyllite, with a larger or smaller proportion of quartz veins.
The effect of the soil-forming factor relief is distinct in the field when observing a sequence of soils from crest to valley bottom on a single slope. Analytical data of such a sequence are available from the profiles 2, 3 and 4 representing upper, middle and lower slope, respectively. We find soil textural differences, but they are not systematic with slope. Gravel content decreases distinctly downslope. If we include other reference profiles from middle and lower slope positions, than we find there is less gravel, and a sandier texture as compared to upper slope and crest sites. Alluvial soils are distinct from upland soils in field characteristics and geography. The one reference profile in alluvium shows an irregular depth trend of exchangeable aluminium.
A north-south climatic gradient is perhaps reflected in a higher content of organic matter in three profiles in the southern part of the study area. Land use differs between these soils.

6.5. Soil classification

The reference profiles of which a complete set of field and laboratory data is available, have been classified in three international systems of soil classification: the system of the United States Department of Agriculture, Soil Taxonomy (Soil Survey Staff, 1975), the FAO-Unesco system that was devised to serve as a basis for the legend of a Soil Map of the World, scale 1:5,000,000 (FAO-Unesco, 1975; FAO, 1988), and the French system of the 'Commission de Pédologie et de Cartographie des sols' (CPCS, 1967). For the classification according to Soil Taxonomy, the latest revision was used (Soil Survey Staff, 1990).

6.5.1. Classification according to Soil Taxonomy

Table 5 gives the diagnostic surface horizon (epipedon), the diagnostic subsurface horizon, the subgroup name, and the particle-size and reaction classes for the soil family.
The following observations and conclusions can be made:

1. All epipedons are ochric, despite the high organic matter content. It is not uncommon in iron-rich, reddish-coloured tropical soils to find that soil colour does not reflect organic carbon percentages the way it does in most soils from temperate regions.
2. In a number of soils clay increase with depth is sufficient to qualify for either an argillic or a kandic horizon. Without exception the horizons where the clay increase requirements are met, have a CEC of less than 16 cmol(+) per kg clay (by 1 M NH_4OAc) and an ECEC of 12 cmol(+) per kg clay. This implies the presence of a **kandic** horizon. Base saturation in the kandic horizon is low, and this added characteristic places the soils in the order of Ultisols. They are either Udults or Humults.
3. An oxic horizon is present in soils that have an equally low CEC and ECEC as is required for the kandic horizon, but that lack the clay increase diagnostic for the latter. These soils are Oxisols. Both Oxisols in Table 5 are Plinthic Hapludox.
4. Soils in the study area with higher CEC7 and ECEC, and that lack the clay increase and other features diagnostic of an argillic horizon, have a **cambic** horizon. The soils belong to the order of Inceptisols, and the subgroup of Typic Humitropepts.
5. No diagnostic subsurface horizon is present in the two sandy soils, profiles 11 and 16; both are Typic Troporthents.
6. There is no apparent relation between Soil Taxonomy subgroup on the one side, and site and/or parent rock on the other, except for profile 11, developed on alluvium, that stands apart in many characteristics. It must be realised, however, that most profiles are from the same catena position, i.e. from crests.
7. Three of the profiles in the southern area are Humults (see also section 6.4.4).

Relevant differentiae for the definition of soil families within a subgroup are, for the Taï reference profiles: **particle-size classes** and **reaction classes**. There are insufficient data to define mineralogy classes, whereas soil temperature classes are irrelevant as all soils belong to the isohyperthermic class. We have defined particle-size classes and reaction classes for a control section between 25 and 100 cm depth. The particle-size classes combine the textural class of the fine earth and the amount of coarse fragments in the whole soil. The three reaction classes that occur are **acid** ($pH<5.0$ in 0.01 M $CaCl_2$ (2:1 soil/water ratio) or $pH<5.5$ in H_2O (1:1 soil/water ratio)), **allic** (> 2 cmol(+) of KCl-extractable Al per kg soil in some 30 cm deep section of the control section) or **non-acid** ($pH>5.0$ in 0.01 M $CaCl_2$ (2:1 soil/water ratio)) in at least some part of the control section). Three soils are in the allic class, two soils are non-acid, the remaining are acid.

6.5.2 Classification according to the FAO-Unesco system

All reference profiles have an **ochric A horizon**, that is defined in the same way as in Soil Taxonomy. The soils with a cambic horizon according to Soil Taxonomy have a **cambic B horizon** in the FAO-Unesco system.
The **ferralic B horizon** in the FAO-Unesco classification corresponds with the oxic horizon in Soil Taxonomy, with one difference: the oxic horizon does not have the clay increase that is diagnostic for an argillic or a kandic horizon, whereas clay increase is not a defined feature of the ferralic B horizon. A clay increase with depth that tallies with the criteria set in Soil Taxonomy for the kandic and the argillic horizon, is diagnostic for the argic B horizon in the FAO-Unesco system. However, the argic B horizon lacks the set of properties which characterises the ferralic B horizon. So, conceptually, horizons defined as either kandic or oxic in Soil Taxonomy, would qualify as ferralic in the FAO-Unesco system. Yet, one characteristic of the 'set of properties' for the ferralic B is lacking in the Taï soils, viz. the requirement that the silt/clay ratio is 2 or less. In the Taï soils this ratio is higher. The implication would be that neither a ferralic, nor an argic or a cambic B horizon would be present in any of the soils that have a kandic or an oxic horizon according to Soil Taxonomy. However, these soils fit very well into the concept of Ferralsols, the major soil grouping of soils with a ferralic B horizon. We have classified them as Ferralsols 1).

6.5.3 Classification according to the French system

In the French system most of our reference profiles would be placed in the 'Classe des Sols Ferrallitiques'. Profiles 11 and 16 would qualify as 'Sols ferrallitiques' only on account of their soil material, but as 'Sols peu évolués' on account of their genesis. We have placed these profiles too into the 'Classe des Sols Ferrallitiques'.
Only in a few cases do the Taï reference profiles respond to the complete set of requirements for any of the 'sous-classes'. Climatic features favour placement in the 'Sous-classe des sols ferrallitiques fortement désaturés en (B)', but the profile morphology of most soils favours placement in the 'Sous-

classe des sols ferrallitiques moyennement désaturés en (B)'. As climatic criteria form a substantial part of the 'sous-classe' definition, we have placed all Taï soils into one and the same 'sous-classe'. The 'sous-classe' 'moyennement désaturée' is then the best choice.
In this 'sous-classe' there are three possible 'groupes' : 'typique', 'humifère' and 'appauvri'. We have placed the profiles with an oxic horizon according to Soil Taxonomy in the 'groupe typique, the Humults and Humitropepts of Soil Taxonomy in the 'groupe humifère'. The other profiles are probably either 'appauvri' or 'lessivé'.
It is difficult to define 'sous-groupes'. The Xanthic Ferralsols of the FAO-classification would probably belong to the 'sous-groupe jaune', the others are probably 'modal'.

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1) In a draft 'Amendment to the revised legend' (FAO, Rome, 1990) it is stated with regard to the ferralic B horizon:
'The ratio of silt-clay being less than 0.2 requires further field testing'.

7 VEGETATION

7.1 Vegetation classification and sampling

It is generally known that a species has demands on the environment in which it grows. This is more pronounced for certain groups of species. Alternatively, ~~we can say~~ that the presence of a certain group of species gives information on the environment. This is how vegetation data, next to giving additional information on plant cover, structure etc., contribute in an essential way to land unit classification.

The more a forest matures, the more the vegetation develops towards a species-rich forest, being an optimum situation dictated by ecological factors. The more a vegetation has been cut and burnt, the more the vegetation contains pioneer plants and weeds. The latter, besides being rather uniform throughout the study area, do not have much indicative value for site characteristics but chiefly indicate human activity. The sites most useful for our classification proved to be those carrying a forest as mature as possible. This was either primary forest, logged or not, or secondary forest older than 20 years.

~~We had a preference for~~ sample plots on the upper part of the toposequence since hydrological processes and variations in soils are best expressed there. Further downslope these features appear often less characteristic for a specific catena. In some cases the presence of a certain group of plants has only indicative value if it is found on crest or upper slope. This is mentioned in the text with an ecological justification. But ~~we also~~ investigated lower positions ~~and we characterized~~ these vegetations ~~too~~. Other kinds of vegetation, like young secondary forest and undergrowth of cocoa and coffee plantations were also studied and characteristic species and structure described.

The field work had to answer two questions:

* which plant communities indicate important ecological variance: climate, soil, geology?
* where can they be found?

In order to provide an answer to these questions one needs a classification, according to which the subject is systematically subdivided into units that are described according to composition and structure, so that correlations with the environment can be established. A systematic description of these units provides a tool for recognition in the field so that these units can be detected, delimited and mapped. In the Taï region three classifications for vegetation have been used previously: Mangenot's (1955), Guillaumet's (1967) and DRC's

(1967). These classifications will be described below.

7.2 Literature review

We will discuss two relevant great schools of vegetation science in a concise and simplified manner.

1. The Clements-Tansley school of phyto-sociology in which communities are classified according to dominant species. Examples for Ghana and Côte d'Ivoire are Taylor (1954) and in some way, DRC (1967).
2. The Zurich-Montpellier, or Braun-Blanquet approach, in which vegetations are classified considering the full floristic composition often with emphasis on characteristic species. These characteristic species may or may not be dominant but should demonstrate a great 'faithfulness' to their community. Examples in Côte d'Ivoire are Mangenot (1955), Guillaumet and Adjanohoun (1960) and Avenard et al. (1971).

Both schools originate from temperate regions. It is evident that a methodology which is based on dominant species, transported to a tropical rainforest where the canopy is usually formed by a fluctuating mixture of species none of which is dominant, is fraught with difficulties. The main defects of the Clements-Tansley scheme are treated by Hall and Swaine (1981, p.12-13).
The Braun-Blanquet method is more adapted to species-rich floras but the long list of plant names, the numerous relevees necessary to produce satisfying results, can hardly be treated 'by hand' without mathematical computer programmes. The possibilities of using the Braun-Blanquet approach in tropical rainforest is treated by Hommel (1987) and by Zonneveld (1988).

Observations by Mangenot (1955)
Mangenot studied forest vegetations in Côte d'Ivoire and he was one of the first to classify them floristically with the help of species groups . Mangenot used the term 'associations végétaux', neither to be confused with 'groupe sociologique', being the usual equivalent of 'sociological species group', nor with 'groupement végétaux', the equivalent of 'community'. He also detected to what extent climatic and edaphic factors could limit the performance of certain species groups.
Concerning Ivorian High Forest on well-drained to moderately well-drained soils he remarked the following. High forest grows where water is sufficiently available. On sandy soils precipitation should not be less than 1300 mm a year, and on clayey soils not less than 1150 mm a year. The species group M1 is present in all High Forest vegetation (species groups M1 through M9 are listed in Appendix 2). If water availability increases, so does species richness. In forest receiving over 1700 mm of rain a year the species group M2 also occurs. Mangenot further divided these humid forests according to regional soil

properties: they were called either 'psammohygrophyl' for forests on sandy soil, or 'pélohygrophyl' for forests growing on more clayey soil. Although Mangenot did not have the opportunity to study the Taï forest as extensively as the forests near Abidjan, he classified it as a 'pélohygrophyl' forest. An example of a 'pélohygrophyl' forest studied thoroughly by Mangenot is the Yapo forest, 50 km north of Abidjan. All 'pélohygrophyl' forests are characterised by the species group M3, occurring next to the groups M1 and M2. Within such a forest soil properties may change over short distances. Local differences, especially in soil texture, are expressed by the presence of new species groups. The group M4 occurs where the soil is sandy, and the species group M5 where the soil is finer-textured. Where soil moisture conditions are even more favourable, both the groups M5 and M6 are present. Mangenot observed that on places with the most favourable soil moisture conditions the forest is enriched by a species group which he called the 'Exclusives' (M7); on these sites the species groups M7, M6 and M5 occur, next to the general groups M1, M2 and M3.
On poorly drained soils Mangenot distinguished a species group characterizing all valley bottom forest (M8), and a second species group (M9) occupying together with M8 those valley bottoms which are mud-flats.

For our study Mangenot's species groups M6 and M7 seem to be of particular interest since they may indicate superior growth conditions.

Some of Mangenot's conclusions :

* all species of species groups are usually present over the entire toposequence, except for the valley bottom;
* species groups are sufficiently well represented in plots of 100 m2 in primary forest;
* species richness is a good indicator for pedoclimatic conditions; sites with more than 50 species per 100 m2 have excellent growth conditions. Here we may find the species group the 'Exclusives' (M7). Sites where 45 species per 100 m2 are found are drier or poorer, or both, than normal. Below about 40 species per 100 m2 the species constituting sociological groups become lost.

Observations by the 'Mission militaire' (1960)

In April 1960 a group of French and Ivorian scientists, among them florists, a geomorphologist and a soil scientist, mainly ORSTOM, organized an expedition straight through the forest from Soubré to Taï. It was probably the second botanic scientific expedition of this type after Chevalier's (around 1907), and the first in which scientists of different disciplines made their observations together. The French colonial army assisted the group, therefore the expedition remained known as the 'Mission militaire' (Adjanohoun and Guillaumet, 1960-1961; Riou, 1960).

A summary of the observations by the 'Mission militaire':

* except for the area next to Soubré, which proved to be sandy with an appropriate 'psammohygrophyl' species composition like the forests on sandy soils near Abidjan, all forests lying more westward could not be placed in the same class, despite the soil often being sandy. The species composition ressembled that of the 'pélohygrophyl' forest of Yapo.
* the group of the 'Exclusives' was surprisingly common, also on rather sandy soils.
* the Mission was surprised to find so much variation in geology, and so many remarkable examples of erosion and ravines;
* the rainfall distribution seemed to be different from elsewhere in Côte d'Ivoire and may have a pronounced influence on the vegetation. The 'Mission' presumed that different forest communities existed on schists, on granite, on gneiss, on amphibolite and on alluvial soils.

Observations by Guillaumet (1967)
Guillaumet studied the forest in south-west Côte d'Ivoire from 1960 to 1979, writing his doctorate thesis in 1967. He concurred with the classification of Mangenot and refined it for use in the Taï forest. What distinguishes the Taï forest from all other ivorian forests is the large number of endemic species. Because of this aspect he called it a forest 'à faciès Sassandrien'.
All primary forest on well-drained to moderately well-drained soils has the species group G1 (species groups G1 through G8 are listed in Appoendix 2). On sandy soils Guillaumet found in addition the group G2, but on finer-textured soils the species group G3 occurs instead of G2. Where water availability and general growth conditions are very good, the species group G4 occurs next to G3 and G1; the group G4 contains many endemic species which he called 'sassandrien' species.
The forest in valley bottoms is characterised by the species group G5, whereas on places with clayey soils also the group G6 occurs. Forest on organic soil contains both the species groups G5 and G7. A special species group, G8, is found on the alluvial deposits of the larger rivers in the forest.

A summary of Guillaumet's conclusions:
* it is not the group of 'Exclusives' (M7) which characterises sites with optimum growth conditions, but mainly the group of endemic species which Guillaumet called 'Sassandrien'1) (G4);
* a sociological group which contains many of Mangenot's 'Exclusives' (G3) is found everywhere on well-drained sites, except for poor and dry places, mainly in the northern part of the forest, where the group G2 is found;
* the discriminating value of the 'Sassandriens' is almost entirely lost on sites south of the 2200 mm isohyte;

1) The term 'sassandrien' was first used by Mangenot (1955) to indicate endemic species of the 'forêts hygrophiles' of western Côte d'Ivoire.

* There are no species groups that are typical for schist, granite, gneiss or other rock types. The development of a species group depends first of all on moisture conditions. Additional factors are: aeration of the soil, and base saturation together with pH.

Classification of the Development and Resources Corporation (1967)
The DRC survey team made a classification of the vegetation that was meant first of all to serve people interested in exploitable timber resources. Only part of the flora was used in the classification. It is doubtful whether many forest types can be distinguished in this way. The classification of Ghanaian forest had been followed (Taylor, 1954), which separates forests types north and south of the 1900 mm isohyet. The DRC team used the terms wet, moist, and dry mixed deciduous, indicating the deciduousness of part of the large trees, over part of the year. This differentiation proved to be of little value for us, considering the scale of the Land Unit map.

7.3 Vegetation classification for the Land Unit Survey

For the Land Unit Survey it was necessary to develop our own classification, not because the existing ones proved inferior, but because of the scale and special purpose of the land unit survey. The methodology of a Land Unit Survey takes into account the floristic composition, and the sampling is based on the landscape approach. This methodology has been described in detail by Zonneveld (1988) and also by Touber et al. (1989). The sampling was executed by making 'relevees'. These are, in this case, descriptions of properties of a small area (6x6 meters and its near surroundings, about 100 to 200 square meters) where a full list of all plant species occuring at that spot are given with some indication of the abundance per species, as well as data on structure, and some additional data on the site such as soil - from auger description -, landform, relief, landuse and several other observable ecological features. In total 253 complete relevees of this type were used as a basis for the classification. For recognition of classification units in the field, once the classification has been established, these time-consuming complete relevees are not always necessary; quicker relevees in which only the then known diagnostic species are recorded, are often sufficient. Each observation by the soil scientist was accompanied either by a complete or an incomplete, quick relevee.

The result of a classification is a subdivision of the vegetation continuum in abstract so-called 'communities'. The tangible equivalent of a community is a three-dimensional body existing of all plant material at a certain spot. One of the ways to represent the results of classification is a dendrogram. Fig. 8 gives such a hierarchy of divisions for our survey, in which 16 communities were identified. The first division sets apart the primary vegetations (community A through L) from vegetations related to agriculture (community I through V). Primary forest communities on uplands differ from those on other major landforms.

Communities are characterized by their full species composition. In order to handle this in spite of the very large amount of species in tropical forest circumstances, the species are grouped in so-called 'sociological species groups'. The species belonging to such a group have a similar behaviour in the vegetation table (matrix). This means that they have more or less similar ecological requirements and indicative value. The species of sociological groups that are more or less restricted to one classification unit - we have used the term 'characteristic species' -are more or less exclusive for a certain unit, or usually at least preferent, that means that outside the unit they may also occur but with much lower frequency and abundance.
Sociological species groups that occur in more than one classification unit also have a function in the classifiation system. They are differentiating between units in which they occur versus those in which they do not occur.
A classification unit - a community - is named after two prominent members among the group of characteristic or differentiating species.

The processing of data in order to arrive at a classification is essentially a statistical, multivariate analysis of a matrix; it can be done by hand (Braun-Blanquet table method) or by computer. In our case the clustering of the relevees was done by the TWINSPAN programme (see Appendix 5).
The results of TWINSPAN processing are shown in three bar diagrams: Figs. 9, 10 and 11. Here the sociological species groups are expressed as bars in the Y direction. The communities or classification units are shown in the X direction. So at a glance one can see out of which species groups each community is composed. In Fig. 9 primary forest communities on uplands are arranged (6 classification units) with a total of 19 sociological species groups. Fig. 9 shows ~~We can, see that~~ each of the sociological groups 1, 4, 6, 10, 12 and 14 are composed of species that are characteristic for one community. These species groups are important for identifying a community in the field. In Figs. 10 and 11 primary forest communities on other landforms, and plant communities related to agriculture are presented in the same manner. Though a classification is usually presented in one unique bar diagram, we were obliged to divide our data into three parts because of the limited capacity of our micro-computers in Côte d'Ivoire.
Sociological groups with occurrence restricted to one plant community are given in the Tables 6 to 21, inclusive. Plant lists of sociological groups occurring over several plant communities are given in Appendix 2.
Next to the floristic characteristics, structural properties are also used as diagnostic characteristics but in tropical forests the importance of structure is far outweighed by that of species composition.

In order to clarify important questions such as: to what degree are differences

between units due to environmental variation, we used ordination, a helpful tool in addition to the clustering technique (TWINSPAN).
Ordination organizes data on species abundance exclusively, leaving environmental interpretation as a subsequent independent step. In diagrams similar entities, either relevees or species, are presented adjacent to each other and dissimular entities are placed far apart. We used the programme DECORANA which calculates 4 sets of solutions (axes) for species and for relevees (see Appendix 5).

Ordination of all data gave three clusters: primary forest, secondary forest and fields. Reordination of primary forest data suffered from the well known phenomenom that the multivariate analysis is dominated by so-called outliers, a few relevees with very different composition which obscure the other features of the data. These relevees, on alluvium, on the steep-sided hill and in valley bottoms, were omitted from further analyses.

A reordination of data from primary forest on well drained soils is shown in Fig. 12. Here, relevees are graphed according to their ordination scores on axes 1 and 2. First we will consider the relevees on uplands, afterwards the relevees in landscapes with a deviating geology. Axis 1 is mainly responsive to the geographic north-south line which corresponds to the environmental moisture gradient. ~~We concluded this after having considered~~ soil and landscape data, since only the gradual increase of rainfall from north to south could explain such a partition. Upland forests having the lowest rainfall have lowest axis 1 values, upland forests having the highest rainfall have highest axis 1 values. Axis 2 is mainly selected for giving the best scatter of points, being arranged in a meaningful way. The vertical lines in Fig. 12, which delimit three rainfall zones, the Northern, the Transitional and the Southern, result from the TWINSPAN classification. The relevees in upland primary forest in the Northern rainfall zone belong to one community, as do those in the Transition rainfall zone. In the Southern rainfall zone, two communities of primary upland forest were distinguished.
The results support the argument that even in such a wet environment as south-west Côte d'Ivoire a small increase in rainfall (about 200 mm per year) over a small interval (about 70 km), is reflected in the species composition of the primary forest on well drained upland soils.

Subsequently we looked at relevees of forest in landscapes where uplands form an association with low inselbergs and rock outcrops (relevees are ringed in Fig. 12). These landscapes constitute separate Land Units, UI1 and UI2. They occur as 'islands' in the upland landscape, in the Northern and Transitional rainfall zone as can be seen in the inserted map on Fig. 12. In this part of the survey area the underlying geology is almost exclusively migmatite/gneiss (see the Land Unit map, Appendix 11). In Fig. 12, however, ~~we meet them~~ mixed with the relevees of the Southern rainfall zone. As we have interpreted axis 1 as representing principally a moisture gradient, we are inclined to think that a different geology (presence of rock outcrops and inselbergs) influences the relationship with moisture. It seems that those landscapes of the Northern and Transition rainfall zones, with different geological features, 'produce' edaphic water which is capable of substituting to a certain extent, the lack of rainwater in these areas, thus permitting the vegetation to resemble those of the Southern rainfall zone.

7.4. Vegetation communities and sociological species groups in the Taï area

7.4.1. Mature forest on Uplands (Fig. 9)

A Community of *Hunteria simii* and *Chidlowia sanguinea*

This community is characterized by the presence of the sociological species group 1 (Table 6) and the occurrence of the sociological groups 2, 3, 29 and 8 (Appendix 2). Table 6 gives information per species including the frequency a species was recorded in samples of this community, and also the number of other communities where its presence had been observed occasionally. The sociological group 1 is well developed from crest to valley bottom. Though the liana *Salacia elegans* seems to be exclusive for this community, the predominance of *Hunteria simii* and *Chidlowia sanguinea* is a more prominent feature. *Hunteria simii* is a shrub with shiny leaves. Fruits are often present, which are large, warty and orange-coloured. *Chidlowia sanguinea* is a fairly big tree with very hard wood, and the leaves are composed of few, large leaflets.

Table 6 Characteristic species of community A: *Hunteria simii* and *Chidlowia sanguinea*, upland primary forest (sociological group 1, Fig. 9)

Species	Family	Percentage frequency	Occurrence elsewhere (number of communities)	Life form
Hunteria simii	Apocynaceae	60	5	shrub
Chidlowia sanguinea	Caesalpiniaceae	36	4	medium-sized tree
Strychnos aculeata	Loganiaceae	52	5	large woody climber
Memecylon cinnamoides	Melastomataceae	40	2	shrub
Ptychopetalum anceps	Olacaceae	40	2	small tree
Buforestia mannii	Commelinaceae	32	2	ground herb
Culcasia saxatilis	Araceae	28	2	small herbaceous climber
Cola caricaefolia	Sterculiaceae	28	3	small tree
Salacia elegans	Celastraceae	28	0	small woody climber
Ouratea subcordata	Ochnaceae	24	2	shrub
Cephaelis peduncularis	Rubiaceae	24	4	shrub
Cercestis sagittatus	Araceae	20	2	ground herb
Monodora myristica	Annonaceae	20	1	medium-sized tree
Rhinacanthus virens	Acanthaceae	20	2	ground herb
Trichoscypha oba	Anacardiaceae	20	2	small tree
Calycobolus heudelotii	Convolvulaceae	16	1	large woody climber
Lonchitis reducta	Dennstaedtiaceae	16	2	fern
Ouratea reticulata	Ochnaceae	16	4	shrub
Salacia calumna	Celastraceae	16	1	small woody climber

The community occupies crest and slope sites in the northern part of the study area, comprising the land units Unm2, Unm3 and the non-inselberg uplands of UI1. It continues further to the north, at least up to the village of Keibli, since all sites which were sampled beyond the northern limit of the study area, still belonged to this community.

B Community of *Uapaca* spp. and *Mendoncia combretoides*

This community can be recognized by the presence of the species listed in Table 7, comprising characteristic species (group 4A) and differentiating species (group 4B). Both groups develop fully on crests and slopes in the area south of the land where community A (*Hunteria/Chidlowia*) is found. The characteristic species group 4A is restricted to this area, while the differentiating species group 4B, though incomplete, also occurs in the valley bottoms further north, where it is found mixed with community A.

We observe that the species group 4B expresses the interchangeability of climatic water and edaphic water. In the north the species of group 4B are confined to valley bottoms where the poorly drained, often waterlogged soils enable these plants to grow under the given climatic conditions. Going further south, as precipitation increases, the species group 4B 'climbs' out of the valley bottom and expands to sites on the slope. Here, on these better-drained soils, they use the moisture provided by the additional rainfall instead of the moisture retained in the soil. Soils remain the same in similar positions of the catena.

The phenomenon described here is well-known from drier regions where swamp plants occupy drier places as the climate becomes more humid. It was described by Walter (1964) as the law of the relative site constancy. Now it is also reported from wet regions, but that it can be detected over so small a range of rainfall - as we observed in the Taï area -, has not been previously recorded. A rainfall-induced zonality in soil characteristics has not been found, and this implies that the feature must be largely attributed to climate.

Another point supporting this theory is the presence of community B on a few crests in the northern part of the study area, where crests are usually covered by community A. Observation of the soil showed that the crests with community B had no gravel. The gravelfree soil would have a higher waterholding capacity, and could compensate for the lower rainfall in the northern zone, thus permitting the development of a community that is normally found on gravelly crests further south, with higher rainfall. DRC (1967) and Fritsch (1980) estimate that about one crest out of ten in the northern rainfall zone does not have gravel. We made our observations in the primary forest between the MAB/IET field station and Taï village. So we have two examples of the same phenomenon: the presence of a vegetation type that is more 'humid' than the type that is normally encountered in a certain location, can be due to soil conditions (i.e. a soil with a higher available-water holding capacity) or to climatic conditions (i.e. a higher rainfall).

The other sociological species groups present, 2, 3, 5, 29, and 8, are given in Appendix 2.

Uapaca trees are easily recognized by their enormous stilt roots. Mendoncia combretoides is a tough liana with leaves that have a cotton-like cover on the back. The community occupies crests and upper slopes in land unit Upm2; in the northern zone land units it covers only a very small area and does not feature on the Land Unit map.

Table 7 Characteristic species (4a) and differentiating species (4b) of community B: *Uapaca spp.* and *Mendoncia combretoides*, upland primary forest (sociological group 4, Fig. 9)

Species	Family	Percentage frequency	Occurrence elsewhere (number of communities)	Life form
4a				
Mendoncia combretoides	Acanthaceae	25	1	large sub-woody climber
Ctenitis protensa	Polypodiaceae	25	3	fern
Drypetes pellegrini	Euphorbiaceae	25	4	small tree
Leptoderris fasciculata	Papilionaceae	25	3	large woody climber
Landolphia membranacea	Apocynaceae	19	2	large woody climber
4b				
*Uapaca guineensis**	Euphorbiaceae	44	2	large tree
*Uapaca heudelotii**	Euphorbiaceae	25	3	large tree
*Cercestis afzelii**	Araceae	63	7	small herbaceous climber
*Anthocleista nobilis**	Loganiaceae	44	2	medium-sized tree
*Caloncoba brevipes**	Flacourtiaceae	44	2	medium-sized tree
*Beilschmiedia mannii**	Lauraceae	38	4	medium-sized tree
*Trichilia heudelotii**	Meliaceae	38	4	medium-sized tree
*Vitex micrantha**	Verbenaceae	38	4	medium-sized tree
*Araliopsis tabouensis**	Rutaceae	31	2	large tree
*Chrysophyllum pruniforme**	Sapotaceae	31	2	large woody climber
*Elaeis guineensis**	Palmaceae	31	4	large palm
*Baphia polygalacea**	Papilionaceae	25	4	small woody climber
*Heinsia crinita**	Rubiaceae	25	3	shrub
*Combretum homalioides**	Combretaceae	19	3	large woody climber
*Raphia sassandrensis**	Palmaceae	19	1	medium-sized palm
*Rhigiocarya racemifera**	Menispermaceae	19	3	small sub-woody climber
*Dacryodes klaineana**	Burseraceae	13	2	large tree
*Kolobopetalum leonense**	Menispermaceae	13	2	small sub-woody climber

* Should be on crest or upperslope

C Community of 'Vaa' (*Gilbertiodendron preussii*) and *Tarrietia utilis*

In this community the large tree *Gilbertiodendron preussii*, or 'Vaa', the local trade name, occurs abundantly from crest to lower slope. Regeneration by seed is profuse so that the plant remains widespread even when the tree has been logged. Another feature of this community is the appearance on crest and upper slope of some species which are confined to swamps in the zones occupied by the two communities discussed above. These species are assigned to group 6B (Table 8), a group of differentiating species with the same ecological significance. Among them figure large trees and rattans. Soils of the migmatite catena do not change over this interval, so again, much should be attributed to increasing rainfall. Characteristic species are given in group 6A (Table 8), while the species of the other sociological groups of this community, 3, 5, 29 and 7 are listed in Appendix 2.

The tree 'Vaa' has a striking red pealing bark. *Tarrieta utilis* is a large tree with prominent angular stilt-roots. The back of the younger leaves is rusty-golden coloured, the leaves are palmate.

The community occurs in land units Utm2, Utm3, Utx2, Utz3, Utc3.

<u>Communities in land unit Ul2</u>

In the Transitional rainfall/vegetation zone which is characterized by soils of the migmatite catena, and the vegetation community 'Vaa', two areas of different geology occur, one north-east of Troya, with the community of 'Ferreclao', the other one near Siéblo-oula, where the community of *Strychnos* and *Chytranthus* occurs. Both areas belong to land unit Ul2, where the migmatite catena occurs in association with the Inselberg variant (Chapter 7); the latter has bare rock and/or large boulders on crest and upper slope. The two occurrences of land unit Ul1 do not show apparent differences in geology or soils, but the vegetation communities are not the same. They are described below as communities D and E, respectively.

Table 8 Characteristic species (6a) and differentiating species (6b) of community C: 'Vaa' (*Gilbertiodendron preussii*) and *Tarrietia utilis*, upland primary forest (sociological group 6, Fig. 9)

Species	Family	Percentage frequency	Occurrence elsewhere (number of communities)	Life form
6a				
Gilbertiodendron preussii	Caesalpiniaceae	63	4	large tree
Hypolytrum poecilolepis	Cyperaceae	44	2	ground herb
Ventilago africana	Rhamnaceae	38	1	large woody climber
Nephthitis afzelii	Araceae	31	5	ground herb
6b				
*Tarrietia utilis**	Sterculiaceae	88	5	large tree
*Uapaca esculenta**	Euphorbiaceae	69	6	large tree
*Xylopia acutiflora**	Annonaceae	69	3	small tree
*Ancistrophyllum opacum**	Palmaceae	56	7	large climbing palm
*Dracaena elliotii**	Agavaceae	25	2	ground herb
*Sacoglottis gabonensis**	Humeriaceae	25	5	large tree

* Should be on crest or upperslope

D Community of 'Ferreclao' (*Millettia rhodantha*) and *Parinari aubrevillei*

[Photo 13)

'Ferreclao', the Oubi name for *Millettia rhodantha* is prominent in this community. It is the Oubi indicator plant for places approppriate for agriculture (section 8.4). The community develops over the entire toposequence except for the valley bottom. It forms an 'island' in the large zone occupied by the community 'Vaa'. The change from 'Vaa' to 'Ferreclao' is abrupt and can easily be seen in the vegetation; however, it is not always evident in the field appearance of soils. Characteristic species, sociological group 10, are given in Table 9. Other sociological species groups, 5, 29, 8, 7, 9 and 11 are listed in Appendix 2.

Table 9 Characteristic species of community D: 'Ferreclao' (*Millettia rhodantha*) and *Parinari aubrevillei*, upland primary forest (sociological group 10, Fig. 9)

Species	Family	Percentage frequency	Occurrence elsewhere (number of communities)	Life form
Millettia rhodantha	Papilionaceae	82	7	small tree
Parinari aubrevillei	Rosaceae	36	4	large tree
Cola heterophylla	Sterculiaceae	91	7	small tree
Polyspatha paniculata	Commelinaceae	73	6	ground herb
Culcasia liberica	Araceae	55	5	large herbaceous climber
Aningeria robusta	Sapotaceae	45	6	large tree
Geophila neurodictyon	Rubiaceae	45	4	ground herb
Leptoderris miegei	Papilionaceae	45	4	large woody climber
Myrianthus libericus	Moraceae	45	4	medium-sized tree
Manotes expansa	Connaraceae	36	5	small woody climber
Polyceratocarpus parviflorus	Annonaceae	36	2	small tree

'Ferreclao' has very large compound leaves. It resists repeated cutting and even some burning. It resprouts with still larger, brilliant light green leaflets.

Parinari aubrevillei is a large tree with curious toothed and gland-tipped leave margins. The back of the leaves have a cotton-like cover.
The community occurs north-east of Troya, in land unit UI2.

E Community of *Strychnos ngouniensis* and *Chytranthus* spp.

In the field it is rather difficult to separate *Strychnos ngouniensis* from other *Strychnos* species. This also counts for the different species of *Chytranthus*. It is remarkable that *Chytranthus setosus*, which seems to be exclusive for this community, is mentioned by Mangenot (1955) as an indicator for the wettest growth conditions he knew in Côte d'Ivoire. *Chytranthus longiracemosum* is another species which is very common here, but it is also widespread elsewhere. The sociological species groups 5, 29, 8, 7, 9, 11 and 13 are present as well (Appendix 2). Among the species listed in Table 10, those assigned to group 12A are truly characteristic species, whereas group 12 B contains merely differentiating species. The latter group comprises species capable of interchanging soil moisture and climatic moisture in a way similar to what has been described for the communities B and C.

Table 10 Characteristic species (12a) and differentiating species (12b) of community E: *Strychnos ngouniensis* and *Chytranthus spp.*, upland primary forest (sociological group 12, Fig. 9)

Species	Family	Percentage frequency	Occurrence elsewhere (number of communities)	Life form
12a				
Strychnos ngouniensis	Loganiaceae	41	2	large woody climber
Chytranthus mangenotii	Sapindaceae	29	1	small tree
Uvariopsis guineensis	Annonaceae	41	4	small tree
Dracaena cameroonlana	Agavaceae	29	5	ground herb
Grewia mollis	Tiliaceae	29	3	small woody climber
12b				
Chytranthus setosus **	Sapindaceae	29	0	small tree
*Baphia nitida***	Papilionaceae	71	4	medium-sized tree
*Culcasia seretii***	Araceae	59	6	small herbaceous climber
*Culcasia piperoides***	Araceae	47	6	small herbaceous climber
*Octoknema borealis***	Octoknemataceae	47	4	large tree
*Popowia mangenotii***	Annonaceae	41	6	small woody climber
*Corynanthe pachyceras***	Rubiaceae	35	5	medium-sized tree
*Anthonotha macrophylla***	Caesalpiniaceae	29	6	medium-sized tree
*Chassalia corallifera***	Rubiaceae	29	6	shrub
*Rhaphidophora africana***	Araceae	29	5	large herbaceous climber
*Trichoscypha chevalieri***	Anacardiaceae	29	3	small tree
*Funtumia africana***	Apocynaceae	24	5	large tree
*Lankesteria brevior***	Acanthaceae	24	3	ground herb

* *Chytranthus longiracemosus* also very common, though widely distributed throughout the study area
** Should be on crest or upper slope

The community has another particularity. In the southern rainfall zone the community is present on a large variety of soils. North of this zone the community appears only on the low inselbergs and rock outcrops near Siéblo-oula, in land unit UI2; it seems that the rocky or stony crests yield sufficient

edaphic water to compensate for the lack of rain. Compared to the community 'Ferreclao', this forest community is more enriched by species common in the south and absent in the north.
Strychnos ngouniensis is a medium-sized liana. The different *Chytranthus* species are all unbranched understorey trees with a tuff of huge compound leaves in top.
The community occurs in land unit UI2, east of Siéblo-oula, and in land units Usg1, Usy2 and Usz2.

F Community of *Spiropetalum heterophyllum* and 'Gnahin' (*Ancistrophyllum laeve*1))

This community possesses many species not encountered elsewhere in the study area. But, as each of these species appears only once or twice in the relevees, they are not mentioned as characteristic species. An important difference with other upland primary forest communities is a denser cover of the forest floor by ground herbs up to 1 meter high (*Mapania* spp., *Dracaena* spp.). In Table 11 purely characteristic species (group 14A) are listed, together with some differentiating species (group 14B). In the most southern part of the survey area the species of group 14B occur over the entire catena, together with the species of group 14A. Together they constitute a well-defined sociological group that is characteristic of community F. Group 14B covers a much wider area than group 14A; it is also found in valley bottoms more to the north where rainfall is less. Lists of species of the other sociological groups, 5, 29, 8, 7, 9 and 13 can be found in Appendix 2. The community is restricted to the extreme south of the study area where it often occurs in a mosaic with the community *Strychnos* and *Chytranthus*. As the mosaic proved to be a fine pattern most of the time, the communities were often mapped as a complex. In the field we found that the community of *Spiropetalum* occupied sites on schists, and the community of *Strychnos* sites which were often granitic. The change from one community to another is probably related to different soil properties; the availability of water may be an important factor. This distinction between the communities E and F seems to be true as far as our study area extends, but it may be lost in wetter environments.
Spiropetalum heterophyllum is a large liana with somewhat angular leaflets. The climbing palm *Ancistrophyllum laeve* is probably exclusive for the community. It is locally known as 'Gnahin' (Oubi name), meaning 'rattan of the rat' for nothing useful can be made of it. We relied on the village rattan confectioner for identification of all palm species; this is very difficult, especially in a juvenile stage.
The community occurs in land units Usy2, Usz2 and Usc3.

Table 11 Characteristic species* (14a) and differentiating species (14b) of community F: *Spiropetalum heterophyllum* and 'Gnahin' (*Ancistrophyllum laeve*), upland primary forest (sociological group 14, Fig. 9)

Species	Family	Percentage frequency	Occurrence elsewhere (number of communities)	Life form
14a				
Spiropetalum heterophyllum	Connaraceae	56	3	large woody climber
Ancistrophyllum laeve	Palmaceae	33	0	large climbing palm
Monodora crispata	Annonaceae	22	2	medium-sized tree
14b				
*Desplatsia chrysochlamys***	Tiliaceae	67	5	small tree
*Pteris burtonii***	Polypodiaceae	67	6	fern
*Oldfieldia africana***	Euphorbiaceae	44	6	large tree
*Alchornea floribunda***	Euphorbiaceae	33	4	shrub
*Pseuderanthemum tunicatum***	Acanthaceae	33	4	ground herb
*Rhaphiostylis cordifolia***	Icacinaceae	33	5	small woody climber
*Salacia lateritia***	Celastraceae	33	7	large woody climber
*Macaranga heterophylla***	Euphorbiaceae	22	2	small tree

Absence of: *Memecylon lateriflorum* (Melastomataceae), *Diospyros canaliculata* (Ebenaceae) and *Polyalthia oliveri* (Annonaceae), abundant in all other primary forest vegetation types.

* Also many species of the genera *Mapania*, *Hypolytrum* (Cyperaceae), *Dracaena*, *Salacia*, *Strychnos* and *Cola* only recorded in this forest type but too rare to appear in classification.
** Should be on crest.

7.4.3 Mature forest on extreme landforms (Fig. 10)

Vegetation on rocky land

The crests and upper slopes of the small inselbergs in land units UI1 and UI2 are covered by a very particular vegetation. This strange flora has been studied by Adjanohoun (1960), Guillaumet (1967) and other botanists. On the most exposed sites the vegetation may change with the season. Places with a slight, though permanent cover are characterized by the species of sociological group 21 (species list in Appendix 2). A constant and frequent inhabitant of inselberg crests is the ground orchid *Oecoeclades maculata*, easily recognized by its large spotted leaves. Another conspicuous plant is the crassophile *Elaeophorbia grandifolia*, growing up to 6 m high. Its milk is used as an ichthypoison by the Oubi. These plants need a light shade, which is usually provided by a dense stand of *Mallotis oppositifolius* and the stingy climber *Tragia vogelii*.

Fig. 10 shows that the sociological group 15 occurs on all extreme landforms. Each species is found widely distributed throughout the study area, but if the entire group occurs, the presence of rocks or alluvium is indicated.

1) Dr. J. Dransfield kindly identified 'Gnahin' as *Ancistrophyllum laeve* (Mann and Wendl.) Drude.

G Community of *Citropsis articulata* and *Stereospermum acuminatissimum*

On the footslopes below the inselbergs in land unit UI1, in the north-eastern part of the study area, and on the slopes between these inselbergs a forest community is found which seems to be drier than any type found in the study area; evidence of this is the dominance of many, very large semi-deciduous trees. Characteristic species of this community (sociological species group 22) are listed in Table 12, lists of other sociological species groups, 21 and 15, are given in Appendix 2.

Citropsis articulata is a low shrub with conspicuous leaves, winged as those of the *Citrus* genus. *Stereospermum acuminatissimum* is a rather large tree; saplings and seedlings are often found on shallow soils. They can easily be recognized by the few large compound leaves. Leaflets are toothed.

Table 12 Characteristic species of community G: *Citropsis articulata* and *Stereospermum acuminatissimum*, primary forest on high inselbergs (sociological group 22, Fig. 10)

Species	Family	Life form
Citropsis articulata	Rutaceae	shrub
Stereospermum acuminatissimum	Bignoniaceae	large tree
Bequaertia mucronata	Celastraceae	small woody climber
Ceiba pentandra	Bombacaceae	large tree
Nesogordonia papaverifera	Sterculiaceae	large tree
Rothmannia whitfieldii	Rubiaceae	small tree
Triplochiton scleroxylon	Sterculiaceae	large tree

H Community of *Hypselodelphys poggeana* and *Pandanus candelabrum*

All vegetation types near rock outcrops and inselberg crests in land unit UI2 can be characterized by the sociological species group 20, given in Table 13. The other sociological groups present, 21 and 15, are listed in Appendix 2. The community counts many large Commelinaceae and climbing Marantaceae, many of them definite indicators of humidity. *Hypselodelphys poggeana* was only observed in this habitat. It is a stout climber with prickly fruits resembling a pyramid. The plant can easily be distinguished from the common *Hypselodelphys violacea*, the only plant which has a very similar appearance, by its much smaller leaves and fruits. On isolated and small rock outcrops the community is poorly represented. *Pandanus candelabrum*, a very conspicuous plant, is a reliable indicator of such sites.
The community occupies exposed places in land unit UI2.

Vegetation of valley bottoms and alluvial plains

A number of forest communities are associated with water courses.

The vegetation of the colluvio-alluvial valley bottoms in the upland area contains elements of the upland community bordering the valley bottom, as well as species that are typical of swamp forest. The latter are well described by Guillaumet (1967) as sociological species groups G6 and G7. For reasons of mapping scale we did not classify the vegetation of the small upland valley bottom lands.

The primary forest bordering the Cavally river and the larger tributaries to the Cavally is indeed very different from upland communities and from swamp forest. It can immediately be recognised by an obvious difference in structure: the forest is neatly layered. A canopy between 20 and 35 metres is constituted mainly by one tree species, *Plagiosiphon emarginatus*, a large tree with small leaflets and a spiny bark. The understorey, up to one and a half metres, is largely dominated by the shrub *Neosloetiopsis kamerunensis* and by saplings of *Plagiosiphon*. These are the prominent members of the sociological species group 18 (Appendix 2), common to all alluvial deposits of some extent.
Forest on Cavally alluvium differs from that along the Audrénisrou, Méno, Gô and Nsé rivers in the understorey tree species that occur next to *Neosloetiopsis*. The latter constitutes a community with a particular understorey. The Oubi call all forest on alluvium 'Sahè'.

Table 13 Characteristic species of community H: *Hypselodelphys poggeana* and *Pandanus candelabrum* primary forest on low inselbergs and rock outcrops (sociological group 20, Fig. 10)

Species	Family	Life form
Hypselodelphys poggeana	Marantaceae	small herbaceous climber
Pandanus candelabrum	Pandanaceae	small tree
Marantochloa congensis	Marantaceae	small herbaceous climber
Oncoba spinosa	Flacourtiaceae	small tree
Palisota hirsuta	Commelinaceae	ground herb
Pavetta staudtii	Rubiaceae	small tree
Scytopetalum tieghemii	Scytopetalaceae	shrub

J Community of 'Sahè', with *Thecacoris stenopetala*
The characteristic species of the community growing on alluvium of the large tributaries to the Cavally river, belong to sociological group 19 (Table 13). Three understorey trees are specific for this habitat: *Thecacoris stenopetala*, *Crotonogyne chevalieri* and *Afrolicanea elaeosperma*. The sociological species groups 15 and 18 are present too (Appendix 2). The community constitutes a sharp difference with the vegetation of small valley bottoms.
Thecacoris stenopetala is a shrub with thick, white, cork-like stems.
The community occurs in land unit A1.

Table 14 Characteristic species of community J: 'Sahè' and *Thecacoris stenopetala*, primary forest alongside major rivers other than Cavally River (sociological group 19, Fig. 10)

Species	Family	Life form
Thecacoris stenopetala	Euphorbiaceae	shrub
Afrolicanea elaeospermum	Rosaceae	small tree
Crotonogyne chevalieri	Euphorbiaceae	shrub
Mapania coriandrum	Cyperaceae	ground herb
Pentaclethra macrophylla	Mimosaceae	large tree
Strychnos usambarensis	Loganiaceae	large woody climber

K Community of 'Sahè', with *Pancovia bijuga*

This community is restricted to Cavally river deposits. Characteristic species are presented in Table 15 (sociological group 17). The other sociological species groups present, 15 and 18, are given in Appendix 2. Two species were only found here, and these are probably exclusive to this community. The understorey tree *Pancovia bijuga* is an inconspicuous tree with shiny leaves. The other exclusive plant is a staggling tree growing in gaps and in secondary forest, a *Macaranga* with affinities to Macaranga sp. A in the Flora of West Tropical Africa (vol. 1, page 408,sub 10) (Hutchinson and Dallziel, 1954-1972). The community occurs in land unit A2.

Table 15 Characteristic species of community K: 'Sahè' and *Pancovia bijuga*, primary forest alongside the Cavally River (sociological group 17, Fig. 10)

Species	Family	Life form
Pancovia bijuga	Sapindaceae	small tree
Baphiastrum confusum	Papilionaceae	small tree
Alchornea cordifolia	Euphorbiaceae	small tree
Dialium aubrevillei	Caesalpiniaceae	large tree
Garcinia kola	Guttifereae	small tree
Lasiodiscus fasciculiflorus	Rhamnaceae	small tree
Macaranga cf. sp.A. in F.W.T.A., t1, p. 408	Euphorbiaceae	small tree
Nauclea xanthoxylon	Rubiaceae	large tree
Olax subscorpioidea	Olacaceae	shrub
Parinari congensis	Rosaceae	large tree
Rhynchospora corymbosa	Cyperaceae	ground herb

L Community of Psilanthus mannii and Hunteria spp.

A community rather isolated from others occupies steep-sided hills in the south-west of the study area. There are some deciduous trees on the top and also a group of plants not encountered elsewhere in our survey area. Some of them await further determination. Characteristic species are shown in Table 16 (sociological group 16). The sociological species group 15 is listed in Appendix 2.

Psilanthus mannii, a rather inconspicuous understorey tree is mentioned in Hall and Swaine (1981, page 265) as an indicator for evergreen forest on isolated hills between 500 and 750 meters high. The two *Hunteria* species are difficult to identify in the field.

The community occupies the upper part of the hills in land unit H.

Table 16 Characteristic species of community L: *Psilanthus mannii* and *Hunteria spp.*, primary forest on steep-sided hill (sociological group 16, Fig. 10)

Species	Family	Life form
Psilanthus mannii	Rubiaceae	small tree
Hunteria eburnea	Apocynaceae	large tree
Hunteria elliotii	Apocynaceae	small tree
Epinetrum scandens	Menispermaceae	small woody climber
Dracaena ovata	Agavaceae	ground herb
Garcinia spp.	Guttifereae	small tree
Ind. 1		medium-sized tree

7.4.3 Secondary forest (Fig. 11)

Depending on the degree of disturbance, secondary forest can be floristically very rich to very poor, often revealing many aspects of the cultural history of the site. Secondary succession in the Taï area was studied in the Taï project of MAB/Unesco (Guillaumet et al., 1984), by Alexandre et al. (1978) and by De Rouw and Van Oers (1988).

In the study area secondary forest occurs where shifting cultivation is practiced, which means it is restricted to areas occupied by Guéré, Oubi, or Krou farmers. We sampled forest fallows which were in the same stage of succession (5 to 12 years old), thus avoiding a classification based on serial stage. In contrast to primary forests which change due to increasing rainfall and to edaphic variation induced by lithology, secondary forests, at least those with fallows of similar age, vary along the toposequence. This means that the three secondary forest communities ~~we distinguished~~ (I, II and III), occur in all rainfall zones. We observed, however, that the different positions they occupy on the slope are not identical in the north and in the south. The secondary forest community which occupies crest, upper and middle slope in the northern part of the study area, will occupy only the crest in a more southern part. Also, the community which develops on lower slopes and even valley bottoms in the northern region, can occupy a much greater part of the slope in the land more south. However, the relation between fallow type and position on the toposequence needs further study.

I Community of *Rutidea parviflora* and *Secamone afzelii*

This fallow community is mainly characterized by woody lianas, Dioscoreae, *Clerodendron* ssp. etc. The sociological species group 23 (Appendix 2) is common to all secondary forest in the 5 to 12 years age class. The sociological group 24, given in Table 17, is specific for this community. In the northern part, the community is present over the entire toposequence, except for the valley bottom, and, sometimes, the lowest part of the slope. In the centre of the study area, its occurrence is limited to upper slope and crest. In the southern part the community is restricted to crests that are higher than average. This is again a demonstration of the interchangeability of edaphic and climatic moisture.

Rutidea parviflora is a sub-woody hairy liana and *Secamone afzelii* is a tough, glaborous liana, woody and slender. Both lianas have small leaves.

The community occurs in land units Unm2, Unm3, Upm2, Utm2, Utm3, Utx2 and Utc3.

Table 17 Characteristic species of community I: *Rutidea parviflora* and *Secamone afzelii*, secondary forest resulting from shifting cultivation (sociological group 24, Fig. 11)

Species	Family	Life form
Rutidea parviflora	Rubiaceae	small sub-woody climber
Secamone afzelii	Asclepiadaceae	small woody climber
Acacia pennata	Mimosaceae	medium-sized woody climber
Baissea zygodioides	Apocynaceae	small woody climber
Byrsocarpus coccineus	Connaraceae	medium-sized woody climber
Cissus diffusiflora	Ampelidaceae	small herbaceous climber
Cissus producta	Ampelidaceae	medium-sized herbaceous climber
Dioscorea praehensilis	Dioscoreaceae	medium-sized woody climber
Erythrococca anomala	Euphorbiaceae	shrub
Millettia zechiana	Papilionaceae	shrub
Sherbournia calycina	Rubiaceae	medium-sized sub-herbaceous climber
Stephania dinklagei	Menispermaceae	small herbaceous climber
Uvaria afzelii	Annonaceae	small woody climber

II Community of *Cleistopholis patens* and *Adenia lobata*

In this community lianas and a few pioneer trees, like *Cleistopholis patens* and *Ricinodendron heudelotii* are characteristic species (sociological group 25, in Table 18). The community occurs in the Northern part mainly in valley bottoms and, occasionnaly, on lower slopes. In the centre of the study area the community occupies the greater part of the slope, except for the valley bottoms, and sometimes the lower slopes. In the southern part the community may develop on crests and upper slopes.

Cleistopholis patens is a medium-sized tree with elongated, shiny leaves. *Adenia lobata* is a fleshy liana with two large, dark glands at the base of the leaves. The community was observed in land units Unm2, Unm3, Upm2, Utm2, Utm3, Utx2, Utc3 and Ul2.

Table 18 Characteristis species of community II: *Cleistopholis patens* and *Adenia lobata*, secondary forest resulting from shifting cultivation (sociological group 25, Fig. 11)

Species	Family	Life form
Cleistopholis patens	Annonaceae	medium-sized tree
Adenia lobata	Passifloraceae	small herbaceous climber
Anthocleista vogelii	Loganiaceae	medium-sized tree
Bertiera racemosa	Rubiaceae	small woody climber
Bussea occidentalis	Caesalpiniaceae	medium-sized tree
Dioscorea burkilliana	Dioscoreaceae	medium-sized sub-woody climber
Discoglypremna caloneura	Euphorbiaceae	medium-sized tree
Leea guineensis	Leeaceae	ground herb
Megaphrynium distans	Marantaceae	ground herb
Ricinodendron heudelotii	Euphorbiaceae	large tree

III Community of 'Kari' (*Hypselodelphys violacea*) and *Marantochloa leucantha*

This community is clearly dominated by stout, fleshy Marantaceae, *Hypselodelphys violacea* ('Kari' in Oubi) and *Marantochloa leucantha*, plants which can form an almost continuous canopy 3 or 4 m above the ground. Another characteristic species is the wine palm *Raphia hookeri*. Pioneers, like *Anthocleista* spp., are also present. The sociological species group 26 is characteristic for the community (Table 19). In the north of the study area the community is usually but poorly developed, and this is evident from a less vigorous development of the Marantaceae. In the central part, this community dominates most valley bottoms and part of the lower slopes. Great stretches of flat, swampy land between the Cavally river and the main Guiglo-Tabou road, that are regularly used for rice cultivation, are covered by this community. In the southern zone the indigenous population is small, and so little secondary forest is found. The 'Kari' community occupied here also the lower parts of the slope. Most members of the Marantaceae family are moderately resistant to cutting and even some burning. They resprout quickly and with their large leaves rapidly cover the ground, preventing the establishment of weeds and other pioneer species.

Hypselodelphys violacea has very large leaves and curious, large prickly fruits resembling a pyramid. *Marantochloa leucantha* is more robust than other Marantochloa species and has very large oval leaves.

The community was recorded in land units Utm2, Utm3, Utx2, Utc3, Ul2, AU, A1 and A2.

Table 19 Characteristic species of community III: 'Kari' (*Hypselodelphys violacea*) and *Marantochloa leucantha*, secondary forest resulting from shifting cultivation (sociological group 26, Fig. 11)

Species	Family	Life form
Hypselodelphys violacea	Marantaceae	medium-sized herbaceous climber
Marantochloa leucantha	Marantaceae	small herbaceous climber
Bertiera bracteolata	Rubiaceae	small sub-woody climber
Cissus polyantha	Ampelidaceae	small herbaceous climber
Cordia platythyrsa	Boraginaceae	large tree
Dioscorea smilacifolia	Dioscoreaceae	small woody climber
Raphia hookeri	Palmaceae	medium-sized palm
Thaumatococcus daniellii	Marantaceae	ground herb
Trachyphrynium braunianum	Marantaceae	medium-sized herbaceous climber

Species particularly frequent but already mentioned in other sociological groups (Appendix 2): *Baphia nitida* (Papilionaceae), *Cercestis afzelii* (Araceae), *Mareya micrantha* (Euphorbiaceae), *Musanga cecropioides* (Moraceae), *Myrianthus arboreus* (Moraceae).

7.4.4 Vegetation types in plantations (Fig. 11)

In the plantations undergrowth has normally been slashed so that all usual fallow trees and lianas are lost. Plantations of poor quality, with an incomplete cover of the tree crop, are dominated by grasses and the forb *Chromolaena odorata* (ex *Eupatorium odoratum*). In (moderately) well kept plantations there is a sparse, mainly woody undergrowth. The latter type of plantation vegetation can be present over the entire toposequence, except for the valley bottom, where all plantations observed were in a poor condition.

Woody undergrowth has resisted repeated cutting and is able to tolerate fairly deep shade. In old plantations, these plants belong to species of the undisturbed forest, though few species are involved and cover is scarce. The more weeding has been done, the less primary forest plants were able to persist or invade, and the poorer the vegetation becomes. Only two vegetation types could be distinguished (IV and V).

IV Community of *Morinda longiflora* and *Clerodendrum* spp.

This vegetation community is characterized by the sociological species group 27, represented in Table 20. It is found all over the study area, independent of topographic position in rather well-managed cocoa plantations, and in fully-grown coffee plantations of good quality. The undergrowth is often enriched by other plants, some of which belong to other sociological groups. These species groups, if well enough represented, may tell something about rainfall zone, or other characteristics discussed in the previous section, like presence of rock outcrops.

Morinda longiflora and all Clerodendrum species of the group are tough lianas with rather conspicious flowers and fruits.

The community occurs in the land units Unm2, Unm3, Upm2, Utm2, Utm3, Utx2, Utz3, Utc3, Usg1, Usy2, Usz2, Ul2, AU, A1 and A2.

Table 20 Characteristic species of community IV: *Morinda longiflora* and *Clerodendrum spp.*, plantation undergrowth (sociological group 27, Fig. 11)

Species	Family	Life form
Morinda longiflora	Rubiaceae	medium-sized woody climber
Clerodendrum schweinfurtii	Verbenaceae	medium-sized woody climber
Clerodendrum splendens	Verbenaceae	medium-sized woody climber
Clerodendrum umbellatum	Verbenaceae	medium-sized woody climber
Clerodendrum volubile	Verbenaceae	small woody climber
Acridocarpus longifolius	Malphigiaceae	large woody climber
Massularia acuminata	Rubiaceae	small tree

Species particularly frequent but already mentioned in other sociological groups (Appendix 2): *Blighia welwitschii* (Sapindaceae), *Cercestis stigmaticus* (Araceae), *Drypetes pellegrini* (Euphorbiaceae), *Chlorophora excelsa* (Moraceae), *Napoleona leonensis* (Lecythidaceae)

Table 21 Characteristic species of community V: *Alstonia boonei* and *Funtumia elastica*, plantation undergrowth (sociological group 28, Fig. 11)

Species	Family	Life form
Alstonia boonei	Apocynaceae	medium-sized tree
Funtumia elastica	Apocynaceae	medium-sized tree

Species particularly frequent but already mentioned in other sociological groups (Appendix 2): *Amphimas pterocarpoides* (Caesalpiniaceae), *Baphia nitida* (Papilionaceae), *Glyphaea brevis* (Tiliaceae), *Mareya micrantha* (Euphorbiaceae). *Elaeis guineensis* (Palmaceae) is rare.

V Community of *Alstonia boonei* and *Funtumia elastica*

This community, like community IV, occurs in well-kept cacao and coffee plantations, independent of topography. However, it is restricted to uplands in the southern rainfall zone (land units Usy2, Usz2, Usc3, H) and land unit AU. Table 21 gives the two characteristic species (sociological species group 28). Three other species are often present but they have already been mentioned as members of other sociological species groups: *Millettia rhodantha*

('Ferreclao'), *Glyphaea brevis* and *Baphia nitida*.
Alstonia boonei is a tree with a curious architecture. *Funtumia elastica* regenerates profusely from seed. Both trees are medium-sized and contain much latex.

7.5 Oubi classification

7.5.1 Primary forest, uplands

Many people, mainly Oubi, were asked whether they distinguished different types of primary forest, where such forests could be found, and in which aspects were they different. As often as possible we asked people to indicate in the field what they considered to be different forest types. ~~We also asked them to~~ classify in their system the forest we sampled. We summarize our knowledge of their classification as follows.
Zones with different upland vegetations are divided by lines perpendiculary on the main road. There are three zones, a northern, a central and a southern zone. The distinction between the northern and the central zone is sharp and lies a few kilometers north of the village Diéré-oula. The main difference between the two zones is the presence of the tree 'Vaa' (*Gilbertiodendron preussii*) in the central zone and its absence in the northern area. Another difference is the experience that rice cultivation is supposed to be easier in the central zone. The distinction between the central and the southern zones is less sharp. It lies somewhere in between the villages Nigré and Para. The change in forest type is defined by the appearence of unfamiliar plants in the southern zone. We are here outside the Oubi territory and Oubi do not have distinct names for those species.
After we had made our classification and drawn our map, we could check these observations. The Oubi seperation between the northern and the central zone coincides with our separation of the Northern (and Intermediate) rainfall zone and the Transitional rainfall zone. The Oubi seperation of the central and the southern zone fits approximately with our distinction between the Transitional and the Southern rainfall zone. Thus the vertical lines on Fig. 12, resulting from mathematical processing of data, are consistent with the forest distinctions made by local people.

7.5.2 Primary forest, extreme landforms

Forest on alluvium and on uplands with inselberg crests is set apart the same way as it is in our classification. These forests are not only floristically, but also structurally, very different from 'normal' upland forest and are thus easily recognized.
A community which was too rare in our survey to be treated separately is called 'Powi-kla' in Oubi. It is dominated by the shrub *Scaphopetalum*

amoenum which forms a dense, almost monospecific understorey by means of vegetative layering, that bears resemblence to a cocoa plantation. Guillaumet (1967) has stated that the community is related to schists, but we could not confirm this. Most of the known 'Powi-kla' sites were in land unit Utm2 and have been cleared for agriculture.

7.5.3 Secondary forest

Oubi give different names to successional stages of forest fallows (Gnesio Tehe 1980) that correspond approximately to the serial stages defined by Alexandre et al. (1978) in the Taï region. Two secondary forest communities will be discussed here for they develop under specific edaphic conditions.

A secondary forest type, usually a young fallow, which often is named after its prominent plant species, 'Kari' (*Hypselodelphys violacea*), occupies swampy ground. It is characterized by the predominance of Marantaceae species. This secondary forest type is well represented in our survey area. We have described it as community III.

A secondary forest type which was rare in our study area is called 'Gbaroo' in Oubi, meaning 'horizontal forest'. It is old to very old secondary forest where the succession has been blocked by the profuse development of many Marantaceae. This produces a horizontal layering of the vegetation. It is restricted to some flat depressions. Few 'Gbaroo' communities are still intact, most of them have been used for agriculture, especially rice, for these places are considered appropriate for cultivation. In the studies of Guillaumet (1967), and Alexandre et al. (1978) 'Gbaroo' is known as 'brousse à Marantacées'. The vegetation needs further study for the mechanism of blockage is not yet understood.

7.5.4 'Ferreclao'

Millettia rhodantha or 'Ferreclao' in Oubi is considered an indicator plant for places favourable for agriculture. In the northern and central part of the study area 'Ferreclao' is often related to rock outcrops and low inselbergs, though it is absent in land unit Ul1. The sites where 'Ferreclao' occurs are small, covering only a few hectares, but in land unit Ul2 it grows over a large area. Occasionally 'Ferreclao' is found on the borders of a river. These areas are also small. In the southern part of the study area, the plant becomes widespread on a variety of soils, independent of rock outcrops. Fig. 13 shows all growth places of 'Ferreclao' known to us. The limit of the Oubi territory corresponds with the region where the occurrence of 'Ferreclao' often indicates an anomaly in the landscape. The relationship between 'Ferreclao' sites and crop yields is rather confusing, as is the relationship with chemical and perhaps other soil properties.

8 LAND USE

In Chapter 2 it was mentioned that for the Land Unit survey use was made of both aerial photographs of 1956, and of SPOT imagery of 1988. One of the features that both photographs and SPOT image showed was land use; the SPOT observations could, in addition, be checked in the field. With observation dates thirty years apart ~~we could thus obtain~~ a picture of changes in land use over the last three decades. We have taken this opportunity and have prepared a Land Use map in which the situation of 1956 and that of 1988, were combined. The Land Use map will be discussed in section 5 of this chapter. The preceeding sections deal with: the development of land rights; the criteria applied for selecting sites suitable for cultivation; the resulting land use pattern in relation to environmental, social and economic factors; and the present cropping systems.

The indigenous population of the study area belongs to three ethnical groups, the Guéré, who settled north of the village Taï, the Oubi who occupy the land between the villages Taï and Nigré, and the Krou, who inhabit the land south of Nigré. They live in villages along the main road and their agricultural practices are very much alike: shifting cultivation and some cocoa and coffee plantations. Differences between the groups are expressed in social organization and in language.

The immigrant population consists of other Ivorians, mainly Baoulé, and foreigners from Burkina Faso and Mali, mainly Mossi. Some live in villages, but most of them inhabit small settlements ('campements') amidst their plantations. Immigrants plant cocoa and coffee and are generally not shifting cultivators.

The Taï National Park consists largely of untouched rain forest. Vegetation that characterises former cultivated fields is found near villages or abandoned settlements, where small patches of primary and late secondary forest can be found as well. The area occupied by primary forest increases markedly as one approaches the Park.

8.1 Land rights

The following section is largely based on interviews with Oubi farmers in the northern part of the study area.

8.1.1 The precolonial period (before 1900)

Land rights were initially acquired by virtue of felling a forest. They extended to the secondary regrowth which follows each cropping. Rights were held by individual households and they were attributed to the chief male member. Although land rights were endowed to men, both men and women executed these rights with equal authority. The wife (or wives) exerted these rights when the husband is deceased or in his absence. Land rights were essentially household rights, permitting the owner to do with the land whatever he wished, and prohibiting anyone else to enter the land. However, permission to others was easily granted, e.g.for purchasing firewood, or poles to construct houses, or medical plants, or for laying traps. Each year a household could extend its domain, if it so wished. However, all land acquired by a man during his lifetime devolves to the community when his household is broken up, so that other Oubi can use it. It is curious that landclaims are not transposed to sons or other heirs. This absence of inheritance of claimed land demonstrates the individuality of the shifting-cultivation farmer, and the abundance of forest. Dove (1983) studied land claims of shifting cultivators in Asia, in dense forest environments. In all cases he found that land rights were remarkably individualistic, an observation similar to ours in the Taï area.

Settlements were concentrated along permanent sources of water; these and larger villages moved regularly.

8.1.2 The colonial period (1900-1960)

The French colonial government attempted to confine the settlements to the one main road, and the local people were obliged to help to construct and maintain the road. Each village was responsible for half the distance to the next village north and half the distance to the next village south. The manner in which the road was thus divided, and responsibilities separated between villages remained after the colonial period. Gradually these boundaries developed into border lines to mark the forest land left and right of the road section that belonged to each village. Boundaries between village territories were rather arbitrary since the number of inhabitants per village did not affect the extent of the territory.

8.1.3 The period since independance (1960-present)

At the time of independence the situation was such that each village held rights to a distinct territory. However, this right was not a communual land tenure, as land rights of shifting cultivating societies are often considered, but the right to prohibit any outside person from farming within the territory. Within the village territory individual claims continued and households were free to use the land as they liked.
Village rights were further developed in the period of the first (Baoulé)

immigrants during the sixties. Households started to record officially, at the 'sous-préfecture' ('Juge de Paix'), the position of all forest traditionally claimed. The forest land was attributed to individuals, making it possible for men and women alike to lawfully own land. Most persons became owner of 15 or 30 hectares of secondary forest and fields and almost every one added also patches of primary forest. The domain itself was marked with cemented boulders. Portions of forest claimed by no one remained in 'reserve'. From this pool land could be taken and given to absent parents and children. The creation of the National Park interfered with the land rights of the Oubi, since large portions of their forest became part of the National Park. During the last enlargement of the bufferzone, in 1982, it was still possible for farmers deprived of their land to purchase some 15 to 20 hectares of forest elsewhere within the village boundary. At present every household practices shifting cultivation within its own forest domain, with boundaries fixed by law and marked in the field with cement.
When immigrants arrived they were conducted to villages that had relatively much land and few people. The Baoulé, who came first, were sent to areas with few claims. The various obstacles were overcome with presents (beer, wine etc.) and the immigrants acquired rights to use the land. Many Baoulé families settled between the villages Taï and Gouléako, and those who had arrived first, received sometimes fifty or more hectares. Baoulé that came later, and foreigners, most of them Burkinabé, received far less land, 4 to 10 ha, and they were directed towards remote places which were still unoccupied, or to land close to the main road where the forest was less high and the soil often swampy and considered less suitable for the cultivation of coffee or cocoa.

Immigrants, mainly Baoulé and Burkinabé, in search for land to plant cash crops and food crops, first 'saturated' other forested areas in Côte d'Ivoire before reaching Taï. Often they arrived so suddenly and in such large numbers that the indigenous farmers did not have enough time to validate their traditional land rights at the 'sous-préfecture', and so they lost much forest (Lena et al. 1978; Chaveau & Richard, 1976). In the Taï area, however, immigrants arrived at a much slower pace, and so the Oubi and Guéré managed to keep part of their traditional territory for their own use.

~~As we can see from~~ the Land Use map (Appendix 10), discussed below, the Oubi living in the central part of the study area, where immigration started later, defended their agricutural territory even better. This is perhaps due to the fact that the immigrants came in small groups and that the Oubi remained the largest group. The Krou, on the other hand, living in the southern part of the study area, were a small group, and they kept little land for their own use when immigrants came to settle.

8.2 Criteria for the selection of land for shifting cultivation

The indigenous farmers convert a forest into arable land with the aim to crop it with rice for one season, and then let it return to forest. In this cropping system a new field is required each year. In choosing the location of their field, farmers consider both the soil and the forest. In case of a secondary forest this encompasses the age (time since last cutting), the structure and the floristic composition.

8.2.1 Age of the secondary forest

The tangled vegetation that follows each cultivation period rapidly acquires a forest-like appearance. The trees that form this forest fallow are, within a range of a few months, of the same age. They are called pioneers, and have a limited life-span. Older secondary forests are often characterised by species that have invaded the fallow at a later stage of development.

In forest fallows in the Taï area two periods of strong decline of pioneer trees can be recognised. The first period is 7 to 9 years after the field was abandoned, and is characterised by a massive deterioration of the pioneer tree Macaranga hurifolia. A second period of decline, affecting trees of many species, occurs after 18 to 23 years of growth. If a farmer wants to cultivate a forest fallow, he can save much work if he chooses the moment of felling to coincide with the decay of certain tree species. He could 'use' the first period of degeneration, but a fallow period of 7 to 9 years is considered too short. The farmer prefers to benefit from the second period of decline. After some twenty years of regrowth the forest is considered to have restored the land to a state in which it can be farmed again.

8.2.2 Quality of the secondary forest

Next to age of the secondary forest, some other aspects are considered by a farmer in selecting a site for preparing a rice field. These include the floristic composition, the structure and the general health condition. All three aspects are important in the selection, but the general health condition, the vigour of the regrowth in relation to its age, is often decisive. If the farmer gets the impression that the pioneer trees are too small for their age, he estimates that no good crop can be expected - even with a favourable floristic composition of the forest. If, however, the secondary vegetation is vigorous, he estimates that a satisfactory rice yield will be obtained - even if some undesirable plants occur.

8.2.3 Quality of the soil

Oubi and Guéré use similar criteria in their judgement of the soil. The surface 10 to 15 cm of soil is sampled by means of a cut-lass, and examined for

colour and texture by squeezing a handful of earth. Three classes of texture are distinguished: clayey, sandy and intermediate, and three categories of colour: blackish, reddish and pale. The darker the colour, or the more clayey, the better the soil. A red clayey soil is considered superior to a dark-coloured sandy soil. Presence or absence of gravel is not considered to be important except in two circumstances : on crests and upper slopes a too thick layer of gravel enhances the risk of lack of water (most farmers), and gravel in lower slope soils is generally desirable because of better drainage (some farmers).
Farmers throughout the study area mention the importance of earthworms for the quality of the soil. Activity of worms is estimated by the number of small moulds ejected on the surface. Fritsch (1982) in his study on earthworms in Taï found a good relation between number of worms and amount of small moulds on the surface. The activity of earthworms is closely related to the quantity of litter available, which, in secondary forest, increases dramatically in periods that the dominant pioneers die off.
The soils near the Cavally River are considered to be, as an average, only moderately suitable for cultivation. Soil textures and soil drainage class are variable, and some of these soils become hard when dry.

8.2.4 Other criteria

A site is also judged by its cropping history, and places are avoided because of a former bad yield. A short walking distance to the home village is an asset. Primary forest is not often used for rice cultivation: the large trees offer great difficulties to felling and burning because of their size, hardness of their wood and the difficulty to get rid of the debris.

8.3 Selected sites for shifting cultivation and for cocoa and coffee plantations

In former times, when only the indigenous Oubi, Guéré and Krou inhabitated the land, rice was grown mainly on lower slopes and parts of valley bottoms. The aerial photographs taken in 1956 showed this. Land close to dwelling places was more intensely cropped than forest at some distance, and soils of lower quality that were lying nearby were cultivated because of their proximity. On the photographs valley bottoms covered by Raphia palms could be identified. Although Raphia occurs disseminated in swampy primary forest, a dominance of these palms is often an indication of former human activity. They spread easily in swampy places, persisting in the community for a long time. Guillaumet (1967) also suggested that Raphia may indicate former human activity, and this was confirmed by farmers interviewed by J. van der Gaag (personal communication).

The intention to use the field not only for rice but also for a subsequent cash crop, coffee or cocoa, has prompted many farmers to fell primary forest, although the clearing of a secondary forest was more their custom. Coffee and cocoa were said to need 'fresh' soils. Although in many cases no such second crop was planted, these intentions have determined the field locations for at least a decade. As 'good' primary forest grew scarcer, forests classified as second rate were also converted into tree crop plantations.

The immigrants that arrived first received remote rather than inferior forest. They settled away from villages, following logging tracks to penetrate into the forest. Some even installed themselves illegally in the bufferzone or in the Park. The immigrants that arrived later did not receive much land, and they planted almost irrespective of site on every piece of forest land which was given to them. At present foodcrops, mainly tubers and maize, are grown in cocoa and coffee plantations during the first years of growth of the tree crops. Nowadays, cocoa and coffee are planted on a variety of soils by indigenous as well as immigrant farmers. The Oubi, Guéré and Krou plant the trees as a follow-up to the rice crop. The immigrants, on the other hand, plant cocoa and coffee immediately after having cleared the land.

8.4 Cropping systems in the Taï area

8.4.1 Shifting cultivation, long cycle

The indigenous population in the Taï region - the Guéré, Oubi and Krou - grow one crop of rainfed rice in rotation with long forest fallows. Following clearing and burning, the land is usually weed-free for some months. Little weeding is done during the cultivation period, provided the rice has had a good start. Forest is then allowed to regenerate itself for eighteen or more years before the land is cropped again. Men do the felling and burning, women are responsible for all other aspects of foodproduction. This rotation is practiced on all upland sites, and over the entire area over which they hold claims. Rice is planted at the onset of the long rainy season and is used for private consumption.
Nowadays increasing population pressure has shortened fallow periods to less than ten years, especially close to the larger villages.

8.4.2 Shifting cultivation, short cycle

A more intensive land use is performed in large, flat, rather swampy areas in the southern Oubi land, the land unit AU. Rice is cropped for only one season and fallows are surprisingly short, not exceeding six years. As no primary or secondary high forest is left today, we have concluded that the region has been cropped for rice over a long time. This was confirmed by the study of the aerial photographs of 1956, and by interviews with farmers. It

was only here that we found rice being produced for a market, and not just for personal consumption. The swampy nature of the land allows for flexibility in the period of rice planting; this is an advantage over the other rice producing areas, since rice can be harvested during a great part of the year. Most of the rice goes to the larger villages Taï and Para.
Many of the weeds belong to stout, climbing Marantaceae (community of 'Kari' (**Hypselodelphis violacea**) and **Marantochloa leucantha**). The weeds are cut back during the cropping period but at the end of the season are allowed to grow out. With large leaves and vigorous growth the ground is rapidly covered. This seems to be rather effective in preventing the spreading of other weeds.

8.4.3 Permanent cultivation

It is not clear exactly when coffee and cocoa were introduced in south-west Côte d'Ivoire, but certainly both crops were known before 1920. Cocoa arrived via Liberia and was usually cultivated because the sweet pulp of its fruits could be fermented into a fresh, lightly alcoholic beverage. Coffee cropping started later and was exclusively for export.
In 1954, when coffee prices were high, production of coffee was propagated. Holas (1957) mentioned a growing popularity for coffee among Oubi and Guéré and describes some of the disruptions it caused to family life. A small promotion and distribution centre was established in Keibli, a few kilometers north of our study area (Schwartz, 1972). Although coffee cultivation around Taï has occurred widespread as can be seen nowadays by the presence of scattered coffee trees in 20 and 30 year old fallows, the total production has always remained at a low level. The owner had to register his plantations at the local authorities right from the start (Holas, 1957). This was the strongest incentive yet experienced for people to live in fixed villages along the road, stronger than the French colonial pressure. World prices started to fall in 1956, and this was followed in 1960 by the withdrawal of price guarantees by the government.
New interest in coffee and in cocoa by indigenous farmers arose with the arrival of immigrants and with the modernization of the extension office in the sixties and seventies. Cocoa requires less work than coffee and the profit per kilogram yield is almost the same. This meant that most immigrants, especially Baoulé chose for cocoa. However, in the Taï region cocoa culture is hazardous, and therefore some farmers, mostly Oubi and Guéré, prefer to cultivate coffee.

Land occupied by Oubi, Guéré or Krou is immediately recognized by the presence of scattered large trees. These trees, often left on purpose, grow over several cultivation periods and survive burning during land clearing. The immigrants cut the undergrowth and the smaller trees. The slashed wood is burnt in piles packed around the foot of the large trees. Burning is repeated until the tree is killed; normally all slashed wood is spent in the operation. So the land occupied by immigrants is either deprived of large trees, or there are only dead trees. The different cultivation practices allow a differentiation on the SPOT image between indigenous and immigrant farms.

8.5 Performance of cocoa

Cocoa cultivation in the Taï area is widespread, and cocoa is planted indiscriminately on all kinds of soil - except for the valley bottom lands and alluvial plains subject to flooding. There is a great variety in management with differences in plant density, weeding, and spraying against pests. Our systematic notes on land use along transects included 1449 observations in cocoa fields that are spread over the entire area south of Poulé-oula.
Fig. 14 shows planting year (and age) of cocoa holdings, all 1449 observations compiled. Observations on mixed cocoa and coffee stands were left out. We can see that only about 6% of cocoa plantations is over ten years old; 1981, 1985 and 1986 were top years of planting. Although farmers nowadays encounter more difficulty in selling cocoa, the rate of plantation expansion has not yet slowed down. We observed many new cases of primary forest felling during our fieldwork in 1989.
In Table 22 information on the ethnic group of owner of the field, and on crop condition are presented. A 'good condition' means: apparently healthy plants, good to average cover considering the age of the crop, and a probably satsfactory yield to be expected. We rated 36 % of the fields observed fields as being in a 'good condition'. A 'poor' crop condition means that die-back, caused by a variety of pests, has attacked the cocoa to a point that the plantation must be considered lost, either now or within a few years; 19 % of our sample was like this. Plantations classified as 'average' often have trees of different age, a result of continuous by-planting where a cocoa tree has died. Trees in this class seem to be healthy but their appearance suggests that they have had growth and development difficulties. Yields will probably remain below a level that makes cultivation worth while. 'Average' plantations covered 45 % of our sample. Fields invaded by weeds were classed separately; 21% of all fields were weed-infested, most of which were among the 'poor' plantations.
Plantations older than 7 years, were generally in a better condition than younger ones. This was particularly evident in regions which appeared already 'saturated' in cocoa plantations. The more recent plantations were, apparently, installed on less favourable sites. The oldest cocoa (and coffee) plantations are situated on upper and middle slopes, on both sides of the timber extraction roads that usually follow the crests. Later the lower slopes were cleared and planted, followed by the crests. Finally, valley bottoms are planted and these youngest plantations are usually of very poor quality. In Table 22 distribution according to ethnic group of owner demonstrates an overall dominance of immigrants. Krou and Oubi hold 5% percent of the plantations in the sample.

The indigenous farmers cultivate more coffee than cocoa, as do some of the smaller Burkinabé groups.
Pure coffee plantations accounted for only a few percent of the total number of observations on tree crop plantations. These were adult plantations and were in good condition.

8.6 The Land Use Map

A Land Use map, scale 1:100,000 (Appendix 10) was made, based on aerial photographs of 1956, SPOT imagery of 1988, and field observations of 1989.

Land use in 1956 was largely shifting cultivation for rice by Oubi, Guéré and Krou. In the legend for the Land Use map (Appendix 10) we distinguished between areas where rice was cropped in rotation with forest fallows (r), areas with slightly disturbed primary forest (pd), and areas with undisturbed primary forest (pf). Primary forest occurring in shifting cultivation areas was given in five classes, r1 to r5, inclusive, with percentages of primary forest cover of over 75, 75-50, 50-25, 25-5 and less than 5, respectively.

Land use in 1988, from SPOT observations, has been indicated in the legend in capital letters, to distinguish it from the 1956 land use. The following four categories were distinguished:

R Rice cropping in rotation with forest fallows, by indigenous farmers;
T Rice cropping in rotation with forest fallows, and cocoa and coffee plantations, by indigenous farmers;
C Cocoa and coffee plantations by immigrants;
M Mixed farming by the indigenous population and by immigrants. Land use is a mixture of T and C.
PL Primary forest, locally exploited.

The percentage cover of primary forest in cultivated areas is indicated in the same way as for land use in 1956; however, in class R there was never more than 25% primary forest (R4, R5), and in class T it was always between 5 and 25% (T4). All five classes of primary forest cover can be found in M and C.

The resulting map allows some interesting conclusions to be drawn on the dynamics of land occupation.
Land use shows a marked difference between the northern and the southern part of our study area. The dividing line is a few kilometers north of the village Diéré-oula. In the northern part, that portion of the land that was in use for shifting cultivation by Oubi and Guéré in 1956, and that is located near the main road, is now occupied by Oubi, Guéré and immigrants together

(r-M). On the other hand, land that was used for rice in 1956 and that was located far from settlements, is now in the hands of immigrants alone (r-C). Slightly disturbed primary forest in 1956, now located near the main road or near a village, has become occupied by both indigenous and immigrant farmers (pd-M). This is the only case where the indigenous farmers have enlarged their territory. Land covered by undisturbed forest in 1956 is now either farmed by immigrants (pf-C), or, if located in bufferzone and Park, has remained forest (pf-PL). In general the original inhabitants of the regions have retained the land close to villages and along the main road; land that was far removed from settlements or from the main road, became occupied by immigrants.

The southern part of the map shows two main differences with the northern part. Firstly, we find that land used by indigenous farmers in 1956, is still occupied by the same ethnic groups in 1988. In these areas rice was cropped so intensively that no high forest was left. Moreover, most of this land is swampy. These two circumstances made it less suitable for cocoa planting, so immigrants were not interested and the land remained Oubi. Rice was and still is the only crop (r-R). Secondly, in some shifting cultivation areas with remnants of primary forest in 1956, part of the forest has been used for tree crops, still by the original Oubi farmers (r-T). On the other hand, as in the northern part, much land that was subject to shifting cultivation in 1956 and that was lying close to the main road now has a mixed population of immigrants and indigenous ethnic groups (r-M). Only a small portion of land used by indigenous farmers in 1956 is now cultivated by immigrants alone (r-C). Most of the land now used by immigrants for tree crops, was primary forest in 1956 (pf-C).

In summary, we can see that the original inhabitants continue to occupy the land bordering the main road. This is roughly the same territory that they occupied in 1956, but cultivation has become more intensive. Immigrants cultivate the land further east, up to the limit of the bufferzone. In the northern part, many farms are situated in the bufferzone, and even in the Park. In the southern part, in contrast, the bufferzone is generally respected. The SPOT image shows that where no timber extraction roads mark the boundary of the bufferzone, farmers have extended their plantations into this zone; if, however, a timber extraction road marks the beginning of the bufferzone, this zone is respected and no cultivation has proceeded beyond that line.

8.7 History of land use, the case of Sakré

An example of thirty years of land occupation is illustrated in Fig. 15. It represents three stages in the land use of a strip of seven square kilometers in the centre of our study area, near the village Sakré. The situation in 1956 was drawn following interpretation of the aerial photographs and the land use

in 1978 was reconstructed following interviews and interpretation of the present situation. For the situation in 1988, on the other hand, 300 observation points were used as well as an interpretation of the SPOT false colour prints, and, in addition interviews were held
The strip of land extending from the village Sakré to the bufferzone was chosen for three reasons:

* all land use patterns distinguished on the aerial photographs of 1956 are present;
* the area is now considered to be 'saturated', and acute problems are becoming visible; such problems will probably arise elsewhere if the remaining forest is felled;
* as Sakré was our field base, observations could be checked and discussed rather easily.

8.7.1 The situation in 1956

In 1956 the village Sakré counted about a hundred inhabitants, all of them Oubi. The land belonging to the village was subject to rotations of rice cultivation and forest fallow. Close to the village rotations were shortest and little high forest was left (r4). Further eastward the primary forest was slightly disturbed, with patches of old secondary forest (pd). One valley bottom filled up with Raphia palms could be detected (R). About three kilometers from the village, another zone with recent fields can be seen, but much high forest persists (r1). Still further east, we find a forest that is apparently as undisturbed as the interior of the National Park (pf). However, between 5 and 6,5 km distance from the village, we detect another stretch of forest slightly altered by man.
The aerial photographs also show that very near the village the entire toposequence of land is devoted to shifting cultivation, while further away only the lower slope and (part) of the valley bottom are used, leaving the forest on slopes and on the crest untouched.

8.7.2. The situation in 1978

Around 1978 the first immigrants installed themselves in Sakré on one side of the road and the Oubi moved to the other side. Logging firms opened up the hinterland to extract timber, and it was along the logging tracks that colonization of the interior started. Close to the village the land is still used for shifting cultivation by Oubi alone (R4). Oubi have planted permanent crops, coffee rather than cocoa, in the adjoining slightly disturbed primary forest zone (T2), and also in the area that had occasional shifting cultivation (r1, in 1956). Tree crop cultivation always begins at fresh sites, i.e. sites with primary forest. Rather close to the village (pd in 1956) this meant: forest on the slopes and crests (lower slopes had been used previously for rice). The land that the Oubi used for shifting cultivation has been somewhat enlarged,

and permanent crops have been planted on part of the primary forest area of 1956. We can say that agricultural activity, both for food and for cash cropping, has moved uphill.
The immigrants were allowed to crop beyond the line separating shifting cultivation land (r1, in 1956) from land covered with (almost) untouched forest (pf, in 1956); this is unit C1. Three small settlements have been built along the logging road. This road follows the crest, and as a result dwellings (of immigrants) and cocoa and coffee fields (by Oubi, C) are concentrated along this road.

8.7.3 The situation in 1988

During the last decade many more immigrants have settled, either in the village (actual size about 2000 inhabitants), or in small settlements. The line separating Oubi land and immigrant land has become very marked, both in the landscape and on the SPOT image. Shifting cultivation extends 3 km east of the village (T5 and T4). Still only one crop of rice is grown, but fallow periods have shortened. In this Oubi land, the area covered by coffee and cocoa plantations (C, in the T4 area) has not much expanded since 1978. It is curious to observe that the vegetation on lower slopes, where shifting cultivation was practiced before, but was neglected in the period of coffee and cocoa planting, has often developed into an impressive secondary forest, particularly rich in oilpalms and Raphia wine palms (S).
In the zone allocated to them (C5), the immigrants have cut all primary forest, except for some swamp forest (P). Some of the immigrants have settled in the bufferzone. Foodcrops have been interplanted with cocoa trees. At this stage of land use development food problems begin to appear in immigrant farming. With ageing plantations all land becomes covered by cocoa, and very little land is left where food crops - mainly maize and cassave - can be interplanted with young cocoa. Possible solutions that are being tried by the immigrants are:

* foodcrops (mainly cassave) and cocoa are planted where former cocoa has died;
* valley bottoms are used for rice cultivation; here too, food crops often replace dead cocoa trees.

In the case of Sakré the situation has evolved to a point where food cropping within the immigrant territory has become very difficult. Many degenerated cocoa plantations have been abandoned, and these are now covered by grasses, sedges and the thicket forming weed *Chromolaena odorata* (ex *Eupatorium odoratum*) (D). It has become common practice for the immigrants that are not able to find a suitable site in their territory for growing food, to ask Oubi farmers permission to use their fields for food cropping, at the moment they (the Oubi) leave it. This is usually after one rice crop, when the Oubi consider the land to be too heavily infested with weeds for further cultivation.

However, in the opinion of immigrant farmers, there is not yet a serious weed problem. If cultivation continues for one or two years (V), these fields develop into degraded thickets, similar to the ones described above as D. This practice of letting immigrants 'finish off' a field worries many Oubi. In the villages Siéblo-oula and Zriglo attempts are now made to prohibit all immigrant farming on recently abandoned fields within the Oubi shifting cultivation zone. In other villages, Sakré and Poulé-oula, such decisisons were already taken in 1986 and 1988 by several individual farmers.
The Oubi continue to crop rice in the area that they occupied for a long time, but rotations have shortened and there is some tree cropping. Immigrants, on the other hand, have turned most of their forest into plantations, and increasingly less land is available for food cropping. Consequently, the region has reached the point where traditional shifting cultivation and the usual mixed cropping of food crops with cocoa trees can not be continued. The intensified food cropping that was tried in the uplands has not been sucessful, perhaps because this meant a too heavy burden on the land. This problem is now under investigation (see Chapter 11).

The Land Use map shows areas equally 'saturated' as the immigrant land near Sakré. Other regions, near the river Méno for instance, are less colonized and resemble the situation of 1978. Other areas are intermediate in their development.

9 LAND UNITS

9.1 Introduction

The Land Unit survey and the resulting Land Unit map with its Legend have been mentioned in previous chapters. Chapter 2 dealt with the methodology of a Land Unit survey, whereas a short description of the Legend was given in Chapter 5, Geomorphology. In Chapter 6 geographic soil units (soil complex, soil association, catena) were described, and in Chapter 7 vegetation units (communities); in both chapters reference was made to the land units in which they occurred. A similar approach could not be followed in Chapter 8, Land use, since in the Taï area land units are seldom units with respect to land use. However, in the description of land units in section 9.2, reference is made not only to natural features like landform, soil and vegetation, but also to land use. The apparent quality of cocoa plantations, as judged from density, canopy, frequency of die-back and degree of weed infestation has been given for those land units where cocoa plantations occur frequently.

The Legend of the Land Unit map (Appendix 11) has a hierarchical structure. Column 1 gives the land unit code as it appears on the map, whereas columns 2 through 6 indicate the various site aspects to which the letters and figures in the codes refer. Column 7 gives the catenas and other geographic soil units, and their relative coverage in each land unit: from dominant (>75%) to inclusions (10-25%). Catenas covering less than 10% of the surface have been disregarded. In column 8 the vegetation communities are presented in the same manner. They have been assigned to three categories: primary vegetation, secondary vegetation, and the undergrowth in cocoa and coffee plantations. Column 9, finally, gives the surface area of each land unit in hectares and in percentage of the total area covered by the survey.

Units of the Land Use map referring to the situation in 1988 have been grouped into larger units and superimposed on the Land Unit map. Land units and land use are thus presented on one map and this facilitates comparison.
The boundaries of National Park and bufferzone are also given on the map. The boundary of the Park was taken from the topographical maps. South of Poulé-oula the boundary of the bufferzone was taken from the SPOT-image; here it is a rather wide strip where the forest has been cut. North of Poulé-oula the boundary as defined in the legal act no. 77348 was used because here the line was invisible on the SPOT image.

9.2 Description of the land units

In this section the most important features of each land unit, and their relationships, are described. The description may include minor features that are not indicated in the Legend.
In the description of soils and vegetation reference is made to soil catenas and other geographic soil units described in Chapter 6, and to vegetation communities described in Chapter 7. Landforms indicated in the land unit descriptions are more extensively treated in Chapter 5.

Uplands

Differences in vegetation between the land units are most clearly expressed in the undisturbed forests. The secondary vegetation, associated with shifting cultivation for rice, is characteristically different between the northern, intermediate and transitional rainfall zones (in the southern zone there is hardly any shifting cultivation). Two communities have been recognized as undergrowth in cocoa and coffee plantations.

Unm2 Undulating to rolling, moderately dissected uplands derived from migmatite; northern rainfall-vegetation zone.
This most northern unit covers about one third of the mapped area. One distinct inselberg is found in the centre of the land unit; it is covered by shallow, skeletal soils, whereas the footslope soils are red-coloured, and have a higher percentage of clay than the soils that have developed from migmatite. The inselberg has been described by Vellema (in preparation).
The drainage pattern is dominantly subparallel to rectangular, but immediately west of the Audrénisrou it is parallel and remarkably wide (Chapter 5). Deep incisions ('ravines') mark the beginning of some of the valley bottoms.
The soils belong mainly to the migmatite catena.
The community Hunteria simii & Chidlowia sanguinea (community A) is most characteristic for the primary forest in the migmatite catena, and it occurs from crest to lower slope. In valley bottoms, and on the rare crests and slopes that contain little ironstone gravel, the community Uapaca spp and Mendoncia combretoides (community B) is found. Shifting cultivation fallows have the community Rutidea parviflora & Secamone afzelii (community I) over the entire toposequence, except for the valley bottom, where the community Cleistopholis patens & Adenia lobata (community II) occurs. In plantation undergrowth we find the community Morinda longiflora & Clerodendrum spp. (community IV).
On both sides of the main road land use is a mixture of shifting cultivation and mainly coffee plantations belonging to the indigenous population, and cocoa and some coffee cropping by immigrants. Approaching the bufferzone, and east of Taï also within the bufferzone, there are only cocoa plantations belonging to immigrants. The quality of the cocoa is probably inferior to that in the south of the survey area; for coffee this is less evident. The land unit

is relatively densely populated, little primary forest remaining outside the protected areas. A large specimen of Kantou guereensis was found on the west side of the main road, about 3 km south of Poulé-oula. This is a sacred tree of the indigenous population. It is a very rare endemic species of which little is known. We found two other specimens, in land units Usg1 and H, respectively. All three trees carried fruits in February.
Most of the former and ongoing research (MAB/Unesco, Agricultural University of Wageningen) has been and is carried out in this land unit.

Unm3 Rolling to hilly, moderately to strongly dissected uplands derived from migmatite; northern rainfall-vegetation zone.

This land unit is more strongly dissected and has steeper slopes than Unm2, probably due to the proximity of the local erosion level: the Cavally river. There are two occurrences of this land unit: south of Daobli, and west of Poulé-oula.
Soils and vegetation are similar to those of land unit Unm2.
South of Daobli almost all land is covered by cocoa, planted by immigrants, and hardly any forest is left. West of Poulé-oula there is a mixture of immigrant and Oubi cultivation, with rice, coffee and cocoa, and some more forest is left. The quality of the cocoa and coffee crops is comparable to that in Unm2.

Upm2 Undulating to rolling, moderately dissected uplands derived from migmatite; intermediate rainfall-vegetation zone.

The landforms and the soils of this land unit are not different from those of Unm2. Land unit Upm2 shows, however, a remarkable difference in vegetation compared with the two northern land units.
The primary forest vegetation on crests and slopes belongs to the community Uapaca spp. & Mendoncia combretoides (community B). Shifting cultivation fallows contain the community Cleistopholis patens & Adenia lobata (community II), except for the crest that is usually characterized by the community Rutidea parviflora & Secamone afzelii (community I). Plantations have community IV.
Land use is equal to that in Unm2. The quality of the cocoa is above average if the entire survey area is considered. Some primary forest is left.

Utm2 Undulating to rolling, moderately dissected uplands derived from migmatite; transitional rainfall-vegetation zone.

Landforms and soils are not different from those of land unit Upm2. Deeply incised drainage gullies on middle and lower slopes ('ravines'), as described for land unit Unm2, occur in Utm2 as well. Slopes vary in steepness. The steepest slopes occur where the crest is covered by remnants of an ironstone crust that may have protected the crest against erosion. Relatively steep slopes are also found near the Cavally river, in a similar position as those occurring in Unm3.
Primary forest, covering the catena from crest to lower slope, is classified as

community 'Vaa' (Gilbertiodendron preussii) & Tarrietia utilis (community C). The secondary forests on the highest crests belong to community I, whereas community II covers crests of average height and slope sites. Secondary forest in valley bottoms and on some of the lower slopes have the community 'Kari' (Hypselodelphys violacea) & Marantochloa leucantha (community III). These sites are usually cultivated with rice in rather short rotations, and the community persists during periods of cultivation. The vegetation indicated as 'Gbaroo' in Oubi (section 7.4) has its largest extension in land unit Utm2, but it is also found in Unm2. Sites with 'Kari' and 'Gbaroo' are preferred for farming, particularly rice. Plantations have community IV undergrowth.
Land use on both sides of the main road is mainly rice and cocoa, cultivated by Oubi or by both Oubi and immigrants. Near the bufferzone there are cocoa plantations by immigrants; only seldom do these plantations penetrate into the bufferzone. The cocoa plantations are sligthly better than average. Some primary forest is left.

Utm3 Rolling to hilly, moderately to strongly dissected uplands derived from migmatite; transitional rainfall-vegetation zone.
Landforms are similar to those of land unit Unm3; both land units border the Cavally alluvial plain and have relatively steep and strongly dissected slopes compared with the other land units developed on migmatite.
The soils belong to the migmatite catena.
No primary forest is left in this land unit. Secondary forest vegetation and plantation undergrowth are the same as in land unit Utm2.
Land use is by Oubi (rice and cocoa) and by immigrants (cocoa). The quality of cocoa plantations is about average.

Utx2 Undulating to rolling, moderately dissected uplands derived from gneiss with schist inclusions; transitional rainfall-vegetation zone.
The landforms of this unit are not much different from those of the land units in the migmatite area.
Most soils belong to either the migmatite or the granite-gneiss catena. Soils of the schist variant also occur but are scattered.
Primary and secondary forest vegetation, and plantation undergrowth are the same as in land unit Utm2.
Cultivation is mainly by immigrant farmers. The apparent quality of cocoa plantations is slightly above average. There are some patches of primary forest.

Utz3 Rolling, moderately to strongly dissected uplands derived from an association of gneiss and granite with schist inclusions; transitional rainfall-vegetation zone.
This land unit that stretches along the Méno westbank, has a characteristic parallel drainage pattern, with relatively wide drainageways.
Most of the soils belong to the migmatite catena, whereas the granite catena covers a lesser surface area. There are minor inclusions of the schist variant.
Primary forest vegetation is the same as in land unit Utm2. There is no

secondary forest as there is no shifting cultivation. Plantation undergrowth belongs to community IV.
Cultivated land consists entirely of cocoa plantations, the quality of which is slightly above average. Some fairly large patches of primary forest are left.

Utc3 Undulating to hilly, moderately dissected uplands derived from a complex of lithological formations; transitional rainfall-vegetation zone.

The major part of this land unit has a rolling relief, but it ranges from undulating to hilly. A remarkable crest occurs near Zriglo; it is long, straight and has steep slopes. The northern part of this land unit is more strongly dissected than the bordering land units.
Like the geology the soil pattern is complex. Soils belong to the migmatite, granite and granite-gneiss catenas, and the schist variant.
Primary and secondary forest vegetation communities and plantation undergrowth are very similar to those of land unit Utm2.
Along the main road a mixed population of Oubi and immigrants cultivate rice and cocoa. The quality of the cocoa plantations is slightly above average. Some patches of primary forest are left.

Usgl Undulating, weakly to moderately dissected uplands derived from granite with minor schist inclusions; southern rainfall-vegetation zone.

Valleyside slopes in land unit Usgl are less steep than in any other upland land unit studied and they are only moderately dissected. Most of the soils belong to the granite catena; soils of this catena are loamy-textured, yellowish-brown, and contain contain quartz fragments and gravel rather than ironstone gravel. A few schist inclusions produce a more reddish, clay-rich soil.
Primary forest in this land unit has been classified as Strychnos ngouniensis & Chytranthus spp (community E). Secondary forest has not been classified as very few of the indigenous Krou population inhabit the area. Plantation undergrowth is community IV.
The land use is mixed Krou (rice, coffee, cocoa) and immigrant (cocoa and coffee) cultivation. The quality of the cocoa plantations is rather poor, but that of coffee is generally good. Coffee is an important crop in this land unit, and in this respect Usgl matches land units Unm2 and Unm3, where also much coffee is grown. Little primary forest is left. A very large specimen of the sacred tree Kantou guereensis was found on an unusually high crest.

Usy2 Undulating to rolling, moderately dissected uplands derived from an association of gneiss and granite; southern rainfall-vegetation zone.

There is little comformity in the interpretation of the lithology of the area covered by this land unit. Bos (1964) classified it as an alternation of gneisses and micaschist-quartzites, Papon (1973) as tuffs and sandstones.
Whatever the lithological nature and variety of the underlying rocks, not much

is reflected in the soils. Most soils can be assigned to the migmatite catena, although they differ slightly from those of the five land units developed over migmatite, by having more fragments of mica. Close to the adjoining land unit H the soils are different; they resemble those of the granite catena.
The primary forest vegetation community E covers all granite sites, and most of those developed over gneiss. Occasionally the community Spiropetalum heterophyllum & 'Gnahin' (Ancistrophyllum laeve) (community F) occurs, and this vegetation unit is characteristic of the wettest upland sites of the study area, where growing conditions are more favourable than on most upland sites. There is hardly any secondary forest. Plantation undergrowth is characterized by community IV, and sometimes by community V. It remains unclear whether community V is associated with the primary forest vegetation community F.
The land is used by immigrants for cocoa and coffee plantations. The quality of the cocoa farms is generally somewhat below average, and it is poor on soils derived from granite. On the latter, however, coffee is often grown, and these plantations are in a good condition. Some primary forest is left.

Usz2 Undulating to rolling, moderately dissected uplands derived from an association of gneiss and granite with inclusions of schist; southern rainfall-vegetation zone.
This land unit shows a distinct alternation of soils derived from granitic and from gneissic parent materials. The soils developed on gneiss contain a moderate amount of ironstone gravel, they are reddish-coloured and clayey, whereas those developed on granite contain quartz fragments, are yellowish-coloured and loamy. The soils have been assigned to the migmatite and granite catenas, and to the schist variant (migmatite is usually similar to gneiss in this area).
Primary forest on granite is community E, on gneiss it is community F; the latter indicates relatively wetter soil conditions. Community F occurs also on schist. There is no secondary forest. Plantation undergrowth is either community IV or community V.
There are cocoa plantations belonging to immigrants. The quality of these plantations is markedly better on the migmatite catena than on the granite catena. East of the Méno river a large area of primary forest is left, but there is much felling for cocoa at present. Since the bridge over the Méno was rebuilt in January 1989, logging has become prevalent.

Usc3 Rolling, moderately to strongly dissected uplands derived from a complex of lithological formations; southern rainfall-vegetation zone.
Within the study area land unit Usc3 covers a relatively small surface in the extreme south. The lithology and the soil pattern are varied and apparently haphazard. Soils belong to the migmatite, granite and granite-gneiss catenas and the schist variant. All soils are very micaceous. Some roads occur in this area, and because of the strong relief there are several road cuts in which saprolite fragments, weathering into a kaolinitic clay, can be clearly recognised.

All primary vegetation belongs to community F, regardless of the underlying geology. There is no secondary forest in this land unit. Plantation undergrowth is usually community V.
Only immigrants cultivating cocoa inhabit the area. The quality of the cocoa plantations is somewhat above average. Little primary forest is left.

Other land units

UI1 Association of undulating to rolling, moderately dissected uplands, and small, steep-sided inselbergs
In this land unit some of the highest crests and upper slopes have the characteristics of small domed inselbergs (bornhardts). The inselbergs are asymmetrical with steep and less steep slopes. The crests have a convex profile and a smooth, rock-paved surface.
Soils on inselberg crests and upper slopes belong to the inselberg variant. The soils on middle and lower slopes and in valley bottoms, on the other hand, are similar to those of the non-inselberg uplands in this land unit; they all belong to the migmatite catena, and are similar to those of the adjoining land unit Unm2.
The primary forest on the inselberg crests and upper slopes is characterised by the community Citropsis articulata & Stereospermum acuminatissimum (community G), while the forest on the other upland sites belongs to the community Hunteria simii & Chidlowia sanguinea (community A). The forest has semi-deciduous characteristics that are more pronounced in this land unit than anywhere else in the study area.
Land unit UI1 is entirely within the National Park, and there is no agriculture. Traces of the last logging activities, around 1976, can still be found.
On the flat-topped inselberg crests droppings of large animals - elephant, buffalo and panther - are often found. In fact these are the only sites in our study area where traces of elephants are nowadays found.

UI2 Association of undulating to rolling, moderately dissected uplands, and small, steep-sided inselbergs
This land unit is similar to land unit UI1; it consists of uplands in which some of the highest crests and upper slopes have the characteristics of inselbergs. However, the relief is lower, and inselberg crests are not as frequent. Inselbergs are either bornhardts or tors (Chapter 6).
Soils of inselberg crests and upper slopes belong to the inselberg variant, otherwise most soils are of the migmatite catena. There are some inclusions of schist, with soils of the schist variant.
The primary forest on the inselberg crests and upper slopes is characterised by the community Hypselodelphys poggeana & Pandanus candelabrum (community H). In that part of the land unit that is situated south-east of Tiéoulé-oula, the primary forest on the non-inselberg upland sites is characterised by community 'Ferreclao' (Millettia rhodantha) & Parinari aubrevillei (community D). In the other area covered by UI2, south-east of Siéblo-oula,

the primary vegetation of non-inselberg sites belongs to the community Strychnos ngouniensis & Chytranthus spp. (community E). Community D is of a slightly drier type than community E.
It should be noted that the primary forest vegetation in the adjoining land units (Utm2 and Utc3) is characterised by community 'Vaa' (Gilbertiodendron preussii) & Tarrietia utilis (community C), that indicates relatively drier sites. So, Ul1 has wetter vegetation types than the bordering land unit.
In contrast, the non-inselberg sites in land unit Ul1 have a relatively drier type of vegetation than the neighbouring land unit Unm2 (see above).
Secondary forest is predominantly the community 'Kari' (Hypselodelphys violacea) & Marantochloa leucantha (community III), but some 'Gbaroo' vegetation is often present. On upper slope and crest community II occurs. Plantation undergrowth is characterised by community IV in the northern part of the land unit, and by community V in the southern part.
Oubi cultivate the land bordering the main road in the northern part of the land unit; more to the east immigrants have established cocoa plantations. The southern part is entirely occupied by Oubi. The quality of the cocoa plantations is fairly good. Some primary forest remains, particularly in the northern part.

H Steep-sided hill

In the south-western part of the study area, bordering the Cavally river, two prominent hill masses rise well above the general level of the uplands.
The soils developed from the basic rocks of these hills belong to the hill catena.
The primary forest has a typical combination of species that belong to community Psilanthus mannii & Hunteria spp. (community L). There is no shifting cultivation. Plantation undergrowth belongs mainly to community V.
On some of the steep slopes immigrants have planted cocoa, covering over half of the slope length. The oldest plantations are found on the lower slope sites and they are generally in a better condition than the younger cocoa found uphill. Some attempts have been made to cultivate crops on the top of the hills, but this has not had much effect on the composition of the primary forest vegetation.
A large specimen of the sacred tree Kantou guereensis is found on the top of one of the hills.

AU Association of alluvial landscape and low uplands.

A pattern of low uplands, lower slope members of upland catenas and river floodplains forms a transitional zone between the uplands and the Cavally alluvial floodplain. This flat to undulating landscape occurs between Tiéoulé-oula and Nigré in two separate areas: one close to the falls of Sélédio (south-west of Tiéoulé-oula), the other one between Sakré and Nigré. The latter includes the lower reaches of the Audrénisrou and Gô rivers.
Most of the soils belong to the alluvial complex. The upland soils form part of the migmatite and granite-gneiss catenas.

No primary forest is left and most of the land unit is covered by secondary forest community III. There is, however, a difference between the above mentioned two areas: in the northern one 'Ferreclao' and the rattan Ancistrophyllum secondiflorum are found, whereas both are absent in the southern area. The small palm Calamus deërratus occurs only in the southern area. Plantation undergrowth in the rare cocoa plantations is community IV.
Only Oubi occupy the land. Rice is cultivated in large fields and in short rotations. This land unit is the main rice-producing region in our study area. Rice is cultivated for own consumption and for the regional market. On some of the higher-lying sites cocoa is planted. The main road, where it crosses land unit AU, is often in bad shape during the rainy season.

A1 Alluvial landscape of tributaries to the Cavally river

The middle and lower reaches of the Nsé, the Audrénisrou and the Méno rivers have built alluvial plains, with well-expressed natural levees, and a complex soil pattern behind the levee. Rapids and rock outcrops are a common feature in the Méno river, they occur less frequently in the other rivers. The alluvial plains are subject to flooding.
The soils belong to the alluvial complex.
Part of the primary forest along the rivers is of a three-layered type, with a distinct understorey - an unusual feature in a tropical rain forest. This forest type, community 'Sahè' & Thecacoris stenopetala (community J), extends upstream along the rivers in narrow colluvio-alluvial plains, but it does not extend into the valley bottoms of the upland catenas. No secondary forest is present. Plantation undergrowth is classified as community IV.
There is very little rice cultivation in this land unit. This may be due to difficult clearing of the forest rather than to adverse soil and hydrological conditions since the dominant tree, Plagiosyphon emarginatus, has very hard wood. There are indications that forest cutting on the alluvial plains does not occur as long as there is primary forest left in the bordering uplands.

A2 Alluvial landscape of the Cavally river

Land unit A2 is a floodplain of varying width along the eastbank of the Cavally river. The natural levees are often well-developed, whereas the land behind the levees has an irregular mesorelief and a complex soil pattern.
The soils belong to the alluvial complex like those of land unit A1, but they have developed in a different parent material.
The primary forest is a three-layered vegetation similar to that in land unit A1, but it belongs to a different community: 'Sahè' & Pancovia bijuga (community K). Secondary forest vegetation resembles community 'Kari' (community III), but is enriched by the shrub Hibiscus surattensis. Plantation undergrowth is community IV.
Shifting cultivation is common, despite the occurrence of the tree Plagiosyphon emarginatus. There are also cocoa plantations belonging to indigenous and immigrant farmers. As most of the plantations are young, and as we observed only a few, not much can be said with regard to their quality. A fair amount

of primary forest remains, but felling is increasing rapidly.

9.3 Quality of cocoa plantations for separate land units or groups of land units

In section 9.5 - with Fig. 14 and Table 22 - the quality of cocoa plantations, and the various factors that have an impact on this quality, have been discussed. The general picture given in that section, will now be focussed on separate land units or groups of land units.
Fig. 16 is based on the same 1449 observations on cocoa plots that were discussed previously. Land units with very little cocoa plantations have been disregarded. We have differentiated between seven cultivation zones:

unit Upm2; intermediate rainfall-vegetation zone
100 observations. One third of the owners were Baoulé, the others were Malinese; both groups had older and younger farms. The cocoa was well-weeded, the percentage of poor cocoa was remarkably low. Most plantations were of average quality.

unit Ul2; transitional rainfall-vegetation zone
101 observations. Most cocoa was farmed by Mossi and Baoulé, the latter owning the relatively older plantations. About 10% of the sample were Oubi holdings with rather old plantations. Farms were well-managed and there was a surprisingly large number of good plantations.

units Utm2, Utm3, Utx2, Utz3 and Utc3; transitional rainfall-vegetation zone
603 observations. Although many fields were weed-infested, the general crop condition was above the average.

unit Usy2; southern rainfall-vegetation zone
432 observations. There were a few Krou plantations, but most of the cocoa was grown by Mossi. One third of the farms suffered from weeds. The general crop condition was slightly below average.

unit Usg1; southern rainfall-vegetation zone
79 observations. Almost all plantations were owned by Mossi. Weed infestation was low. A large number of plantations was in a poor condition.

units Usz2 and Usc3; southern rainfall-vegetation zone
112 observations. Baoulé, Mossi and Malinese accounted for about equal numbers. Weed infestation was low. The general crop condition was above average.

unit H; southern rainfall-vegetation zone

22 observations. All cocoa plantations were by Mossi. Most of the older plantations, that are situated on the footslopes, were of good quality; more uphill the plantations were younger and of lesser quality.

It is remarkable that the highest percentages of good cocoa plantations are in the two land units with steeper slopes and rock outcrops: UI2 and H. Rainfall zones do not seem to influence cocoa quality, except probably for the northern zone.

10 DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

10.1 Introduction

In this study we have presented an inventory of the natural resources of the Taï area and some information on land use and the history of land use. Our tools were: recent SPOT satellite imagery, aerial photographs of 1956, thematic maps, literature on the region, the experience of the survey team from earlier studies in the Taï area, and field work. The Land Unit approach that we followed has contributed to a better understanding of the relationships between abiotioc and biotic aspects of the land.

The principal results of the survey are given below, in a section on conclusions and discussion, under three headings: those related to the procedures and methodology that we followed, those related to the natural resources, and those related to land use. The final section, on recommendations and on relations with other research, is structured in a similar manner.

10.2 Discussion and conclusions

10.2.1 On methodology

SPOT remote sensing imagery was used since no recent aerial photographs could be ontained. Unfortunately, images of only one revolution were available, so that steroscopic study was not possible. This ruled out the possibility of identifying landforms on the satellite image, except for extreme landforms such as inselberg crests, steepsided hills and river alluvium. But it is unlikely that the low relief of the uplands would have shown up in stereoscopic image. On the other hand, the false-colour image produced, on a scale of 1:50,000, was very useful in identifying some vegetation types and patterns, and some - not all - forms of land use. Interpretation of the latter was difficult because of the small size of the fields, whereby weed-infested tree crop plantations with an open canopy looked very much like young secondary forest on the satellite image. But even in those cases where land use was distinct on the SPOT image, it could not be used for defining land units as, with some exceptions, land use had little relation to land units. In areas of primary forest, where the relation between vegetation and land unit is more distinct, the satellite image was blurred by haze. Moreover, in processing the SPOT tape emphasis was given to maximum contrast in the cultivated zone, at the expense of the forested zone.

SPOT enables differentiation between primary forest, secondary forest and cultivated fields; it does not differentiate between untouched and logged forest. However, the smallest cultivated field can be spotted in a forest, and this makes SPOT an excellent tool in monitoring the park area with an eye on possible offenders. SPOT and other remote sensing imagery could be equally useful in monitoring future changes in land use. We found that fields cultivated by the indigenous population could be clearly distinguished from those used by immigrants, and that areas with short-circle (less than 6 years fallow) forms of shifting cultivation were distinct from those with a longer period of rotation (the period of regrowth is normally around 20 years). Degraded land, covered by thickets, could also be detected. No distinction could be made between cocoa and coffee plantations. For orientation in the field the SPOT images were of little use.

see separate sheet attached

Land forms could be identified on aerial photographs of 1956, and this was a great asset for the delimitation of land units. The photographs were also of great value for orientation in the field, at least in those areas relatively little affected by changes in land use. Without the help of both aerial photographs and SPOT false-colour imagery the Land Unit survey would have been impossible.

10.2.2 On the inventory of natural resources and the Land Unit map

The variation in geology, soils and vegetation increases from North to South. In the North there are but a few land units, each covering a large area, in the South the average land unit covers a much smaller surface area. Furthermore, the variation within each land unit is greatest in the south, particularly in soils.

With the exception of a few land units that are characterised by a distinct landform and a specific lithology (e.g. H), in most of the survey area differences in lithology are small (gneiss, granitic gneiss, migmatite, schist) and they are not accompanied by characteristic landforms. In the few cases where landform and lithology stand out clearly from the surrounding uplands (e.g. schist and granite inclusions in migmatite rock) their surface area may be so small that they are not easily detected in the field, and do not show up on SPOT or on aerial photographs. The dense cover of vegetation and the lack of outcrops adds to this. Soils are only distinct indicators of geology where they are residual, i.e. on crest sites, or in deeper horizons that may show the saprolite. Lithological differences proper are often clearer than soil differences, and this even applies to residual soils. Thus, the relation land unit-lithology is more pronounced than the relation lithology-soils.

Soil were characterised on the level of land units by assigning them to a particular soil catena, or - in complex land units - to more than one catena, including catena variants. In all upland land units the catena concept was adhered to in soil cartography.

In a number of cases differences in vegetation rather than differences in landform/geology/soils defined land units. This applies particularly to the migmatite uplands in the northern, intermediate and transitional rainfall/ vegetation zones. The mature forest vegetation changes characteristically with changes in water availability. This is shown in a gradual transition in species composition along a slope, and by the fact that species groups occurring in valley bottoms in the northern part are found on crests and upper slopes in the southern part where rainfall is higher. Because of this distinct trend in vegetation the study area was divided into four rainfall/vegetation zones, in accordance with forest communities. These form the second level of generalisation in the land unit legend. The ecological importance of this differentiation is confirmed by the cultivation practices of local farmers. It is also consistent with the classification of forests by Oubi farmers.

Soil material has an impact on water availability. Differences in soils (and geology) therefore have an effect on vegetation comparable with that of rainfall: rainfall and edaphic water are to some extent interchangeable. The boundaries of some land units were thus defined on the basis of a combination of lithology, soils and vegetation, e.g. UI1, UI2, H, A1 and A2. These land units are distinct from upland land units in lithology, relief, soil, structure and floristic composition of the vegetation, and land use.

Primary forest changes according to differences in rainfall and/or edaphic water, whereas secondary forests change first of all with position in the catena. The three secondary forest communities that we distinguished occur in all rainfall/vegetation zones. However, there is also a - subordinate - relation with position in the catena. E.g. the secondary forest community that occupies crest, upper and middle slope in the northern zone, is found in the southern zone on crests only.

In some cases land units tallied with classification of land by local farmers. This applies to the land units with inselberg crests and to alluvial plains, and also to the boundary of the transitional and the southern rainfall/vegetation zones.
Land unit UI2, in which some of the crest and upper slope sites have inselberg characteristics, occurs in the transitional rainfall-vegetation zone, and has, over its entire surface area, a vegetation that is similar to that of land units in the southern zone. The environment in these land units may produce edaphic water that substitutes for the lower precipitation as compared to the southern zone.

10.2.3 On the Land Use map

By comparison of aerial photographs of 1956 and SPOT imagery of 1988, it became clear to what extent land use has changed over the last thirty years.

Major changes resulted from the opening up of the land by timber extraction roads, the establishment of the National Park and the bufferzone, and massive cocoa planting by immigrant farmers.

There is, surprisingly, little similarity between Land Unit map and Land Use map. How can this be explained? Prior to the arrival of immigrants only a very extensive system of shifting cultivation was practiced: one year of rice was followed by a period of about 20 years of regrowth. The rice thrived on the nutrients contained in the ash of the burned forest rather than on the nutrients of the mineral soil, and so the nature of the soil was of relatively little importance.
Immigration caused a shortage of land, and compelled indigenous farmers to shorten the period of regrowth in shifting cultivation. Moreover, there was an increasing tendency to grow tree crops, both among indigenous farmers and immigrants. With higher demands on soil and water, the intrinsic differences in soil fertility and waterholding capacity between soils are now beginning to show in health condition of the crop (notably in cocoa) and in agricultural production. Differences among soils are also becoming more apparent as there is now a greater variety in crops as well as in cultivation methods. This trend is so recent that the farmers have not yet gained the experience that is required for a proper choice of crop and of cultivation method for a specific soil. At this stage a Land Unit map can contribute to a better understanding of soil-crop-water relationships. In a few cases there is a close correlation between Land Unit and use of the land. Land unit AU, for example, showed a more intensive cultivation in 1956 than other areas.

Guéré, Oubi and Krou presently occupy about the same area of land as in 1956. Most of the land is located along both sides of the main road but at present there is also much immigrant farming along the road. An exception is formed by some flat plains, subject to flooding, where only rice is cultivated by indigenous farmers.

In 1956 shifting cultivation was mainly practiced on lower slopes and parts of the valley bottoms, but in recent times rice cultivation has moved uphill. This change is the result of two factors, both related to the growing popularity of tree crops. Firstly, tree crops do not thrive well on flooded land, and, since a rice crop precedes the tree crop, fields had to be found higher up the slope. Secondly, tree crops need 'fresh soil'and that was, in shifting cultivation areas, only available on middle slope and higher positions.

Under pressure of limited availability of land, farmers in shifting cultivation tend to reduce the length of the fallow period rather than to increase the period of cropping. Fallow periods around 20 years are considered best and in most areas they are still over 10 years. On the other hand, flat plains, that are subject to flooding, are more intensely cultivated, with fallow periods not exceeding 6 years.

Immigrants generally received remote-lying land. The majority of them settled along timber extraction roads in primary forest, felling the forest and establishing cocoa plantations.

Most cocoa plantations are less than ten years old. Cocoa is still expanding although the health status of the plantations is often poor, the production per tree low, and the market prices low. It suffers from pests and diseases, and, in addition, the low fertility of the soil in combination with a distinct dry season, seems to have a negative effect on growth and on fruit bearing. In regions that become 'saturated' with cocoa, land of inferior quality is increasingly being used.

Cocoa plantations north of Taï village are generally poorer than to the south. A survey of the cocoa fields south of Poulé-oula showed that 19% must be considered a failure, whereas 36% has now, and is expected to have in future, a satisfactory production. Some 45% of the plantations is in an intermediate position. In part of these latter fields some improvement can be expected from better management. However, most farmers tend to compensate for poor yields by extending their cocoa farms rather than by improving upon their management.

Quality of the cocoa is apparently unrelated to land unit, with the exception of land units UI2 and H where plantations are above average, and land unit Usg1, where a large number of plantations is in a poor condition. Similarly, there is a lack of any pronounced relationship between quality of cocoa and the position of the field in the toposequence. If farmers have a free choice they start cultivation on the slopes, and only when land becomes scarce do they turn to crest and valley bottom sites. In our survey we found that most cocoa in valley bottoms was of poor quality.

Large parts of the bufferzone east of Taï have been brought under cocoa. In the southern part, however, the bufferzone is generally respected, probably because a well-marked former timber extraction road almost coincides with its outer boundary.

Strict maintenance of the bufferzone, however, will result in a more intensified cultivation of land in the agricultural zone. This land scarcity may well stimulate the indigenous farmers to more vigorously protect the land they claim. The immigrants are in a relatively weaker position, especially the Burkinabé that arrived late and only gained a few hectares of land per household.

With falling market prices and the abolition of a Government guarantee price the area of cocoa is not likely to expand much further. However, there will certainly be some expanse of cocoa growing in areas with primary forest, and many farmers are inclined to compensate for a cropping failure by trying to grow cocoa somewhere else. On the other hand, coffee may become more popular since, in general, the prospects for coffee growing are better than those for cocoa.

10.3 Recommendations; relation with other research

Land use in the areas surrounding a natural reserve is a critical factor in safeguarding the protected land. In order to protect the last remnants of tropical rain forest in West Africa, and notably the Taï National Park, knowledge is required on land use policies and relevant land utilization types for both the bufferzone and the agricultural land beyond it. Such knowledge is more important for the preservation of the reserve than a profound knowledge of the ecosystem in the undisturbed interior of the reserve.
Prevention of illegal settlement in the reserved area - by clearly demarcating the bufferzone and by strong judicial action against offenders - is not enough. Restrictive measures are bound to fail if not accompanied by proper land use in both the agricultural zone and the bufferzone. For the bufferzone a type of land use is recommended that combines forest protection with use of the forest by the local farmers. If the bufferzone is part of the land that can be used by the local communities as forest, use and management of it may create a positive attitude towards the idea of protecting the interior forest area. At the same time the bufferzone may create revenues for the local farmers.

Farming systems in the agricultural zone are often geared towards short-term profit (cocoa), whereas ecological site characteristics are not taken sufficiently into account. In other words, farming systems should be more in accordance with land units. There are some exceptions: land unit AU has superior rice production with rather short fallow periods and this cropping system should, if possible, be extended and intensified. Comparable fallows on flat, moist terrain could be developed in a similar way. Moisture is available during most of the year, and this allows for flexibility in planting and harvest time. The region has possibilities for growing wetland rice in some of the wider valley bottoms and in alluvial plains. This potential has hardly been developed and deserves further study.
Land units with superior cocoa plantations, notably UI2, should be more strongly directed towards cocoa, whereas cocoa planting should be discouraged in land units where most of it is of poor quality, notably in Usg1.
More detailed soil and vegetation surveys are required for those land units that lack uniformity in lithology and soils, but that have, at the same time, valuable soil resources. An evaluation should also be made on the soil characteristics of sites with an abundance of 'Ferreclao'.

Similar Land Unit surveys as ours should be considered for other areas surrounding the National Park, for both bufferzone and agricultural zone. Such a survey is especially required in the southern and eastern parts since there is much forest devastation by illegal intruders.

We have given a first, empirical, classification on the suitability of land units for cocoa in sections 8.5 and 9.3. A more comprehensive physical land evaluation over the entire survey area, and for several land utilisation types, still to be defined, is recommended. Relevant land utilisation types would include the cultivation of wetland rice, of coffee and cocoa, of yams and various horticultural crops, as well as different forms of agro-forestry. The results of ongoing and future agricultural research will supply the data necessary for such a land evaluation. The Land Unit map allows extrapolation of research from experimental fields to other areas with the same site characteristics, i.e. to areas assigned to the same land unit.

The following research activities are interesting in this respect.
Earlier agronomic research by Budelman (~~1988a, b, c~~), weed studies by De Rouw (De Rouw and Van Oers, 1988) and forest studies by Vooren (~~1985; 1986; 1987~~).
Present research by the Agricultural University of Wageningen, the Netherlands includes studies on nutrient cycling in upland rice and maize cultivation (Noij et al. 1987; Van Reuler and Janssen, ~~1988a; 1988b~~; 1989), on cocoa, and in areas with intensified food cropping.
A research project on estimating gross inputs and outputs in undisturbed forest, jointly carried out by the Tropenbos Foundation and the Agricultural University, has started recently.
Land utilization in the bufferzone could be a combination of forestry and the gathering of other forest products. Studies on land use and management alternatives for the bufferzone are proposed by the Agricultural University of Wageningen in collabaoration with the 'Direction et Contrôle des Grands Travaux' (DCGTx) of Côte d'Ivoire, the Tropenbos Foundation and the German Agency for Technical Cooperation (GTZ). Bufferzone studies are geared towards rehabilitation of forest in those parts of the zone where former agricultural or timber extraction activities have destroyed the original vegetation, and towards appropriate land use in largely intact parts. The latter might include animal husbandry, collection of forest products, and selective logging.

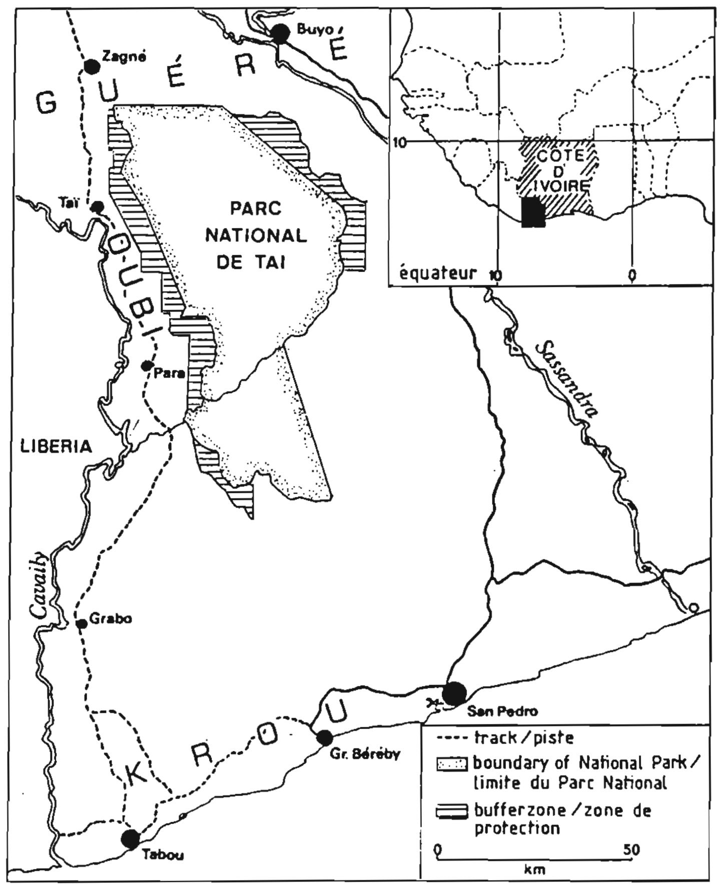


Fig. 1: Location map of Taï National Park and surroundings

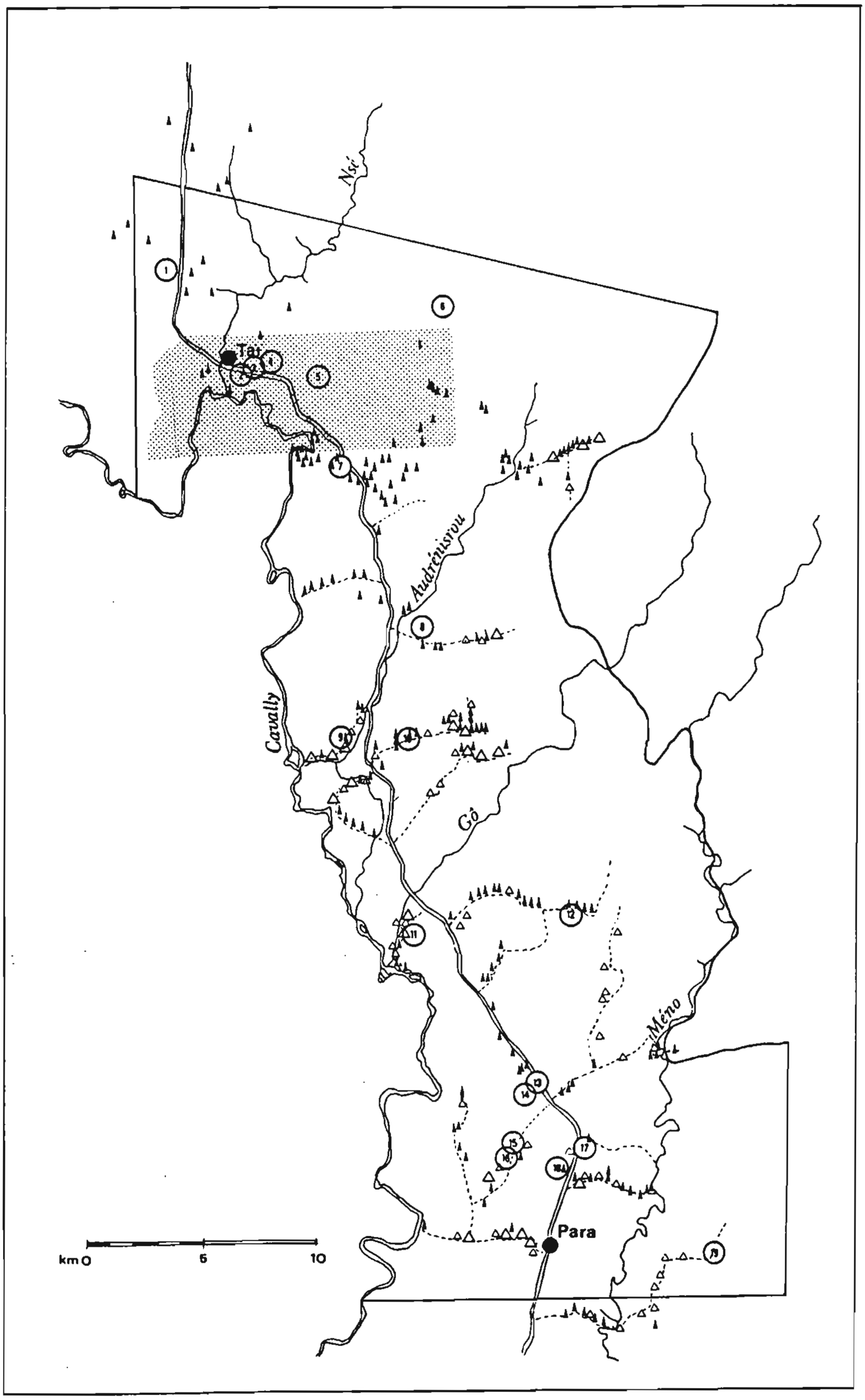


Fig. 2: Observation plots of the Land Unit Survey

- soil and site observation with complete floristic inventory
- soil and site observation with incomplete floristic inventory
- toposequence. with incomplete floristic inventory
- soil profile pit
- 1:50.000 soil survey area (Vellema, in preparation)

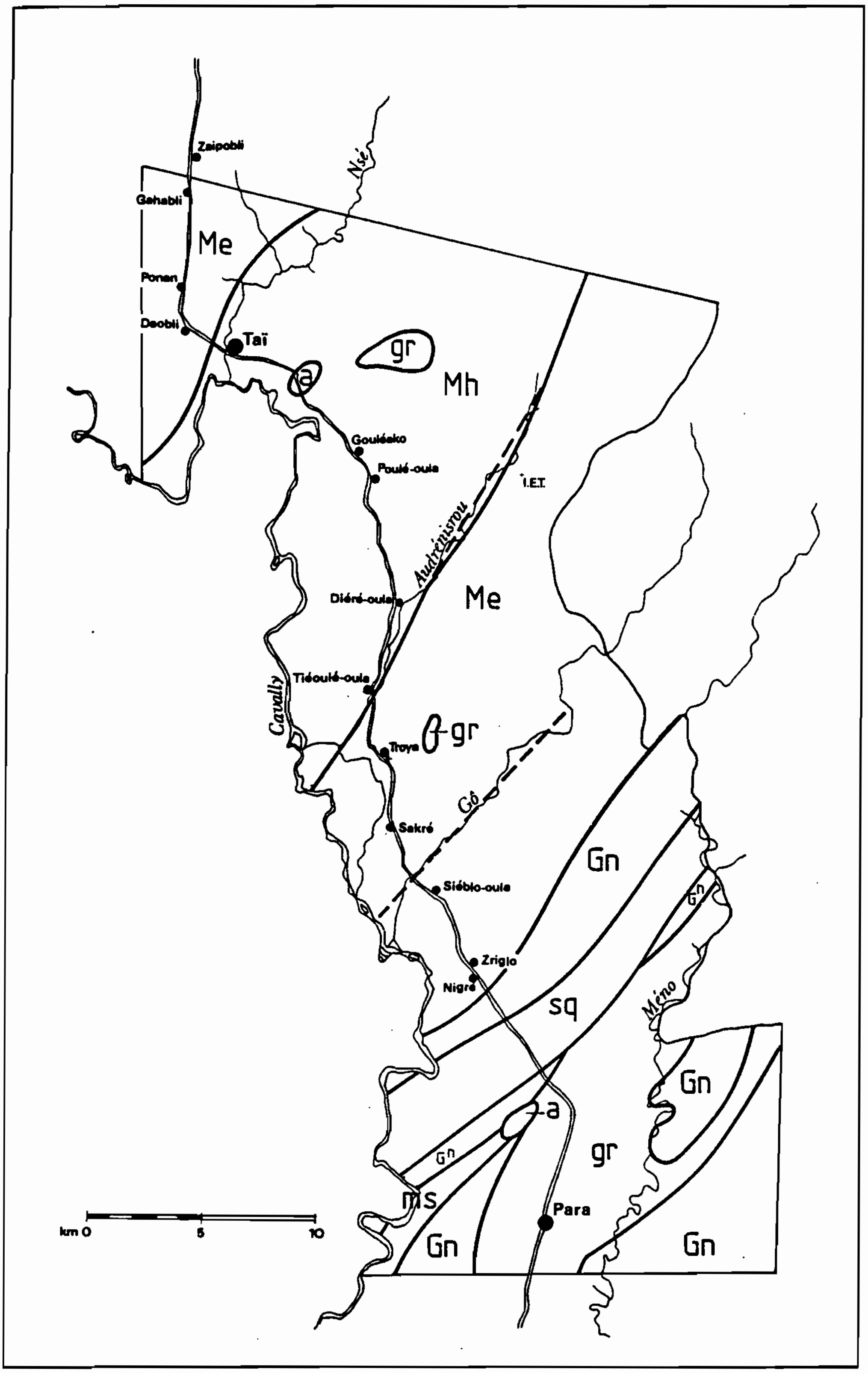


Fig. 3: Geological map (after Bos, 1964, simplified)

Eburneen
ms - mica schistes
sq - schistes-quartzites
gr - granites
a - amphibolite

dezelfde tekst voor Engelse en Franse versie

Liberien
Gn - gneiss
Mh - migmatites heterogenes
Me - migmatites homogenes

--- fault (in Engelse versie) / faille (in Franse versie)

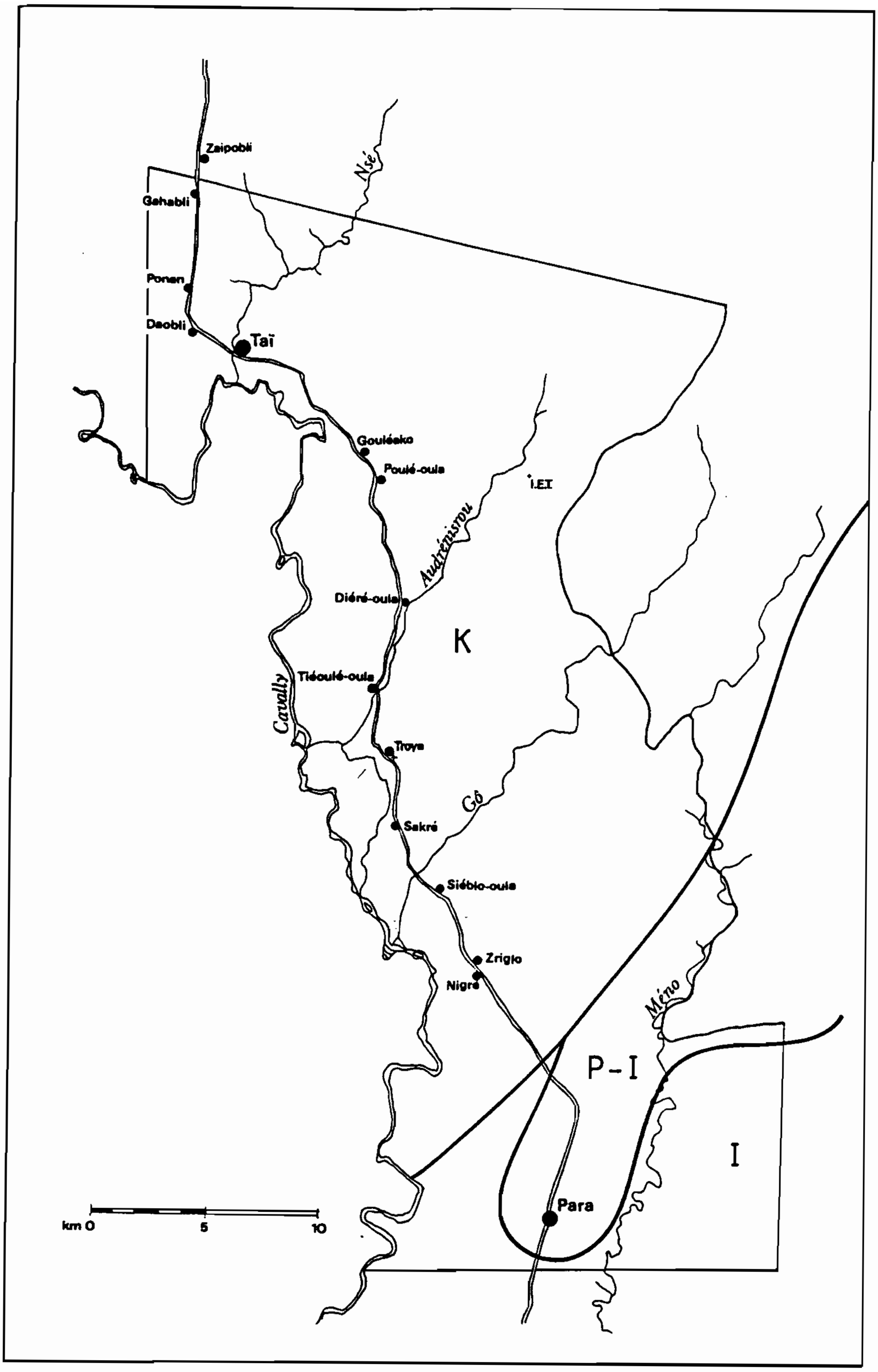


Fig. 4: Soil associations in the Taï area according to DRC (1967)
K: Daobli-Baole-Kolea association | dezelfde tekst
I: Saoua-Bedoule-Daole association | voor Engelse en
P: Naurou-Niagui-Kroon association | Franse versie
(see also Appendix 6)(Eng.) of (voir aussi Annexe 6)(Fr.)

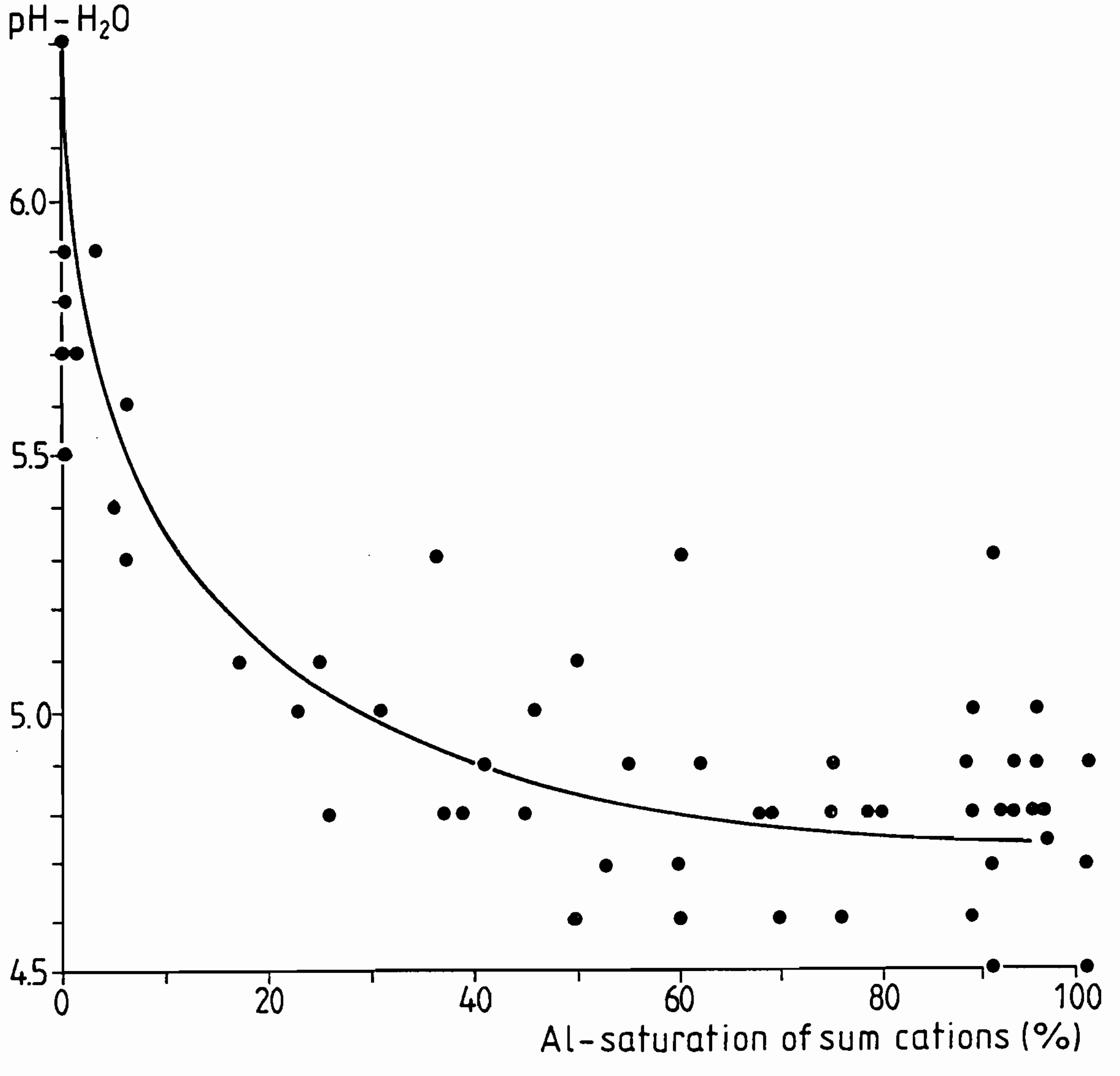


Fig. 6: pH - aluminium saturation relationships in 11 soils in the central and southern part of the survey area

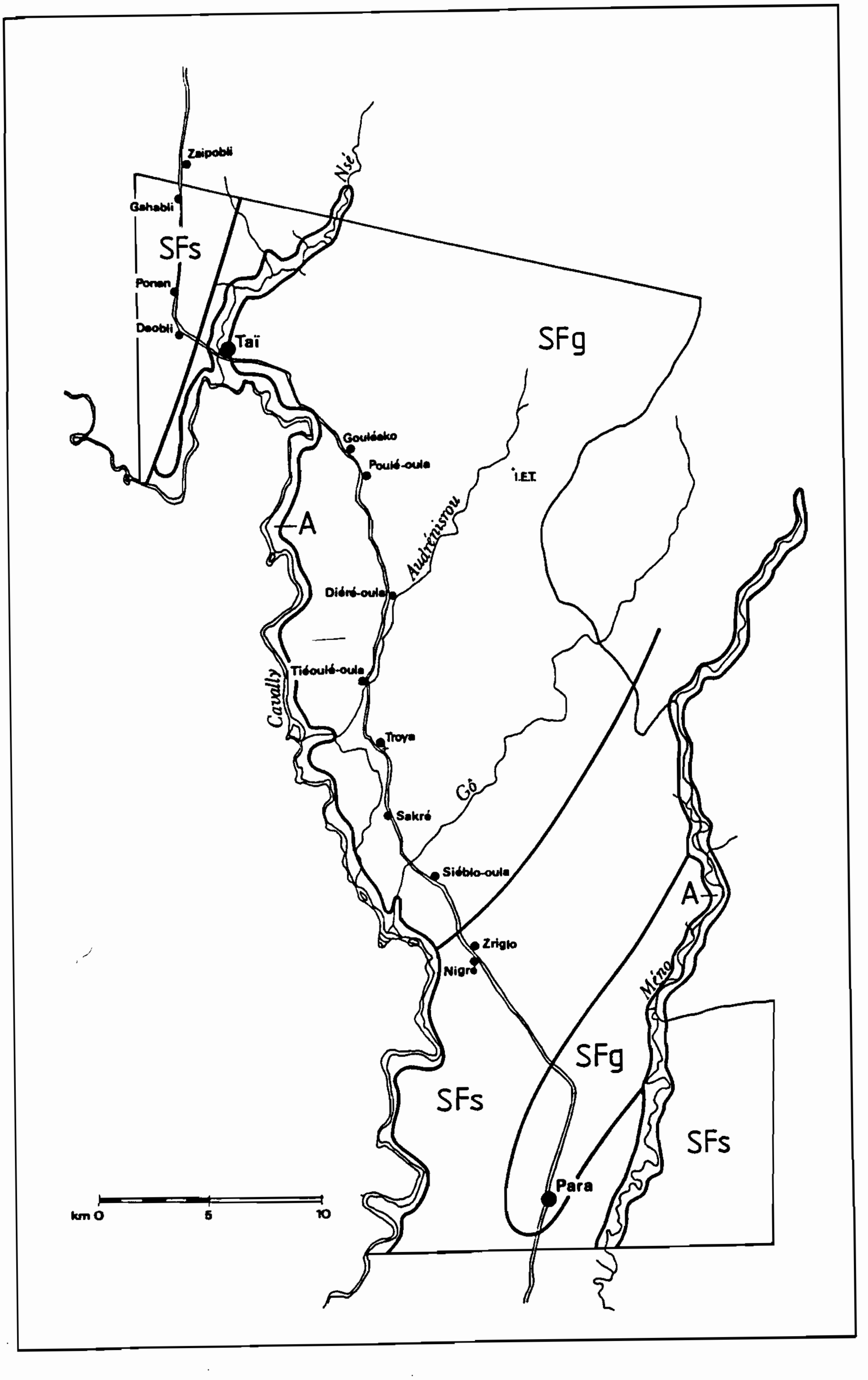


Fig. 5: Soil units in the Taï area according to Parraux (1971)
SFg: Sols ferrallitiques remaniés modaux issus de granites
SFs: Sols ferrallitiques remaniés modaux issus de schistes
A: Sols peu évolués / Sols hydromorphes minéraux

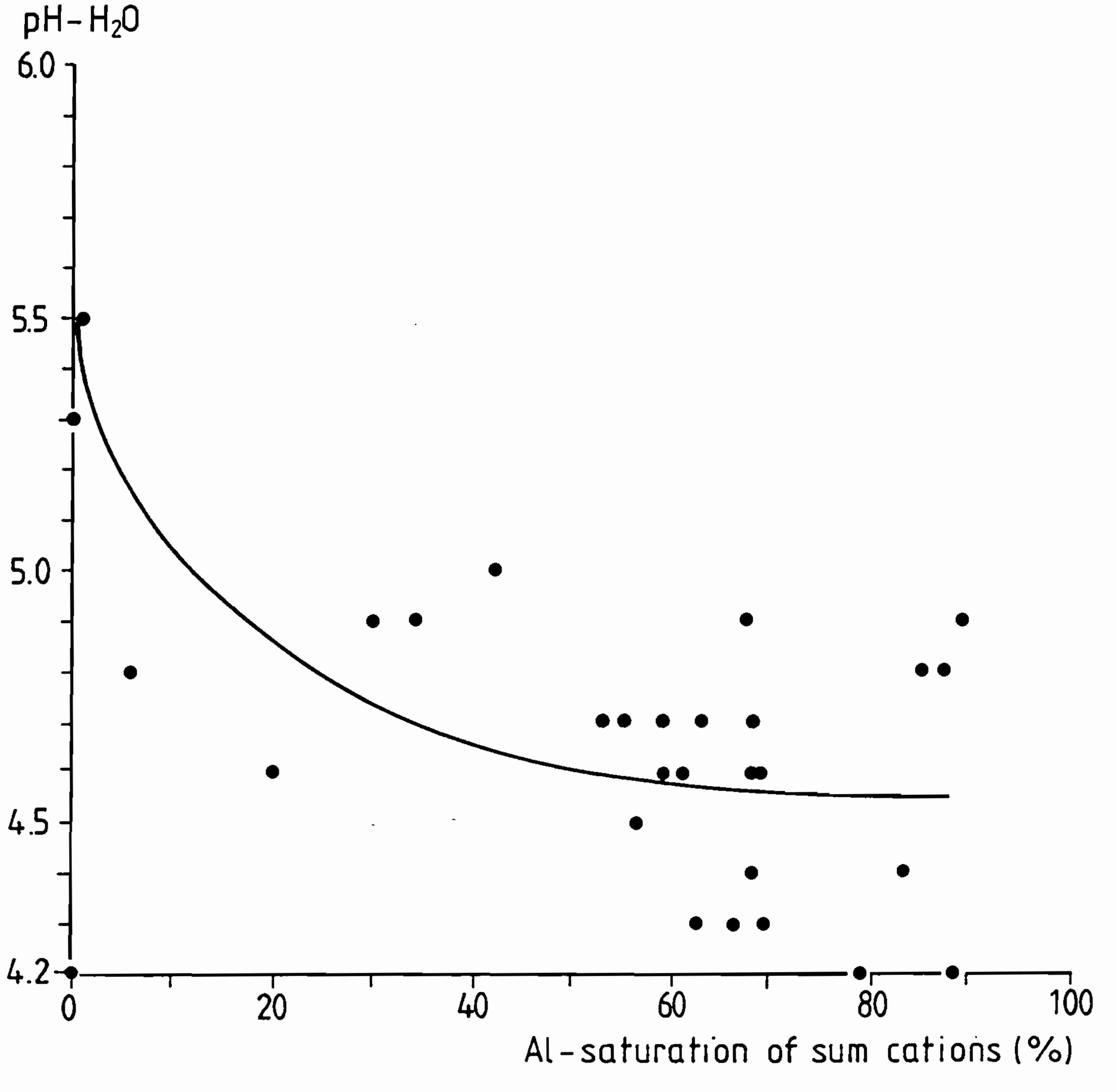


Fig. 7: pH - aluminium saturation relationships in 6 profiles in the surroundings of Taï

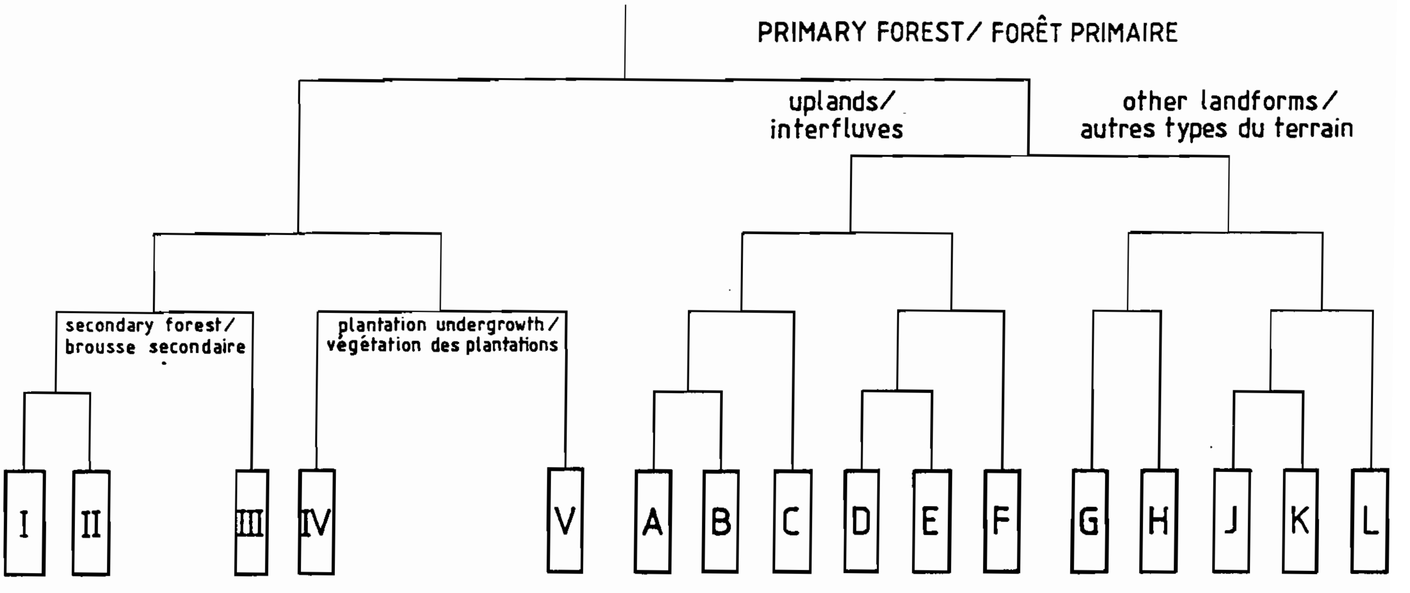


Fig. 8: Dendrogram representing hierarchy of divisions calculated by TWINSPAN, resulting in 16 communities

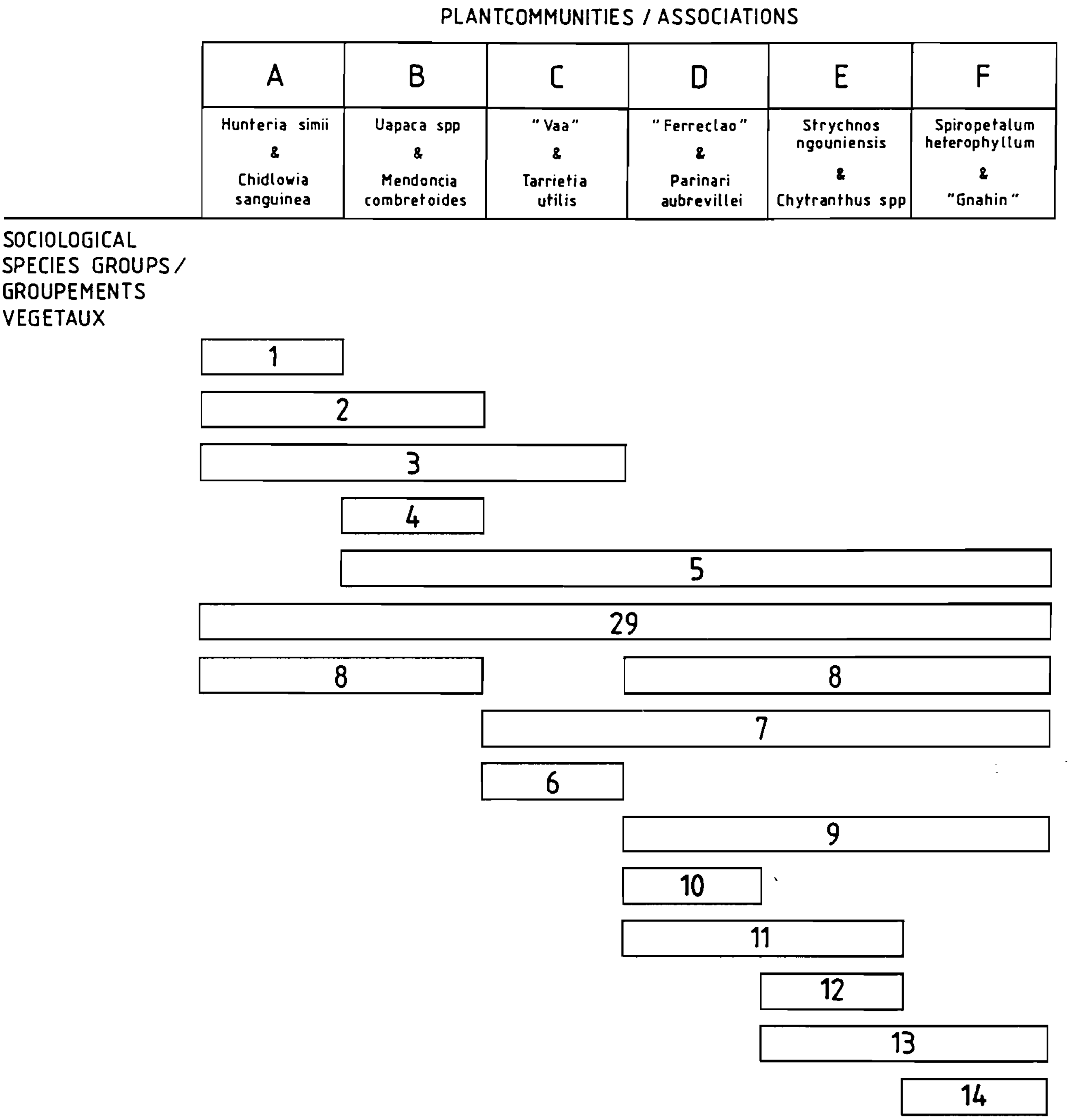


Fig. 9: Bar diagram representing distribution of sociological groups over 6 primary upland forest communities

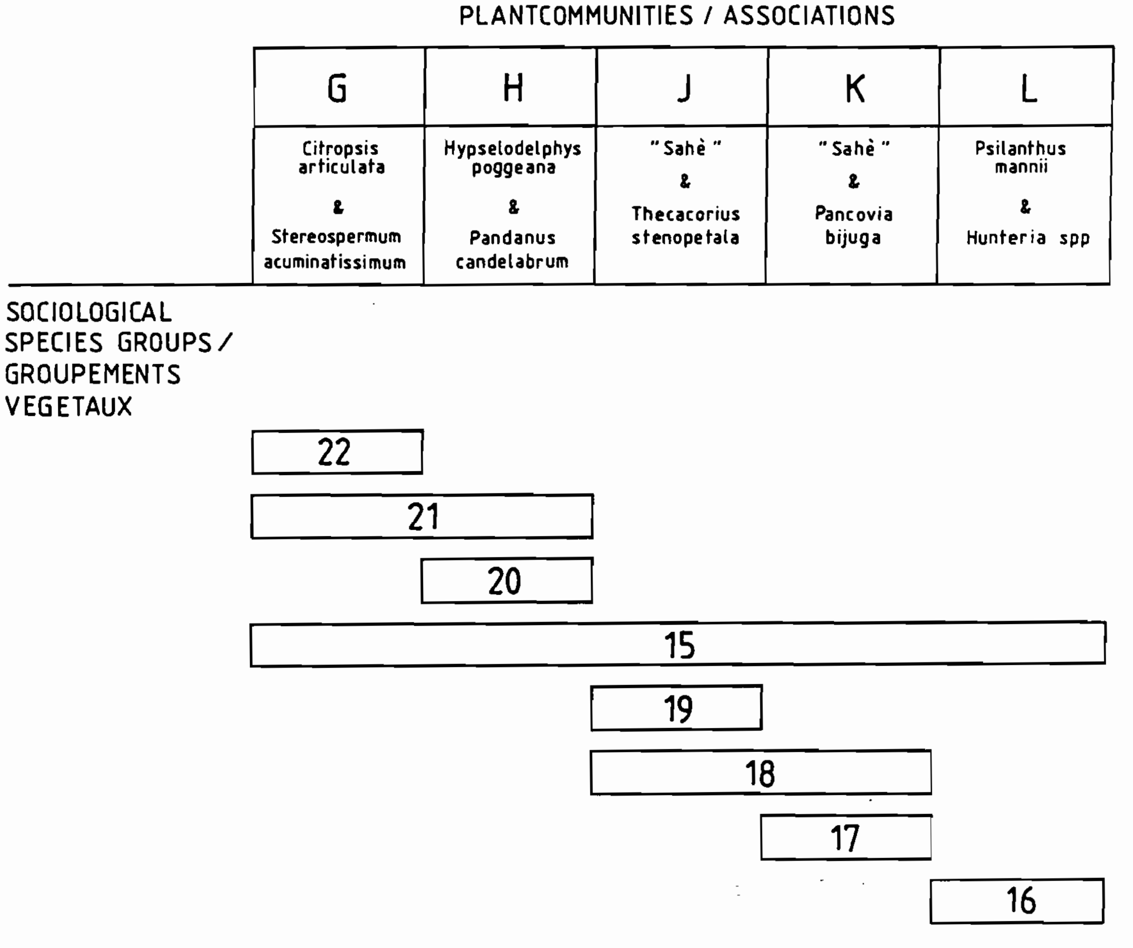


Fig. 10: Bar diagram representing distribution of sociological groups over 5 primary forest communities on extreme landforms

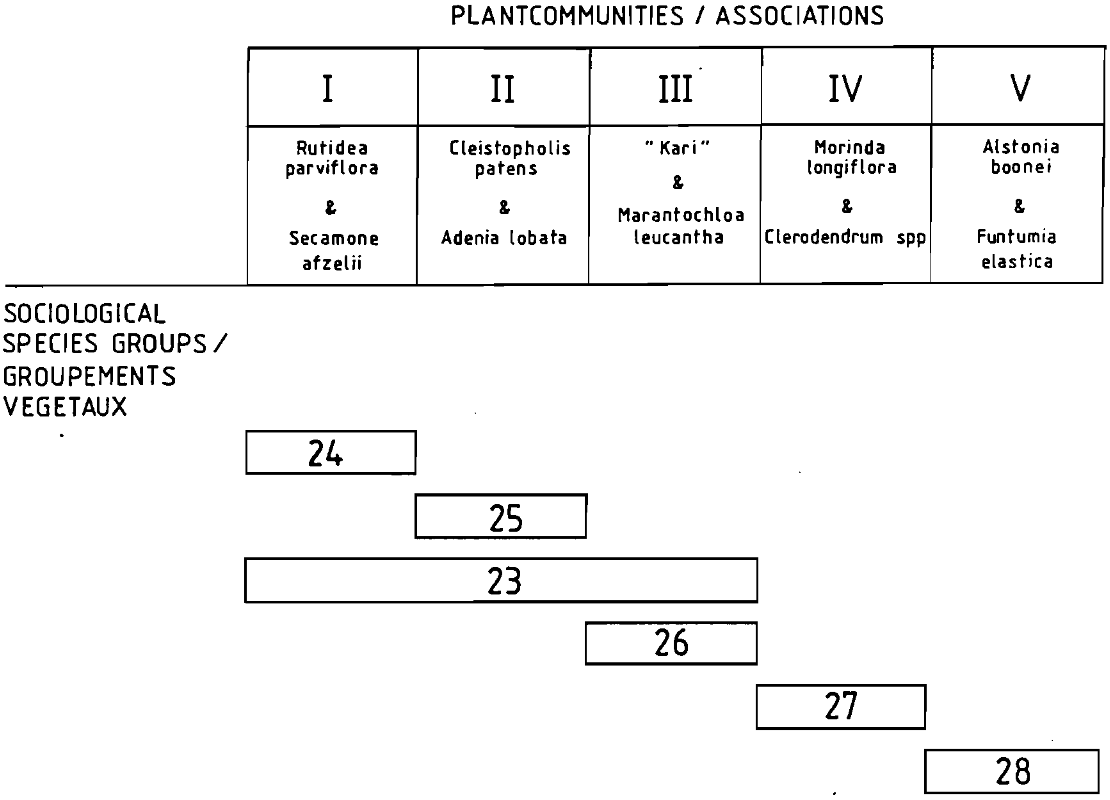


Fig. 11: Bar diagram representing distribution of sociological groups over 5 communities related to agriculture

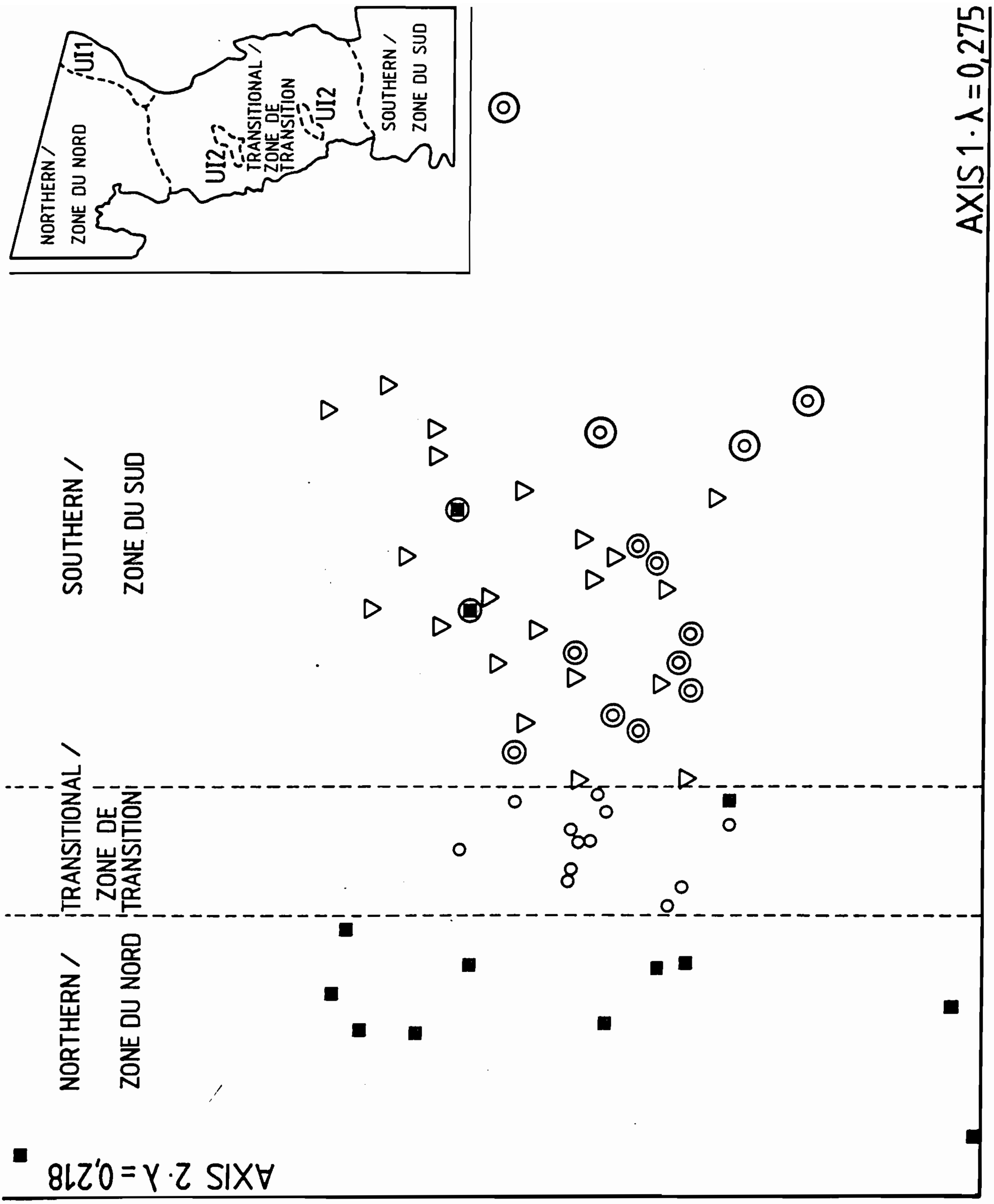


Fig. 12: Ordination of relevees in upland primary forest on middle slope, upper slope and crest, partitioned into rainfall-vegetation zones

- relevees in Northern rainfall-vegetation zone
- relevees in Transitional (and Intermediate) rainfall-vegetation zone
- relevees in Southern rainfall-vegetation zone
- relevees in land units with inselbergs and rock outcrops

Inset map shows schematically the location of rainfall-vegetation zones and of land units with inselbergs and rock outcrops (UI1 and UI2)

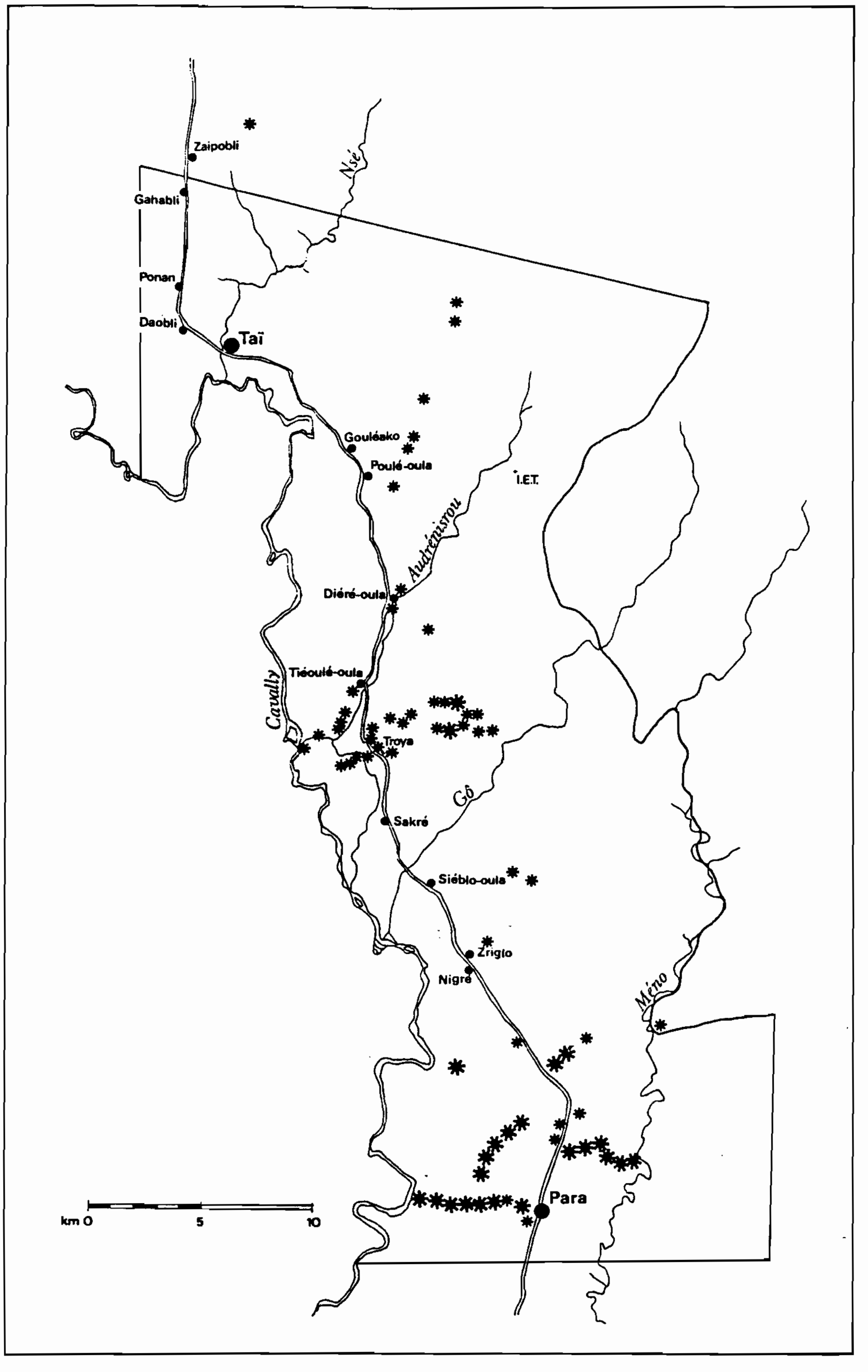


Fig. 13: Sites with 'Ferreclao' (Millettia rhodantha) recorded during the survey and in previous studies (1979-1989) by the vegetation scientist

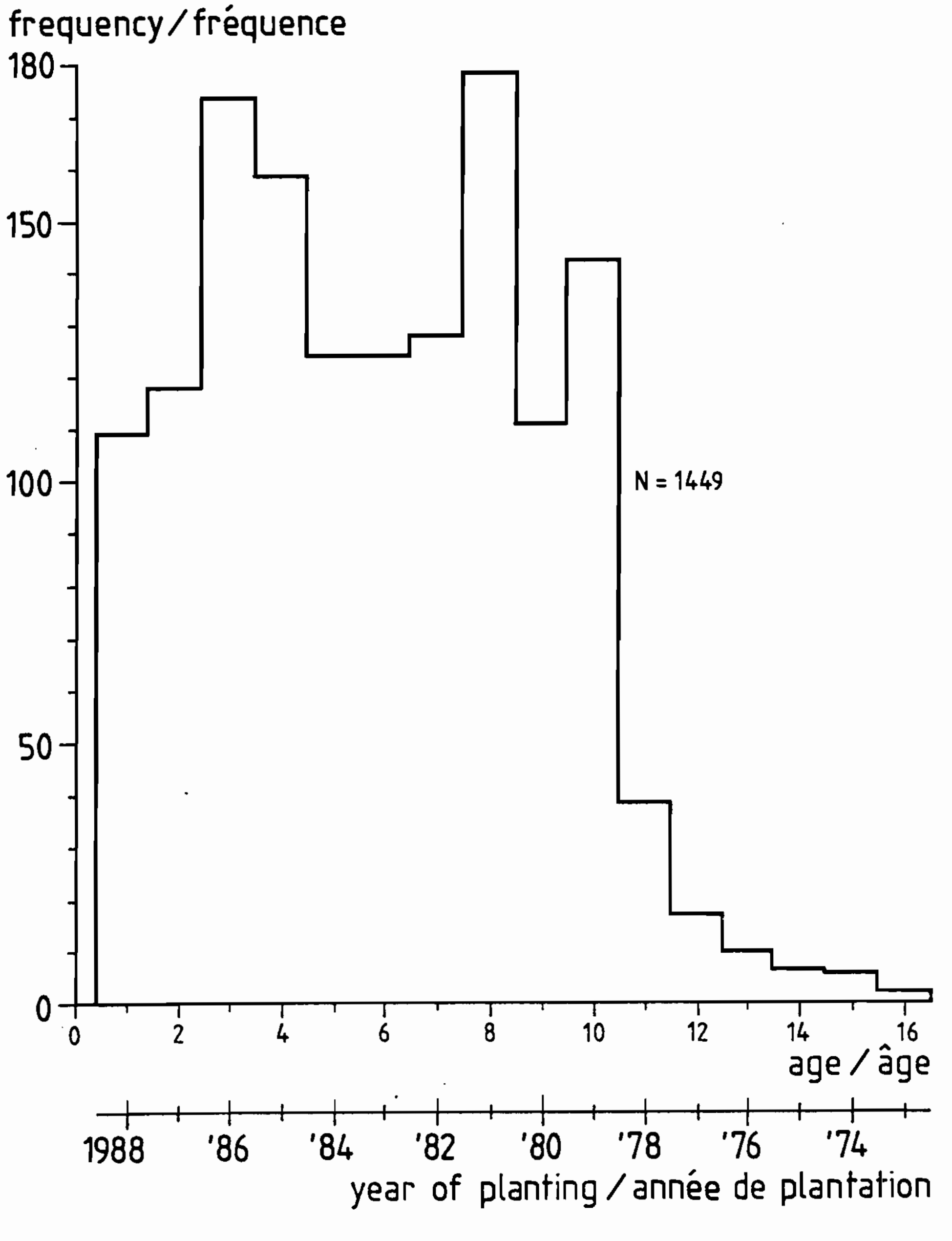


Fig. 14: Age of cacao plantations south of Poule-oula, based on 1449 observations

Fig. 15: Three stages in the land use history of Sakre village

1956: Oubi occupy the land
1978: immigrants settle along the timber extraction road
1988: immigrants outnumber Oubi

<u>Land use legend</u> (symbols for main land use types are the same as used in Appendix 10)

1956

- r1 shifting cultivation by Oubi: > 75% primary forest left
- r4 ditto: 5-25% primary forest left
- pf undisturbed primary forest
- pd slightly disturbed primary forest
- **R** valley bottom with Raphia palms

1978

- R4 shifting cultivation by Oubi; 5-25% primary forest left
- T2 shifting cultivation and cocoa and coffee plantations by Oubi; 50-75% primary forest left
- C1 cocao plantations by immigrants; > 75% primary forest left
- **C** cocoa and coffee fields by Oubi

1988

- T5 shifting cultivation and cocoa and coffee plantations by Oubi; < 5% primary forest left
- T4 ditto; 5-25% primary forest left
- C5 cocoa plantations by immigrants; < 5% primary forest left
- **B** limit of bufferzone
- **C** coca and coffee fields by Oubi
- **D** degraded land covered by grass or thickets
- **P** primary forest
- **S** secondary forest rich in oilpalm
- **V** fields with prolonged food cropping

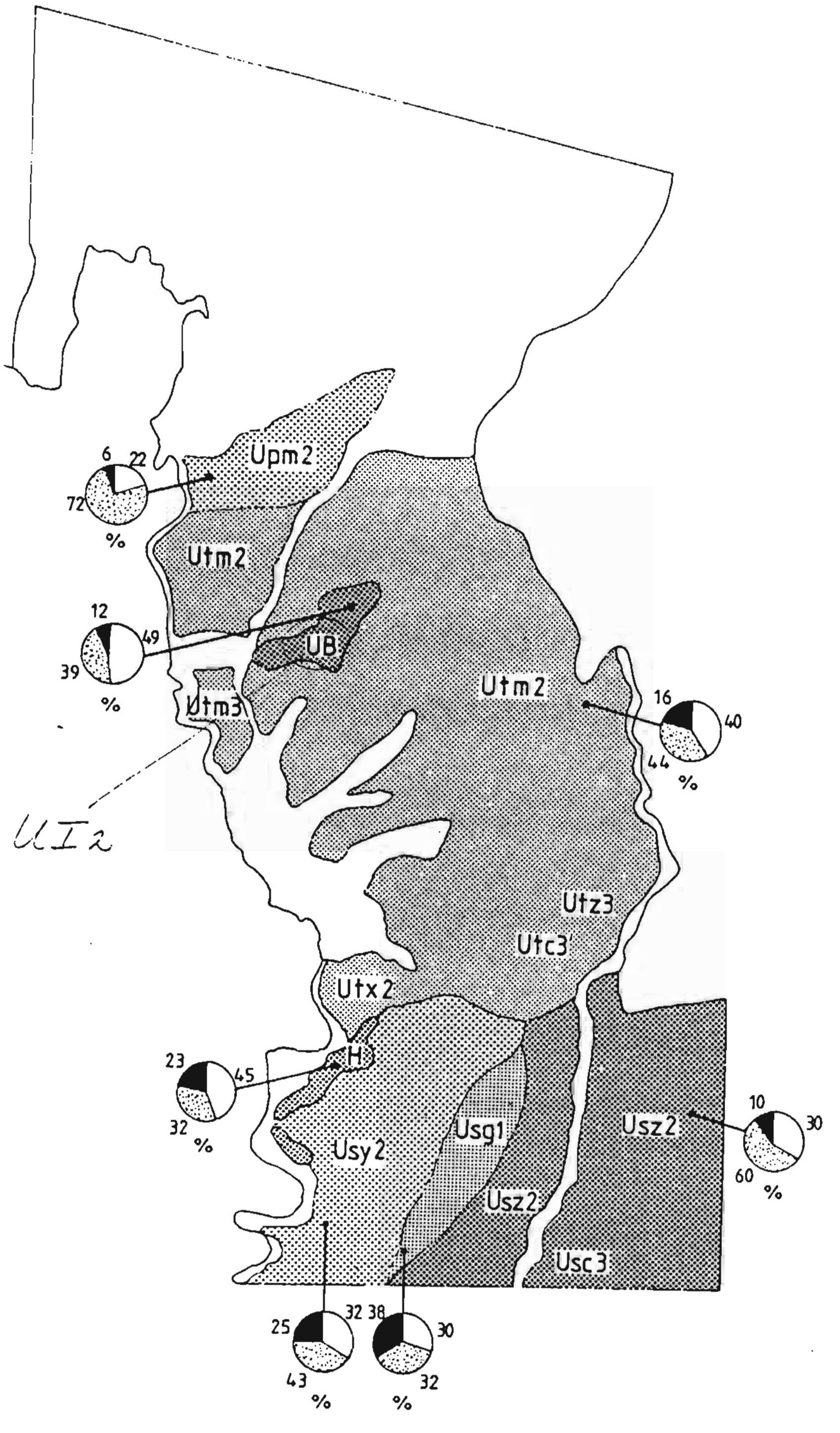
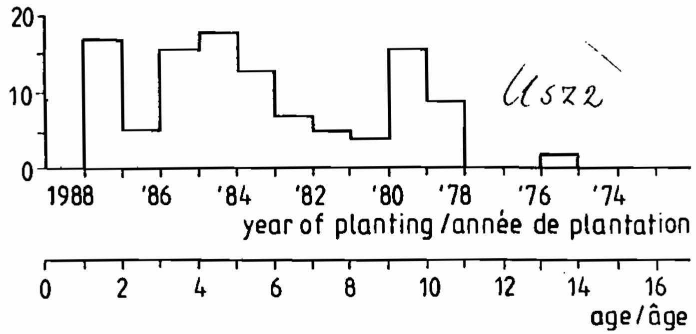
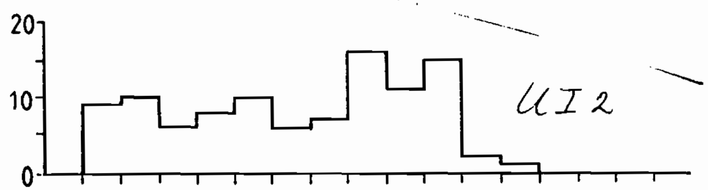
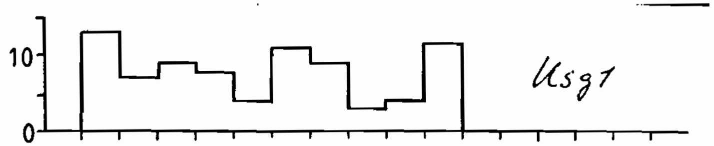


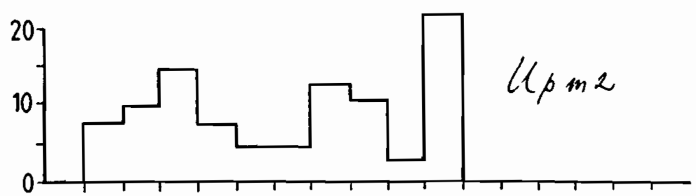
Fig. 16: Cocoa plantations south of Poulé-oula: age, number of plantations in each age group, and crop condition, for each land unit or group of land units

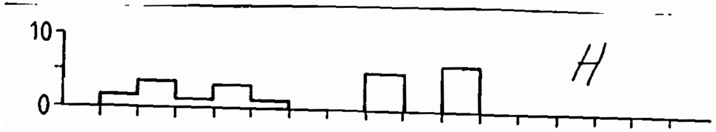
- crop in good condition
- crop in poor condition
- crop in average condition

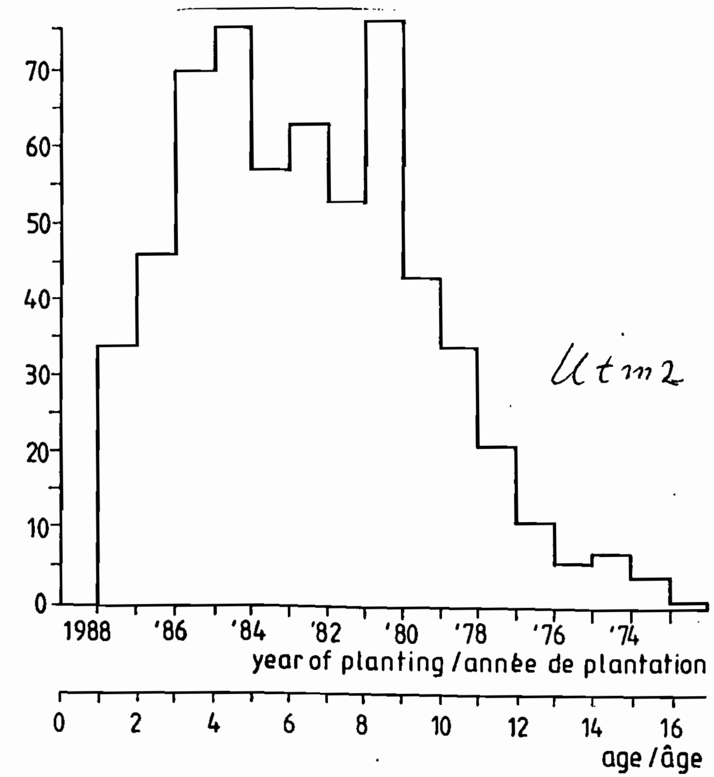

Usz2
1988 '86 '84 '82 '80 '78 '76 '74
year of planting / année de plantation
age / âge

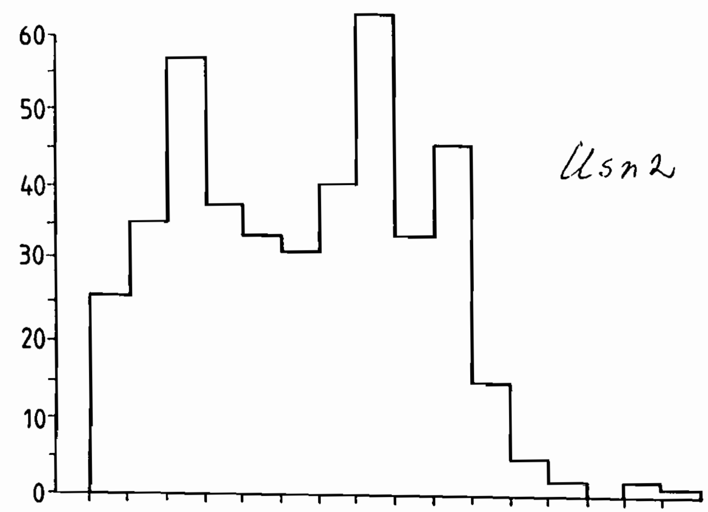

UI2


Usg1


Upm2


H


Utm2
1988 '86 '84 '82 '80 '78 '76 '74
year of planting / année de plantation
age / âge


Usn2

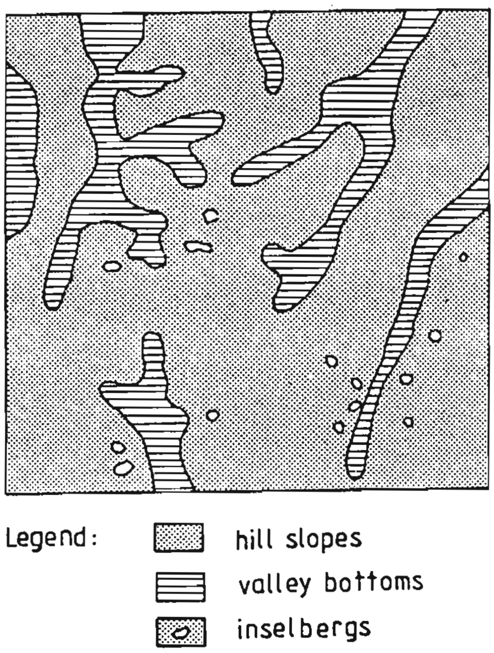
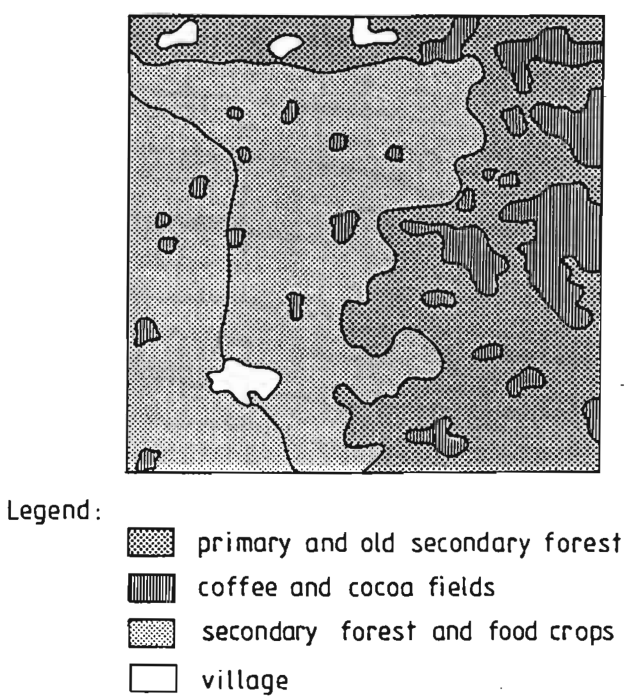


Fig. 17: Key area in the forest zone, scale 1:50,000
Legend: - hill slopes
- valley bottoms
- inselberg crests



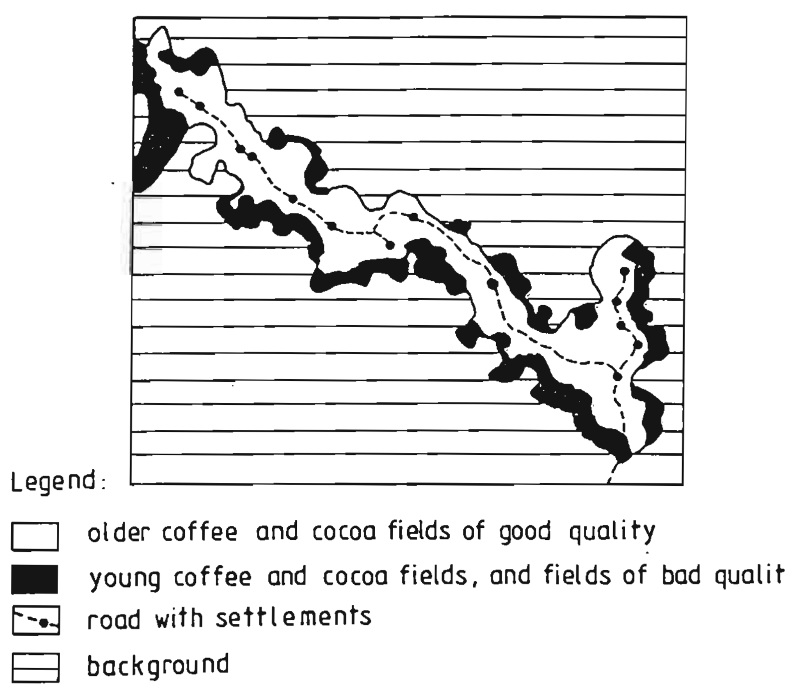


Fig. 18: Key area in the cultivated zone. scale 1:50.000
Legend: - primary and old secondary forest
- coffee and cocoa fields
- secondary forest and food crops
- village

Fig. 19: Key area of cocoa and coffee plantations along a road. scale 1:50.000
Legend: - older coffee and cocoa fields of good quality
- young coffee and cocoa fields, and fields of poor quality
- road with settlements
- other vegetation and land use

APPENDIX 1

Processing of SPOT imagery and samples of interpretation

The SPOT satellite is a multi-spectral scanning system (MSS). The reflected radiance is recorded in three bands for pixels of 20x20 meter:
1. 0.50-0.59 m (green);
2. 0.61-0.68 m (red);
3. 0.79-0.89 m (near infrared).
The values of the reflected radiance per band were converted to digital numbers in a range of 1 to 256. In order to produce an image, these digital numbers are represented by colours, as follows: band 1 in blue; band 2 in green; band 3 in red.

Problems were encountered in processing optimum images with high contrast due to the actual low range in digital data values per band and due to the occurrence of haze in the area with primary forest. In the National Aerospace Laboratory (NLR) at Emmeloord, the Netherlands, it was attempted to solve these problems by using different stretching techniques. SPOT 1-2-3 imagery of reasonable quality was produced of the agricultural zone, but the effect of haze in the forest zone could not be totally eliminated.
Further processing, focussed on the agricultural zone, was done at the Remote Sensing Unit of the Department of Soil Science and Geology, Wageningen Agricultural University. Optimum contrast was reached by using the following technique.
The original 3-band data set was extended with ratios 2-1 / 2+1, 3-2 / 3+2, 1 / 1+2+3 and 2 / 1+2+3. The correlation coefficients of the set with 7 variables were studied. The combination
3-2 / 3+2 - 3 - 1/1+2+3 showed lowest correlation indices (average of 2 correlation coefficients) and was supposed to show highest discrimination in land cover.
Another product was made by clustering in unsupervised classification using the extended data set. Based on field observations, classes were evaluated for their relevance in this study and where necessary have been categorised in a new cluster. These new products have to be tested in the terrain in a later phase of the study.

Examples of interpretation using SPOT 1-2-3 false colour combination

Table 23 shows the legend used for translation of the colours on the SPOT 1-2-3 combination into land cover.

Several key areas have been studied. The results are given in Fig's 17, 18 and 19.

Appendix II Species list per sociological species group*

2a. Classification of primary forest in Côte d'Ivoire by Mangenot (1955)

Code : M1
Species : *Baphia nitida, Canarium schweinfurtii, Castanola paradoxa, Cnestis ferruginea, Cola caricaefolia, Corynanthe pachyceras, Diospyros heudelotii**, *Dracaena surculosa, Hugonia platysepala, Landolphia hirsuta, Landolphia owariensis, Neuropeltis acuminata, Ochthocosmus africanus, Pancovia bijuga, Piper guineense, Piptadeniastrum africanum, Pycnanthus angolensis, Rinorea elliotii, Sarcophrynium brachystachys, Sphenocentrum jollyanum, Strombosia glaucescens, Thonningia sanguinea, Tiliacora dinklagei, Ventilago africana, Xylopia villosa.*

Code : M2
Species : *Allanblackia floribunda, Alsodeiopsis staudtii**, *Ancistrophyllum opacum, Ancistrophyllum secondiflorum, Angylocalyx oligophyllus, Anopyxis klaineana, Cercestis afzelii, Cola digitata, Cola heterophylla, Combretodendron macrocarpum, Ctenitis protensa, Coula edulis, Culcasia angolensis, Culcasia scandens, Dacryodes klaineana, Desplatsia chrysochlamys, Diospyros sanza-minika, Funtumia africana, Garcinia smeathmannii**, *Geophila afzelii, Geophila hirsuta, Hypolytrum africanum**, *Icacina mannii, Lasianthus batangensis, Lophira alata, Maesobotrya barteri, Mendoncia iodioides, Neuropeltis prevosteoides, Octoknema borealis, Omphalocarpum ahia**, *Parinari glabra**, *Parkia bicolor, Pleiocarpa mutica, Pteris burtonii, Rhaphidophora africana, Sacoglottis gabonensis, Strephonema pseudocola, Trichoscypha arborea, Uapaca esculenta, Uapaca guineensis.*

Code : M3
Species : *Cercestis stigmaticus, Chrysophyllum pruniforme, Dichapetalum toxicarium, Diospyros mannii, Dracaena humilis, Eremospatha macrocarpa, Ixora laxiflora, Memecyclon guineense, Ouratea schoenleiniana, Pachypodanthium staudtii, Ptychopetalum anceps, Scytopetalum tieghemii.*

Code : M4
Species : *Diospyros canaliculata.*

Code : M5
Species : *Afrosersalisia afzelii, Buchholzia coriacea, Calycobolus heudelotii, Chlamydocarya macrocarpa, Chrysophyllum subnudum**, *Dichapetalum cymulosum, Drypetes chevalieri, Epinetrum cordifolium, Eriocoleum kerstingii**, *Heisteria parvifolia, Monodora myristica, Salacia nitida, Tabernaemontana crassa, Turraeanthus africanus**, *Xylopia acutiflora.*

Code : M6
Species : *Antidesma membranaceum.*

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* Nomenclature is according to the Flora of West Tropical Africa (Hutchinson, Dallziel and Hepper, ...) except for the Clastaceae, where the monograph of Hallé (1962) was followed, and for the Araceae which were named after Knecht (1963). The latter two authors have worked in Taï.

Code : M7
Species : *Buforrestia mannii, Cephaelis yapoensis, Chytranthus setosus, Ctenitis variabilis, Diospyros chevalieri, Diospyros gabunensis*, Drypetes aylmeri, Eremospatha hookeri, Isolona thonneri, Mapania baldwinii, Mapania coriandrum, Mapania linderi, Soyauxia floribunda, Tarrietia utilis.*

Code : M8
Species : *Calamus deërratus, Mitragyna ciliata, Spondianthus preussii.*

Code : M9
Species : *Halopegia azurea, Maschalocephalus dinklagei, Protomegabaria stapfiana*.*

2b Classification of primary forest in South-West Côte d'Ivoire by Guillaumet (1967)

Code : G1
Species : *Aframomum sceptrum, Agelaea obliqua, Alchornea floribunda, Allanblackia floribunda, Ancistrophyllum opacum, Ancistrophyllum secundiflorum, Anopyxis klaineana, Antidesma oblonga, Anthonotha fragans, Anthonotha macrophylla, Baphia nitida, Beilschmiedia bitehi*, Blighia welwitschii, Buchholzia coriacea, Bussea occidentalis, Calycobolus africanus, Cephaelis peduncularis, Cercestis afzelii, Chassalia corallifera, Chidlowia sanguinea, Chlorophora excelsa, Cola caricaefolia, Cola chlamydantha, Cola heterophylla, Cola nitida, Combretodendron macrocarpum, Corymborkis corymbosa, Coula edulis, Craterispermum caudatum, Craterogyne kameruniana*, Ctenitis protensa, Culcasia parviflora, Culcasia scandens, Desplatsia chrysochlamys, Dichapetalum angolense, Diospyros canaliculata, Diospyros soubreana, Dorstenia smythei, Dracaena surculosa, Drypetes chevalieri, Enantia polycarpa, Entandrophragma angolense, Entandrophragma candollei, Entandrophragma cylindricum, Erythrophleum ivorense, Funtumia africana, Garcinia afzelii, Garcinia smeathmannii*, Geophila afzelii, Geophila obvallata, Geophila repens*, Guaduella oblonga, Helictonema velutina*, Iodes liberica, Irvingia gabonensis, Khaya anthotheca, Landolphia dulcis, Landolphia membranacea, Landolphia owariensis, Maesobotrya barteri, Mammea africana, Massularia acuminata, Microdesmis puberula, Monodora myristica, Napoleana leonensis, Nephthitis afzelii, Neuropeltis prevosteoides, Olax gambecola*, Ouratea morsonii*, Panda oleosa, Pararistolochia macrocarpa*, Parinari excelsa, Parinari glabra*, Pauridiantha hirtella, Penianthus zenkeri, Pentaclethra macrophylla, Pentadesma butyracea, Picralima nitida*, Piptadeniastrum africanum, Pollia condensata, Psychotria subobliqua, Pycnocoma macrophylla, Rhaphidophora africana, Rinorea elliotii, Rinorea ilicifolia, Rothmannia whitfieldii, Sphenocentrum jollyanum, Stanfieldiella imperforata, Strephonema pseudocola, Strombosia glaucescens, Strychnos aculeata, Tabernaemontana crassa, Tarenna bipindensis*, Tetrapleura tetraptera*, Tetrorchidium didymostemon, Thonningia sanguinea, Tieghemella heckelii, Tricalysia reflexa, Trichilia heudelotii, Tricoschypha arborea, Uapaca esculenta, Uapaca guineensis, Voacanga bracteata*, Xylopia acutiflora.*

Code : G2
Species : *Carpolobia lutea, Cephaelis abouabouensis, Endosiphon primuloides*, Erythrococca africana*, Heisteria parvifolia, Hymenostegia afzelii, Hypolytrum* spp., *Lasiodiscus fasciculi-*

florus, Polyalthia oliveri, Raphiostylis beninensis, Salacia uregaensis.

Code : G3
Species : *Acridocarpus longifolius, Buforrestia mannii, Cephaelis yapoensis, Chytranthus longiracemosus, Coffea humilis, Corynanthe pachyceras, Ctenitis variabilis, Deinbollia cuneifolia, Diospyros gabunensis*, Dracaena humilis, Drypetes ivorensis, Guarea leonensis, Ixora laxiflora, Lasianthus batangensis, Mapania baldwinii, Mapania linderi, Mapania superba*, Memecylon guineense, Ouratea duparquetiana, Ouratea schoenleiniana, Palisota barteri, Ptychopetalum anceps, Renealmia maculata*, Scytopetalum tieghemii, Trichoscypha beguei, Trichoscypha chevalieri.*

Code : G4
Species : *Adiantum vogelii, Agelaea obliqua, Berlinia occidentalis, Cephaelis biaurita, Cephaelis mangenotii, Cercestis stigmaticus, Chrysophyllum pruniforme, Culcasia mannii*, Cynometra ananta, Decorsella paradoxa, Dicranolepsis persei, Diospyros chevalieri, Diospyros heudelotii*, Diospyros kamerunensis*, Diospyros mannii, Diospyros vignei, Dracaena smithii, Eremospatha macrocarpa, Eugenia miegeana*, Geophila neurodictyon, Ixora aggregata*, Klainedoxa gabonensis, Lomariopsis guineensis, Mapania coriandrum, Mapania macrantha*, Neostenanthera gabonensis, Ouratea subcordata, Placodiscus pseudostipularis, Popowia mangenotii, Sacoglottis gabonensis, Selaginella vogelii, Tarrietia utilis, Tetracera potatoria, Tetrorchidium oppositifolium*.*

Code : G5
Species : *Anthocleista vogelii, Carapa procera, Cleistanthus polystachyus, Cleistopholis patens, Dialium dinklagei, Gilbertiodendron ivorense, Gilbertiodendron limba, Gilbertiodendron robynsianum*, Kigelia africana, Macaranga heudelotii, Millettia sanagana*, Myrianthus serratus, Nauclea pobeguinii*, Omphalocarpum ahia, Oxyanthus formosus, Oxyanthus pallidus, Oxyanthus subpunctatus, Pandanus candelabrum, Pellegriniodendron diphyllum, Polystemonanthus dinklagei*, Spondianthus preussii, Xylopia parviflora.*

Code : G6
Species : *Ancistrocladus abbreviatus, Cathormion altissimum*, Crudia klainei, Cynometra megalophylla*, Gluema ivorensis*, Leucomphalos capparideus*, Memecylon membranifolium, Millettia chrysophylla, Pachystela brevipes, Pterocarpus santalinoides*, Treculia africana, Uapaca heudelotii, Uncaria africana.*

Code : G7
Species : *Ataenidia conferta, Calamus deërratus, Costus schlechteri, Gilbertiodendron splendens, Halopegia azurea, Marantochloa leucantha, Marantochloa purpurea*, Maschalocephalus dinklagei, Mitragyna ciliata, Protomegabaria staudtii*, Raphia hookeri, Raphia sassandrensis, Sarcophrynium brachystachys, Staurogyne capitata*, Symphonia globulifera, Uapaca paludosa.*

Code : G8
Species : *Acridocarpus smeathmannii, Alchornea cordifolia, Anthocleista djalonensis, Combretum racemosum, Dichapetalum toxicarium, Entada scelerata, Flagellaria guineensis, Heteropteris leona*, Hexalobus crispiflorus, Isonema smeathmannii, Ormocarpum verrucosum*, Quisqualis indica*, Tetracera alnifolia.*

2c Classification of primary forest, secondary forest and plantation undergrowth in this report

Code : Sociological group 2 (sociological species groups are indicated in Figs. 9, 10 and 11)

Species : *Anthonotha fragans, Carpolobia lutea, Cephaelis biaurita, Cissus aralioides, Culcasia scandens, Decorsella paradoxa, Drypetes chevalieri, Erythrophleum ivorense, Glyphaea brevis, Mareya micrantha, Parkia bicolor, Salacia miegei, Triclisia macrophylla.*

Code : Sociological group 3
Species : *Amphimas pterocarpoides, Cephaelis yapoensis, Culcasia dinklagei, Culcasia longivaginata, Mapania baldwinii, Nauclea diderrichii, Newtonia duparquetiana, Strychnos cuminodora, Trichoscypha arborea, Triphyophyllum peltatum.*

Code : Sociological group 5
Species : *Aphanostylis leptantha, Cuervea macrophylla, Diospyros sanzaminika, Eremospatha macrocarpa, Geophila afzelii, Pyrenacantha vogeliana, Sarcophrynium brachystachys, Spondianthus preussii, Thalia welwitschii.*

Code : Sociological group 7
Species : *Ctenitis variabilis, Dracaena humilis*[1], *Landolphia hirsuta, Ouratea schoenleiniana, Trichoscypha beguei.*

Code : Sociological group 8
Species : *Agelaea trifolia, Antiaris welwitschii, Canthium hispidum, Griffonia simplicifolia, Guarea cedrata, Heisteria parvifolia, Jasminium pauciflorum, Palisota barteri, Piptadeniastrum africanum, Platysepalum hirsutum, Psychotria sciadephora, Pycnocoma macrophylla, Xylopia villosa.*

Code : Sociological group 9
Species : *Ancistrophyllum secundiflorum*[1], *Asplenium africanum, Cola lateritia* var. *maclaudi, Enantia polycarpa, Euadenia trifoliolata, Hugonia rufopilis, Linociera mildbraedii, Lomariopsis rossii*[1], *Lovoa trichilioides, Lychnodiscus reticulatus, Tricalysia macrophylla.*

Code : Sociological group 11
Species : *Calamus deërratus*[1], *Deinbollia pinnata, Drypetes ivorensis, Neuropeltis prevosteoides, Neuropeltis velutina, Oxyanthus formusus*[1], *Rinorea oblongifolia, Stanfieldiella imperforata, Sterculia oblonga.*

Code : Sociological group 13
Species : *Eugenia calophylloides, Hugonia platysepala, Myrianthus arboreus, Piptostigma aubrevillei, Salacia erecta.*

Code : Sociological group 15
Species : *Cuviera acutiflora, Dorstenia smythei, Hymenostegia afzelii, Pachypodanthium staudtii, Rinorea ilicifolia.*

Code : Sociological group 18
Species : *Coffea humilis, Daniellia thurifera, Dichapetalum pallidum, Millettia chrysophylla, Neosloetiopsis kamerunensis, Plagiosyphon emarginatus, Salacia leonensis.*

Code : Sociological group 21
Species : *Corymborkis corymbosa, Elaeophorbia grandifolia, Hibiscus surattensis, Mallotus oppositifolius, Mildbraedia paniculata, Oeceoclades maculata, Tragia* cf. *vogelii.*

Code : Sociological group 23
Species : *Albizia adianthifolia, Fagara macrophylla, Harungana madagascariensis, Kolobopetalum chevalieri, Macaranga barteri, Macaranga hurifolia, Scleria barteri, Tragia benthami, Xylopia aethiopica.*

Code : Sociological group 29
Species : *Calycobolus africanus, Chrysophyllum taiense, Diospyros chevalieri, Diospyros mannii, Diospyros soubreana, Garcinia gnetoides, Landolphia owariensis, Maesobotrya barteri, Marantochloa filipes, Napoleona leonensis, Neuropeltis acuminata, Piper guineense, Rhaphiostylis beninensis, Rinorea longicuspis, Salacia debilis, Strombosia glaucescens, Tiliacora dinklagei, Xylopia quintasii.*

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* Species not recorded in our survey
[1] Should be on crest or upper slope

Appendix III Compilation of information on plant species used in vegetation classification in South-West Côte d'Ivoire

Physiognomy, ecology and distribution of plant species.

Column 1 Species

Column 2 Life form

T = Large tree capable of exceeding 30 m of height
t = Smaller tree or shrub
C = Large climber capable of reaching the canopy
c = Climber confined to understorey
h = Ground herb
f = Fern

Column 3 Global distribution

En = Endemic, species restricted to South-West Côte d'Ivoire with possible extention westward to Liberia
Go = Guinea occidental, species occurring only westward of the Dahomey Gap
GC = Guinea-Congolian, species occurring on both sides of the Dahomey Gap
Tr = Transgressor, species occurring in vegetations other than lowland rainforest

Column 4 Sociological species group number according to this study (see Figs. 9, 10, 11)

* = Species frequently recorded not showing a preference for any of the sociological species groups
+ = Number of records of the species too few to permit attachment to a sociological species group
- = Species not recorded in our survey

Column 5 Sociological species group number according to earlier classifications

M = Classification by Mangenot (1955)
G = Classification by Guillaumet (1967)

Column 6 Local name

(O) = Oubi
(G) = Guéré
(T) = Trade name

Species name	Life form	Distri- bution	Classifications LUST	Other	Local name
Acacia pennata	c	Tr	24		(O): Gnê-ran-gbo; (G): Nran
Acridocarpus longifolius	C	GC	27	G3	
Acridocarpus smeathmannii	c	GC	+	G8	
Adenia lobata	c	GC	25		(O): Pahu-in-hulu; (G): Kpahô-dulu
Adiantum vogelii	f	Tr	*	G4	
Aframomum sceptrum	h	GC	*	G1	
Afrolicanea elaeosperma	t	GC	19		
Afrosersalisia afzelii	T	GC	*	M5	(O): Djru-kpa-è; (G): Bètê-è
Agelaea obliqua	C	GC	*	G1	
Agelaea trifolia	c	GC	8		
Albizia adianthifolia	T	Tr	23		(O): Gbê; (G): Zaohè-zahin
Alchornea cordifolia	t	GC	17	G8	(O): Pôrô; (G): Pôhô
Alchornea floribunda	t	GC	14	G1	(O): Sorombia; (G): Djla-daha
Allanblackia floribunda	t	Go	+	G1, M2	(O, G): Montu
Alsodeiopsis staudtii	c	GC	-	M2	
Alstonia boonei	T	GC	28		(O): Kla-tuhu; (G): Mohin
Amphimas pterocarpoides	T	GC	3		(O): Plèdu; (G): Tantu-è; (T): Lati
Ancistrocladus abbreviatus	C	GC	+	G6	
Ancistrophyllum laeve	C	?	14		(O): Gnahin
Ancistrophyllum opacum	C	GC	6	G1, M2	(O): Klarè; (G): Kula-è-zondoho
Ancistrophyllum secondiflorum	C	GC	9	G1, M2	(O): Djôllo; (G): Kloho
Angylocalyx oligophyllus	t	GC	+	M2	
Aningeria robusta	T	GC	10		
Anopyxis klaineana	T	GC	+	G1, M2	
Anthocleista djalonensis	t	Tr	-	G8	(O): Dju-angblô
Anthocleista nobilis	T	GC	4		(O): Dju-angblô; (G): Mbô-tu-ê
Anthocleista vogelii	t	Tr	25	G5	(O): Dju-angblô; (G): Mbô-tu-ê
Anthonotha fragans	T	GC	2	G1	(O, G): Ziê-loa
Anthonotha macrophylla	t	GC	12	G1	
Antiaris welwitschii	T	GC	8		(O): Kôrai; (G): Bluba-è/Dyè; (T): Ako
Antidesma membranaceum	t	Tr	+	M6	
Antidesma oblonga	t	Go	*	G1	
Aphanostylis leptantha	C	Go	5		
Araliopsis tabouensis	T	Go	4		
Asplenium africanum	f	GC	9		
Ataenidia conferta	h	GC	*	G7	
Baissea zygodioides	c	Go	24		
Baphia nitida	t	GC	12	G1, M1	(O, G): Djahin
Baphia polygalacea	c	GC	4		
Baphiastrum confusum	C	GC	17		
Beilschmiedia bitehi	T	En	-	G1	
Beilschmiedia mannii	t	GC	4		(O): Srê; (G): Bi-le-è
Bequaertia mucronata	c	GC	22		
Berlinia occidentalis	T	Go	-	G4	
Bertiera bracteolata	c	GC	26		(G): Njiri-blo-dubu
Bertiera racemosa	c	GC	25		(O): Kluha-cafê; (G): Kula-cafê
Blighia welwitschii	T	GC	*	G1	(O): Djêa-tu; (G): Zu-i-agahè

Buchholzia coriacea	T	GC	*	G1, M5	(O): Duhutu; (G): Sabagn-lu
Buforrestia mannii	h	GC	1	G3, M7	(O): Lo-hu-on; (G): Ton-pêhi
Bussea occidentalis	t	Go	25	G1	(O): Massè-hè; (G): Daba-gu-yon
Byrsocarpus coccineus	c	Tr	24		
Calamus deërratus	C	GC	11	G7, M6	(O): Toruha; (G): Blêhê
Caloncoba brevipes	t	En	4		(O): Rêraree; (G): Kpon-tu-è/Gwêrê-a
Calycobolus africanus	C	GC	29	G1	
Calycobolus heudelotii	C	GC	1		(O): Plo-hulu; (G): Plo-dubu
Calycobolus parviflorus	c	Go	+	M5	
Canarium schweinfurtii	T	GC	*	M1	(O): Gee-sè-tu; (G): Botu-è; (T): Aielê
Canthium hispidum	c	GC	8		
Carapa procera	T	Tr	+	G5	(O): Trèlo; (G): Flon-monhen
Carpolobia lutea	t	GC	2	G2	(O): Paropan
Cathormion altissimum	t	GC	-	G6	
Ceiba pentandra	T	Tr	22		(O, G): Djô; (T): Fromager
Cephaelis abouabouensis	t	Go	+	G2	
Cephaelis biaurita	t	Go	2	G4	
Cephaelis mangenotii	h	Go	+	G4	
Cephaelis peduncularis	t	Tr	1	G1	(O): Gnopodjolobo
Cephaelis yapoensis	t	Go	3	G3, M7	(O): Hêro-hu-on; (G): Dohè-kolâ
Cercestis afzelii	c	GC	4	G1, M2	(O): Gamin-hi-i; (G): Mlanhi
Cercestis sagittatus	h	En	1		
Cercestis stigmaticus	c	GC	*	G4, M3	
Chassalia corallifera	t	Go	12	G1	
Chidlowia sanguinea	T	Go	1	G1	(O): Kôwè
Chlamydocarya macrocarpa	C	Go	+	M5	
Chlorophora excelsa	T	Tr	*	G1	(O): Ngbè; (G): Gnê; (T): Iroko
Chromolaena odorata	h	Tr	*		(O, G): Indépendance
Chrysophyllum pruniforme	C	GC	4	G4, M3	(O): Gbêhê
Chrysophyllum subnudum	t	GC	-	M5	(O): Go-fatu; (G): Yrê-yêtu
Chrysophyllum taiense	T	En	29		(O): Taru-tu; (G): Dahu-tu
Chytranthus longiracemosus	t	GC	12	G3	
Chytranthus mangenotii	t	Go	12		
Chytranthus setosus	t	GC	12	M7	
Cissus aralioides	c	Tr	2		
Cissus diffusiflora	c	GC	24		(O): Plê-plê-hulu; (G): Gweenon-gbahè
Cissus polyantha	c	GC	26		
Cissus producta	c	GC	24		(O): Dja-kplê-kple; (G): Sohon-hin
Citropsis articulata	t	GC	22		
Cleistanthus polystachyus	t	GC	*	G5	
Cleistopholis patens	t	GC	25	G5	(O): Pow-wê; (G): Gba-hutu-ê
Clerodendrum schweinfurtii	c	Tr	27		
Clerodendrum splendens	c	GC	27		(O): Gwee-yê-tawa
Clerodendrum umbellatum	c	Tr	27		
Clerodendrum volubile	c	GC	27		(O): Nêpu; (G): Nimpu
Cnestis ferruginea	c	GC	*	M1	(O): Gwee-gnaron; (G): Gwee-è-ziè
Coffea humilis	t	En	18	G3	(O): Kola-café; (G): Kula-kafê
Cola caricaefolia	t	GC	1	G1, M1	(O): Gwee-kora; (G): Kankola
Cola chlamydantha	t	GC	+	G1	(O): Gla-o-hêwee
Cola digitata	t	GC	+	M2	
Cola heterophylla	t	GC	10	G1, M2	(O): Nu-gkêsona/Klabo-a

Cola lateritia var. *maclaudi*	t	GC	9		(O, G): Gôziman
Cola nitida	t	Go	*	G1	(O): Hu-yé-tu/Wêtu; (G): Y-êtu
Combretodendron macrocarpum	T	GC	*	G1, M2	(O): Tutu-ê; (T): Abalê
Combretum homalioides	C	GC	4		
Combretum racemosum	C	GC	*	G8	
Cordia platythyrsa	T	Go	26		(O): Nolen
Corymborkis corymbosa	h	Tr	21	G1	
Corynanthe pachyceras	t	GC	12	G3, M1	(O): Sahitiré
Costus schlechteri	h	GC	*	G7	(O): Zêhê-yu-è; (G): Don-kpahu
Coula edulis	t	GC	*	G1, M2	(O): Hôtu; (G): Sratu/Syê-latu; (T): Noisette
Craterispermum caudatum	t	GC	*	G1	(O): Klu-tu-è; (G): Ku-ê-tu-è
Craterogyne kameruniana	t	Go	-	G1	
Crotonogyne chevalieri	t	Go	19		
Crudia klainei	T	GC	+	G6	
Ctenitis protensa	f	GC	4	G1, M2	
Ctenitis variabilis	f	GC	7	G3, M7	
Cuervea macrophylla	C	GC	5		
Culcasia angolensis	C	GC	+	M2	
Culcasia dinklagei	h	GC	3		
Culcasia liberica	C	En	10		
Culcasia longivaginata	h	En	3		
Culcasia mannii	h	GC	-	G4	
Culcasia parviflora	c	GC	+	G1	
Culcasia piperoides	c	Go	12		
Culcasia saxatilis	c	Go	1		
Culcasia scandens	c	GC	2	G1, M2	
Culcasia seretii	c	Go	12		
Cuviera acutiflora	t	GC	15		
Cynometra ananta	T	Go	+	G4	
Cynometra megalophylla	T	GC	-	G6	
Dacryodes klaineana	T	GC	4	M2	(O): Ku-tanhantu/Zu-mantu; (G): Trô
Daniellia thurifera	T	Go	18		(O): So-wê-tu; (G): Zu-ê; (T): Paro
Decorsella paradoxa	t	GC	2	G4	
Deinbollia cuneifolia	En	+	G3		
Deinbollia pinnata	t	GC	11		
Desplatsia chrysochlamys	t	GC	14	G1, M2	(O): Taraza-hu-on; (G): Djee-la-hè
Dialium aubrevillei	T	Go	17		(O): Sè-hèm-lè; (G): Gwee-nilin
Dialium dinklagei	T	GC	+	G5	
Dichapetalum angolense	C	GC	*	G1	(O): Pè-rai-tu; (G): Djinlo-gwee-yé-non
Dichapetalum cymulosum	c	GC	+	M5	
Dichapetalum pallidum	c	GC	18		(G): Kolen-nji-fè
Dichapetalum toxicarium	t	Go	*	G8, M3	
Dicranolepsis persei	t	Go	*	G4	(O): Nigbè-tu-é; (G): Nimin-ka-yè
Dioscorea burkilliana	c	GC	25		(O): Ti-yengli; (G): Té-ku-an
Dioscorea praehensilis	c	GC	24		(O): Hini
Dioscorea smilacifolia	c	GC	26		
Diospyros canaliculata	t	GC	*	G1, M4	(O): Garô; (G): Gbo-tu
Diospyros chevalieri	t	Go	29	G4, M7	(O): Klu-hatii; (G): Kpa-hu-lin
Diospyros gabunensis	t	GC	-	G3, M7	
Diospyros heudelotii	t	Go	-	G4, M1	

Diospyros kamerunensis	t	GC	-	G4, M6	
Diospyros mannii	t	GC	29	G4, M7	(O): Garonan; (G): Djéhè
Diospyros sanza-minika	t	GC	5	M2	(O): Kâi; (G): Wa-nin
Diospyros soubreana	t	GC	29	G1	(O): Gré-mié; (G): Bi-hi-gnla-hen
Diospyros vignei	t	Go	*	G4	
Discoglypremna caloneura	t	GC	25		(O): Fôhô-tu; (P): Pôhô-tu
Dorstenia smythei	t	Go	15	G1	
Dracaena camerooniana	h	GC	12		
Dracaena elliotii	h	Go	6		
Dracaena humilis	h	GC	7	G3, M3	(O): Pu-tu-hè; (G): Gbaha-hu-in
Dracaena ovata	h	GC	16		(O): Pu-tu-hè
Dracaena smithii	t	Go	*	G4	
Dracaena surculosa	t	GC	*	G1, M1	(O): Pu-tu-hè; (G): Bu-kpa
Drypetes aylmeri	t	Go	+	M7	
Drypetes chevalieri	t	GC	2	G1, M11	
Drypetes ivorensis	t	Go	11	G3	
Drypetes pellegrini	t	Go	4		
Elaeis guineensis	t	GC	4		(O): Kpôhô-gbè-djô; (G): Kpo-hô; (T): Palmier
Elaeophorbia grandifolia	t	GC	21		(O): Hula-gboro; (G): Glô-gbolo
Enantia polycarpa	t	GC	9	G1	(O): So-tu; (G): So-hin
Endosiphon primuloides	h	GC	-	G2	
Entada scelerata	c	GC	+	G8	
Entandrophragma angolense	T	GC	+	G1	(O, G): Dôhu-hè; (T): Tiama
Entandrophragma candollei	T	GC	+	G1	(O): Gnon-dôhu-hè; (G): Tchran-dôhu-hè
Entandrophragma cylindricum	T	GC	+	G1	
Epinetrum cordifolium	c	GC	*	M5	
Epinetrum scandens	c	Go	16		
Eremospatha hookeri	C	GC	+	M7	
Eremospatha macrocarpa	C	GC	5	G4, M3	(O): Nga-hin/Kplallè; (G): Gain
Eriocoelum kerstingii	t	GC	-	M5	
Erythrococca africana	t	GC	-	G2	
Erythrococca anomala	t	GC	24		
Erythrophleum ivorense	T	GC	2	G1	(O): Dje-rutu; (G): Dju-hu-hé; (T): Tali
Euadenia trifoliolata	t	GC	9		(O): Tu-i-tahan; (G): U-lintan-kahiè
Eugenia calophylloides	t	Go	13		
Eugenia miegeana	t	GC	-	G4	
Fagara macrophylla	T	GC	23		(O): Gbossu-hè; (G): Gbo-lu-è
Flagellaria guineensis	c	Tr	+	G8	
Funtumia africana	T	GC	12	G1, M2	(O): Folu-wlo-atu; (G): Ku-oro-atu
Funtumia elastica	T	GC	28		(O): Wlo-atu; (G): Oro-atu
Garcinia afzelii	t	GC	*	G1	(O): Gblôt-u-è; (G): Djé-i-gbéni
Garcinia gnetoides	t	GC	29		
Garcinia kola	t	GC	17		
Garcinia smeathmannii	t	GC	-	G1, M2	
Garcinia sp. 1	t		16		
Geophila afzelii	h	GC	5	G1, M2	(O): Bao-hô-huhii; (G): Kulâ-pôhé
Geophila hirsuta	h	GC	*	M2	
Geophila neurodictyon	h	GC	10	G4	
Geophila obvallata	h	GC	*	G1	(O): Bao-hô-huhii; (G): Kulâ-pôhé
Geophila repens	h	Tr	-	G1	

Gilbertiodendron ivorense	t	En	*	G5	(T): Métoloba
Gilbertiodendron limba	t	Go	*	G5	(T): Métoloba
Gilbertiodendron preussii	T	GC	6		(O): Ba-wê; (T): Vaa
Gilbertiodendron robynsianum	t	Go	-	G5	
Gilbertiodendron splendidum	t	Go	+	G7	(O): Ba-wohè
Gluema ivorensis	T	GC	-	G6	
Glyphaea brevis	t	Tr	2		
Grewia mollis	c	GC	12		
Griffonia simplicifolia	C	GC	8		(O): Ba-du-à; (G): Gnè-nanga
Guaduella oblonga	h	GC	*	G1	(O): Sro-pinnon; (G): Sa-hohon-pèlê
Guarea cedrata	T	GC	8		(O): Gbè-a-tu; (T): Bossê
Guarea leonensis	t	En	+	G3	
Halopegia azurea	h	GC	*	G7, M9	(O): Hrin-hu-an; (G): Sran-konhu
Harungana madagascariensis	t	Tr	23		(O): Tora; (G): Srôhè
Heinsia crinita	t	GC	4		(O): Hiro-wandê; (G): Kula-dilê
Heisteria parvifolia	t	GC	8	G2, M9	(O): Koro-ulatu; (G): Kula-dé
Helictonema velutina	C	GC	-	G1	
Heteropteris leona	c	GC	-	G8	
Hexalobus crispiflorus	t	GC	+	G8	
Hibiscus surattensis	h	Tr	21		(O): Kloa-gboa
Hugonia platysepala	C	GC	13		
Hugonia rufopilis	c	Go	9		
Hunteria eburnea	T	GC	16		
Hunteria elliotii	t	GC	16		
Hunteria simii	t	En	1		(O): Nolin-hu-an
Hymenostegia afzelii	t	GC	15	G2	(O): Kbing-kbing-sahè; (G): Zô-sahân
Hypolytrum africanum	h	GC	-	M2	
Hypolytrum heteromorphum	h	GC	*	G2	
Hypolytrum poecilolepis	h	Go	6	G2	
Hypselodelphys poggeana	c	GC	20		(O): Tihu-hin-kari
Hypselodelphys violacea	c	GC	26		(O): Kari; (G): Gahi
Icacina mannii	C	GC	+	M2	
Iodes liberica	C	GC	+	G1	
Irvingia gabonensis	T	GC	+	G1	(O): Gbêlé/Bélétu; (G): Kplêtu
Isolona thonneri	t	GC	-	M7	
Isonema smeathmannii	t	Go	*	G8	
Ixora aggregata	t	En	-	G4	
Ixora laxiflora	t	Go	*	G3, M3	
Jasminium pauciflorum	c	Tr	8		
Kantou guereensis	T	En	+		(O, G): Kantu
Khaya anthotheca	T	GC	+	G1	(O): Dè-gihin; (G): Nolô-huhè-yré
Kigelia africana	T	Go	+	G5	(O, G): Montu
Klainedoxa gabonensis	T	GC	*	G4	(O): Talè; (G): Gblo-hahè; (T): Kroma
Kolobopetalum chevalieri	c	GC	23		(O): Nôlôli
Kolobopetalum leonense	c	Go	4		
Landolphia dulcis	C	GC	*	G1	(O): Gbagli; (G): Klèhèd-bu
Landolphia hirsuta	C	GC	7	M1	
Landolphia membranacea	C	GC	4	G1	(O): Kpô-hulu; (G): Péhê/Gulô-gweebê
Landolphia owariensis	C	GC	29	G1, M1	
Landolphia togolana	c	GC	-	M1	
Lankesteria brevior	h	GC	12		(O): Gnamba/hawèmin; (G): Gnê-angnon

Lasiantus batangensis	t	GC	+	G3, M2	
Lasiodiscus fasciculiflorus	t	GC	17	G2	
Leea guineensis	h	GC	25		(O): I-i-hèlê
Leptoderris fasciculata	C	GC	4		
Leptoderris miegei	C	GC	10		(O): Kpa-hulu-saha
Leucomphalus capparideus	C	GC	-	G6	
Linociera mildbreadii	t	GC	9		
Lomariopsis guineensis	f	GC	*	G4	
Lomariopsis rossii	f	GC	9		
Lonchitis reducta	f	GC	1		
Lophira alata	T	GC	+	M2	(O): Wao-tu; (G): Fao-hè
Lovoa trichilioides	t	GC	9		(G): Tchranlôhu-è
Lychnodiscus reticulatus	t	GC	9		
Macaranga barteri	t	GC	23		(O): Kpèpè-yô; (G): Poyè
Macaranga cf. sp. *A. FWTA*	t		17		(O): Pê-yo'Cavally'
Macaranga heterophylla	t	GC	14		(O): Buwapi-hô
Macaranga heudelotii	t	Go	+	G5	
Macaranga hurifolia	t	GC	23		(O): Pê-yô; (G): Gahi-faw-ho
Maesobotrya barteri	t	GC	29	G1, M2	(O): Gbôhotu; (G): Zahè-lohu
Mallotus oppositifolius	t	Tr	21		(G): Gnahèkula-è
Mammea africana	T	GC	+	G1	(O): Hônlôntu;; (G): Srutu-ê
Manotes expansa	c	En	10		
Mapania baldwinii	h	Go	3	G3, M7	
Mapania coriandrum	h	Go	19	G4, M7	
Mapania linderi	h	Go	+	G3, M7	
Mapania macrantha	h	GC	-	G4	
Mapania superba	h	GC	-	G3	
Marantochloa congensis	c	GC	20		(O): Bai-bai; (G): Zibokônhu
Marantochloa filipes	h	GC	29		(O): Bay bay
Marantochloa leucantha	c	GC	26	G7	(O): Duli
Marantochloa purpurea	c	GC	-	G7	
Mareya micrantha	t	GC	2		(O): Wanbê; (G): Trahin
Maschalocephalus dinklagei	h	Go	+	G7, M9	
Massularia acuminata	t	GC	27	G1, M2	(O): Lôdjurê; (G): Gain-djulu-è
Megaphrynium distans	h	Go	25		(O): Srai-huhii; (G) :Srai-kônhii
Memecylon cinnamomoides	t	Go	1		
Memecylon guineense	t	GC	*	G3, M3	(O): Gu-è-gwee-é; (G): Gu-ê-sahin
Memecylon lateriflorum	t	GC	*		
Memecylon membranifolium	t	GC	*	G6	
Mendoncia combretoides	C	Go	4		
Mendoncia iodioides	c	GC	-	M2	
Microdesmis puberula	t	GC	*	G1	(O): Klahatu-ê; (G): Nlolo-ê
Mildbraedia paniculata	t	GC	21		(O): Domassa/Waho-è; (G): Gwê-yênin
Millettia chrysophylla	c	GC	18	G6	
Millettia rhodantha	t	Go	10		(O): Ferreklao; (G): Fêminkula
Millettia sanagana	t	GC	-	G5	
Millettia zechiana	t	GC	24		(O): Tirrissaohô; (G): Blubo
Mitragyna ciliata	T	GC	+	G7, M8	(O): Taw; (G): Niombolo-è
Monodora crispata	t	GC	14		
Monodora myristica	t	GC	1	G1, M5	(O): Hanlontu-è/Balla-djô-tu; (G): Sontu-è

Monodora tenuifolia	t	GC	*	M1	(O): So-dus-darô
Morinda longiflora	c	GC	27		(O): Hirowandé
Myrianthus arboreus	t	GC	13	M1	(O): Térôtu; (G): Tôbôtu-è
Myrianthus libericus	t	Go	10		(O): Djré-térôtu; (G): Gbayobo-tôbôtu-è
Myrianthus serratus	t	GC	+	G5	
Napoleona leonensis	t	GC	29	G1, M1	(O): Mahângân/Djinlo; (G): Gwé-wèdjè
Nauclea diderrichii	T	Tr	3		(O): Tohotu; (G): Dohotu-è/Gnaléhin
Nauclea pobeguinii	T	GC	-	G5	
Nauclea xanthoxylon	T	GC	17		
Neosloetiopsis kamerunensis	t	Tr	18		(O): Gboa-sahè; (G): Sahân-kpahu
Neostenanthera gabonensis	t	GC	*	G4	
Nephthitis afzelii	h	Go	6	G1	
Nesogordonia papaverifera	T	GC	22		(T): Kotibé
Neuropeltis acuminata	C	GC	29	M1	(O): Pluhulu/Sasalingbé-hu-è; (G): Plodubu
Neuropeltis prevosteoides	C	Go	11	G1, M2	
Neuropeltis velutina	c	Go	11		
Newtonia duparquetiana	t	GC	3		(O, G): Gbla-tu-è
Ochthocosmus africanus	t	GC	*	M1	
Octoknema borealis	T	Go	12	M2	(O): Guhôtu; (G): Gu-é-sratu
Oeceoclades maculata	h	Tr	21		
Olax gambecola	t	GC	-	G1	
Olax subcorpioidea	t	GC	17		
Oldfieldia africana	T	En	14		
Omphalocarpum ahia	T	Go	+	G5, M2	
Oncoba spinosa	t	GC	20		(O): Kohontu
Ormocarpum verrucosum	c	GC	-	G8	
Ouratea duparquetiana	t	GC	*	G3	(O): Gnombè-huhon; (G): Kula-poha
Ouratea morsonii	t	En	-	G1	
Ouratea reticulata	t	GC	1		
Ouratea schoenleiniana	t	Go	7	G3, M3	(O): Gnombèhuhon; (G): Vahan-tu-è
Ouratea subcordata	t	GC	1	G4	
Oxyanthus formosus	t	GC	11	G5	
Oxyanthus pallidus	t	GC	*	G5	
Oxyanthus subpunctatus	t	GC	+	G5	
Pachypodanthium staudtii	T	GC	15	M3	(O): Klôklô-tu; (G): Vahè; (T): Aniketi
Pachystela brevipes	T	Tr	+	G6	
Palisota barteri	h	GC	8	G3	(O): Gnéronkla; (G): Sahôn-guhen
Palisota hirsuta	h	GC	20		(O): Gnèron-klaklao; (G): Kohodru-glo-aglo
Pancovia bijuga	t	GC	17	M1	
Panda oleosa	t	GC	*	G1	
Pandanus candelabrum	t	Go	20	G5	
Parinari aubrevillei	T	GC	10		(O): Tchrô; (G): Trô
Parinari congensis	T	GC	17		
Parinari excelsa	T	Tr	*	G1	(O): Kontu-è; (G): Kotu-è
Parinari glabra	T	GC	-	G1, M2	
Pararistolochia macrocarpa	c	GC	-	G1	
Parkia bicolor	T	GC	2	M2	(O): Bohotu; (G): Nigbéhi-gô/Pohin
Pauridiantha hirtella	t	GC	+	G1	

Pavetta staudtii	t	GC	20		
Pellegriniodendron diphyllum	t	GC	+	G5	
Penianthus zenkeri	t	GC	+	G1	
Pentaclethra macrophylla	T	GC	19	G1	(O): Djulôtu
Pentadesma butyracea	t	GC	+	G1	(O, G): Srutu-è
Picralima nitida	t	GC	-	G1	
Piper guineense	c	GC	29	M1	(O): Pohan-ulu; (G): Poi-hin-dubu
Piptadeniastrum africanum	T	GC	8	G1, M1	(O, G): Gô; (T): Dabéma
Piptostigma aubrevillei	t	GC	13		
Placodiscus pseudostipularis	t	Go	+	G4	
Plagiosyphon emarginatus	T	En	18		(O): Sahè; (G): Sahan
Platysepalum hirsutum	C	GC	8		(O): Kpahulu
Pleiocarpa mutica	t	GC	*	M2	
Pollia condensata	h	GC	*	G1	
Polyalthia oliveri	t	GC	*	G2	(O): Soho-dudaro; (G): Pulu-è
Polyceratocarpus parviflorus	t	GC	10		
Polyspatha paniculata	h	GC	10		
Polystemonanthus dinklagei	t	En	-	G5	
Popowia mangenotii	c	GC	12	G4	(O): Paréo-hu-on; (G): Bahié-honlon
Protomegabaria stapfiana	t	GC	-	G7, M9	
Pseuderanthenum tunicatum	h	GC	14		
Psilanthus mannii	t	GC	16		
Psychotria sciadephora	t	GC	8		
Psychotria subobliqua	t	GC	*	G1	
Pteris burtonii	f	GC	14	M2	
Pterocarpus santalinoides	T	Tr	-	G6	
Ptychopetalum anceps	t	Go	1	G3, M3	(O): Séhi-é-tu-é; (G): Gnlon-kayè
Pycnanthus angolensis	T	GC	*	M1	(O): Turutu; (G): Di-iyè
Pycnocoma macrophylla	t	GC	8	G1	(O): Kloa-pu-o; (G): Béhédohi
Pyrenacantha vogeliana	c	GC	5		
Quisqualis indica	c	Tr	-	G8	
Raphia hookeri	t	GC	26	G7	(O): Hylo; (G): Dolu; (T): Raphia bangui
Raphia sassandrensis	t	En	4	G7	(O): Djakaha; (G): Djandolu; (T): Raphia papot
Renealmia maculata	h	GC	-	G3	
Rhaphidophora africana	C	GC	12	G1, M2	
Rhaphiostylis beninensis	C	GC	29	G3	(O, G): Plapla
Rhaphiostylis cordifolia	c	En	14		
Rhigiocarya racemifera	c	GC	4		(O): Hu-lingli
Rhinacanthus virens	h	GC	1		
Rhynchospora corymbosa	h	Tr	18		
Ricinodendron heudelotii	T	GC	25		(O): Karetu; (G): Kolotu
Rinorea elliotii	t	GC	-	G1, M1	
Rinorea ilicifolia	t	Tr	15	G1	(O): Gni-é-hulo-huhon; (G): Kalaka-hulin
Rinorea longicuspis	t	Go	29		(O): Kparu-tu
Rinorea oblongifolia	t	GC	11		(O): Ko-tu-è
Rothmannia whitfieldii	t	Tr	22	G1	(O): Plè-huhon/Mblè; (G): Bohè-ghon
Rutidea parviflora	c	GC	24		
Sacoglottis gabonensis	T	G	6	G4, M2	(O): Tèhè-tu; (G): Déhè-tu-è
Salacia calumna	c	En	1		
Salacia debilis	c	GC	29		

Salacia elegans	c	Tr	1		
Salacia erecta	c	GC	13		
Salacia lateritia	C	G	14		
Salacia leonensis	t	GC	18		
Salacia miegei	c	Go	2		
Salacia nitida	C	GC	+	M5	
Salacia uregaensis	t	GC	+	G2	
Sarcophrynium brachystachys	h	GC	5	G7, M1	(O): Gbêhêrêhê/Blêhu-on; (G): Diankoho
Scaphopetalum amoenum	t	Go	+		(O): Dawi
Scleria barteri	c	GC	23		(O, G): Gnan
Scytopetalum tieghemii	t	Go	20	G3, M3	(O): Sêhi-ê-tu-ê; (G): Fahê-gbohè
Secamone afzelii	c	GC	24		(O): Tihi-huhi
Selaginella vogelii	f	GC	-	G4	
Sherbournia calycina	c	Go	24		(O): Gbêhêrêhê/Blêhu-on; (G): Diankoho
Soyauxia floribunda	t	Go	*	M7	(O): Palu-tu
Sphenocentrum jollyanum	t	GC	+	G1, M1	
Spiropetalum heterophyllum	C	GC	14		
Spondianthus preussii	T	GC	5	G5, M8	(O): Nêkara; (G): Baw-hangu
Stanfieldiella imperforata	h	Tr	11	G1	
Staurogyne capitata	h	GC	-	G7	
Stephania dinklagei	c	GC	24		(O): Ti-gblô-hu-on
Sterculia oblonga	T	GC	11		(O): Po-huhin; (T): Bi
Stereospermum acuminatissimum	T	GC	22		
Strephonema pseudocola	T	GC	*	G1, M2	(O): Tu-hètu
Strombosia glaucescens	T	GC	29	G1, M1	(O): Hu-hê; (G): Su-hen-su-wê
Strychnos aculeata	C	GC	1	G1	(O): Gahu-hulu; (G): Gôtu
Strychnos cuminodora	C	Go	3		(O): Njalo-huhin
Strychnos ngouniensis	C	GC	12		
Strychnos usambarensis	C	Tr	19		
Symphonia globulifera	t	Tr	+	G7	
Tabernaemontana crassa	t	GC	+	G1, M5	
Tarenna bipindensis	c	GC	-	G1	
Tarrietia utilis	T	Go	6	G4, M7	(O): Baohè-soho;; (G): Baohè/Zi-êloa
Tetracera alnifolia	c	GC	+	G8	(O): Glê-hulu
Tetracera potatoria	C	GC	*	G4	(O): Glê-hulu; (G): Zo-hutu
Tetrapleura tetraptera	t	GC	-	G1	
Tetrorchidium didymostemon	t	Tr	*	G1	(O): Glê-hulu; (G): Zêhê-dubu
Tetrorchidium oppositifolium	t	GC	-	G4	
Thalia welwitschii	h	GC	5		(O): Di-uhon
Thaumatococcus daniellii	h	GC	26		(O): Ko-hu-hin; (G): Flaê-kon-hii
Thecacoris stenopetala	t	GC	19		(O): Ha-yrê-mbamum; G): Za-yrê-gomgbo
Thonningia sanguinea	h	Tr	+	G1, M1	(O): Uru-ohon; (G): Glu-glan
Tieghemella heckelii	T	GC	+	G1	(O): Dju-rutu; (G): Dju-lutu; (T): Makorê
Tiliacora dinklagei	C	Go	29	M1	(O): Kpala-kpala; (G): Kula-hê-dubu
Trachyphrynium braunianum	c	GC	26		(O): Du-li
Tragia benthami	c	Tr	23		(O): Hu-hen; (G): Su-hen
Tragia vogelii	c	GC	21		
Treculia africana	T	GC	+	G6	(O): Hu-rutu; (G): Y-urutu
Tricalysia macrophylla	t	GC	9		
Tricalysia reflexa	t	GC	*	G1	

Trichilia heudelotii	t	GC	4	G1	(O): Tahantu
Trichoscypha arborea	t	GC	3	G1, M2	(O): Narô; (G): Zimantu
Trichoscypha beguei	t	Go	7	G3	
Trichoscypha chevalieri	t	Go	12	G3	
Trichoscypha oba	t	GC	1		
Triclisia macrophylla	C	GC	2		
Triphyophyllum peltatum	C	En	3		
Triplochiton scleroxylon	T	GC	22		(O): Pôhôtu; (G): Hu-lo-lu-è; (T): Samba
Turraeanthus africanus	T	GC	-	M5	
Uapaca esculenta	T	GC	6	G1, M2	(O): Gbôwè; (G): Gbu-lu-è
Uapaca guineensis	T	GC	4	G1, M2	(O): Gbôwè; (G): Gbu-lu-è
Uapaca heudelotii	T	GC	4	G6	(O): Gbôwè
Uapaca paludosa	t	GC	+	G7	
Uncaria africana	C	GC	+	G6	(O): Kpo-dao/Zalu; (G): Bèhé-ku-hin
Uvaria afzelii	c	Go	24		(O): Paréo-hu-on; (G): Bahié-konhu
Uvariopsis guineensis	t	GC	12		
Ventilago africana	C	GC	6	M1	
Vitex micrantha	t	Go	4		(O): Parakla; (G): Gbaha-palu-trô/ Kpa-tu-è
Voacanga bracteata	c	GC	-	G1	
Xylopia acutiflora	t	GC	6	G1, M11	
Xylopia aethiopica	t	GC	23		(O): Pow-wé; (G): Gbohè-plu
Xylopia parviflora	t	GC	+	G5	
Xylopia quintasii	t	GC	29		(O): Gbohè-zôhô; (G): Gbohè
Xylopia villosa	t	GC	8	M1	

Appendix IV List of plant species mentioned in the text

ACANTHACEAE
Endosiphon primuloides T. Anders ex Benth.
Lankesteria brevior C.B. Cl.
Mendoncia combretoides (A. Chev.) Benoist
Mendoncia iodioides (S. Moore) Heine
Pseuderanthenum tunicatum (Afz.) Milne-Redhead
Rhinacanthus virens (Nees) Milne-Redhead
Staurogyne capitata E.A. Bruce

ADIANTACEAE
Adiantum vogelii Mett. ex Keys

AGAVACEAE
Dracaena camerooniana Bak.
Dracaena elliotii Bak.
Dracaena humilis Bak.
Dracaena ovata Ker-Gawl.
Dracaena smithii Bak.ex Hook.f.
Dracaena surculosa Lindl.

AMPELIDACEAE
Cissus aralioides (Welw. ex. Bak.) Planch.
Cissus diffusiflora (Bak.) Planch.
Cissus polyantha Gilg & Brandt
Cissus producta Afz.
Leea guineensis G. Don

ANACARDIACEAE
Trichoscypha arborea (A. Chev.) A. Chev.
Trichoscypha beguei Aubr. & Pellegr.
Trichoscypha chevalieri Aubr. & Pellegr.
Trichoscypha oba Aubr. & Pellegr.

ANCISTROCLADACEAE
Ancistrocladus abbreviatus Airy Shaw

ANNONACEAE
Cleistopholis patens (Benth.) Engl. & Diels
Enantia polycarpa (DC.) Engl. & Diels
Hexalobus crispiflorus A. Rich.
Isolona thonneri (De Wild. & Th. Dur.) Engl. & Diels
Monodora crispata Engl. & Diels
Monodora myristica (Gaertn.) Dunal
Monodora tenuifolia Benth.
Neostenanthera gabonensis (Engl. & Diels) Exell
Pachypodanthium staudtii Engl. & Diels
Piptostigma aubrevillei Ghesq. ex Aubrev.
Polyalthia oliveri Engl.
Polyceratocarpus parviflorus (Bak.f.) Ghesq.
Popowia mangenotii Sillans
Uvaria afzelii Sc. Elliot
Uvariopsis guineensis Keay
Xylopia acutiflora (Dunal) A. Rich.
Xylopia aethiopica (Dunal) A. Rich.
Xylopia parviflora (A. Rich.) Benth.
Xylopia quintasii Engl. & Diels
Xylopia villosa Chipp

APOCYNACEAE
Alstonia boonei De Wild.
Aphanostylis leptantha (K. Schum.) Pierre
Baissea zygodioides (K. Schum.) Stapf
Funtumia africana (Benth.) Stapf
Funtumia elastica (Preuss) Stapf
Hunteria eburnea Pichon
Hunteria elliotii (Stapf) Pichon
Hunteria simii (Stapf) H. Huber
Isonema smeathmannii Roem. & Schult.
Landolphia dulcis (R. Br. ex Sabine) Pichon
Landolphia hirsuta (Hua) Pichon
Landolphia membranacea (Stapf) Pichon
Landolphia owariensis P. Beauv.
Landolphia togolana (Hallier f.) Pichon
Picralima nitida (Stapf) Th. & Dur.
Pleiocarpa mutica Benth.
Tabernaemontana crassa Benth.
Voacanga bracteata Stapf

ARACEAE
Cercestis afzelii Schott
Cercestis sagittatus Eng.
Cercestis stigmaticus N.E. Br.
Culcasia angolensis Welw. & Schott
Culcasia dinklagei Aké Assi
Culcasia liberica N.E. Br.
Culcasia longivaginata Engl.
Culcasia mannii (Hook.F.) Engl.
Culcasia parviflora N.E. Br.
Culcasia piperoides A. Chev.
Culcasia saxatilis A. Chev.
Culcasia scandens P. Beauv.
Culcasia seretii De Wild.
Nephthitis afzelii Schott
Rhaphidophora africana N.E. Br.

ARISTOLOCHIACEAE
Pararistolochia macrocarpa (Duch.) Poncy

ASCLEPIADACEAE
Secamone afzelii (Schultes) K. Schum.

ASTERACEAE
Chromolaena odorata (L.) King & Robinson

BALANOPHORACEAE
Thonningia sanguinea Valh.

BIGNONIACEAE
Kigelia africana (Lam.) Benth.
Stereospermum acuminatissimum K. Schum.

BOMBACACEAE
Ceiba pentandra (L.) Gaertn.

BORAGINACEAE
Cordia platythyrsa Bak.

BURSERACEAE
Canarium schweinfurtii Engl.
Dacryodes klaineana (Pierre) H.J. Lam

CAESALPINIACEAE
Amphimas pterocarpoides Harms
Anthonotha fragans (Bak.) Exell & Hillcoat
Anthonotha macrophylla P. Beauv.
Berlinia occidentalis Keay
Bussea occidentalis Hutch.
Chidlowia sanguinea Hoyle
Crudia klainei Pierre ex De Wild.
Cynometra ananta Hutch. & Dalz.
Cynometra megalophylla Harms
Daniellia thurifera Benn.
Dialium aubrevillei Pellegr.
Dialium dinklagei Harms
Erythrophleum ivorense A. Chev.
Gilbertiodendron ivorense (A. Chev.) J. Léonard
Gilbertiodendron limba (Sc. Elliot) J. Léonard
Gilbertiodendron preussii (Harms) J. Léonard
Gilbertiodendron robynsianum Aubr. & Pellegr.
Gilbertiodendron splendidum (A. Chev. ex Hutch. & Dalz.) J. Léonard
Griffonia simplicifolia (Vahl ex DC.) Baill.
Hymenostegia afzelii (Oliv.) Harms
Pellegriniodendron diphyllum (Harms) J. Léonard
Plagiosyphon emarginatus (Hutch. & Dalz.) J. Léonard
Polystemonanthus dinklagei Harms

CAPPARIDACEAE
Buchholzia coriacea Engl.
Euadenia trifoliolata (K. Schum. & Thonn.) Oliv.

CELASTRACEAE
Bequaertia mucronata (Exell) R. Wilcz.
Cuervea macrophylla (Vahl) R. Wilcz. ex N. Hallé
Helictonema velutina (Alz.) R. Wilcz. ex N. Hallé
Salacia debilis (G. Don) Walp.
Salacia calumna N. Hallé
Salacia elegans Welw. ex Oliv.
Salacia erecta (G. Don) Walp.
Salacia lateritia N. Hallé
Salacia leonensis Hutch. & Moss.
Salacia miegei N. Hallé
Salacia nitida (Benth.) N.E. Br.
Salacia uregaensis R. Wilcz.

CHAILLETIACEAE
Dichapetalum angolense Chodat.
Dichapetalum cymulosum (Oliv.) Engl.
Dichapetalum pallidum (Oliv.) Engl.
Dichapetalum toxicarium (G. Don) Baill.

COMBRETACEAE
Combretum homalioides Hutch. & Dalz.
Combretum racemosum P. Beauv.
Quisqualis indica L.
Strephonema pseudocola A. Chev.

COMMELINACEAE
Buforrestia mannii C.B. Cl.
Palisota barteri Hook.
Palisota hirsuta K. Schum.
Pollia condensata C.B. Cl.
Polyspatha paniculata Benth.
Stanfieldiella imperforata (C.B. Cl.) Brenan

CONNARACEAE
Agelaea obliqua (P. Beauv.) Baill.
Agelaea trifolia (Lam.) Gilg
Byrsocarpus coccineus K. Schum. & Thonn.
Cnestis ferruginea DC.
Manotes expansa Soland. ex Planch.
Spiropetalum heterophyllum (Bak.) Gilg

CONVOLVULACEAE
Calycobolus africanus (G. Don) Heine
Calycobolus heudelotii (Bak. ex Oliv.) Heine
Calycobolus parviflorus (Mangenot) Heine
Neuropeltis acuminata Benth.
Neuropeltis prevosteoides Mangenot
Neuropeltis velutina Hallier f.

CYPERACEAE
Hypolytrum africanum Nees ex Steud.
Hypolytrum heteromorphum Nelmes
Hypolytrum poecilolepis Nelmes
Mapania baldwinii Nelmes
Mapania coriandrum Nelmes
Mapania linderi Hutch. & Dalz.
Mapania macrantha (Boeck.) Pfeiff.
Mapania superba G.B. Cl.
Rhynchospora corymbosa (L.) Britt.
Scleria barteri Boeck.

DENNSTAEDTIACEAE
Lonchitis reducta C. Chr.

DILLENIACEAE
Tetracera alnifolia Wild.
Tetracera potatoria Afz. ex G.Don

DIONCOPHYLLACEAE
Triphyophyllum peltatum (Huth. & Dalz.) A. Shaw

DIOSCOREACEAE
Dioscorea burkilliana J. Miège
Dioscorea praehensilis Benth.
Dioscorea smilacifolia De Wild.

EBENACEAE
Diospyros canaliculata De Wild.
Diospyros chevalieri De Wild.
Diospyros gabunensis Gürke
Diospyros heudelotii Hiern
Diospyros kamerunensis Gürke
Diospyros mannii Hiern
Diospyros sanza-minika A. Chev.
Diospyros soubreana F.White
Diospyros vignei F. White

EUPHORBIACEAE
Alchornea cordifolia (K. Schum. & Thonn.) Müll. Arg.
Alchornea floribunda Müll. Arg.
Antidesma membranaceum Müll. Arg.
Antidesma oblonga (Hutch.) Keay
Cleistanthus polystachyus Hook.f. ex Planch.
Crotonogyne chevalieri (Beille) Keay
Discoglypremna caloneura (Pax) Prain
Drypetes aylmeri Hutch. & Dalz.

Drypetes chevalieri Beille
Drypetes ivorensis Hutch. & Dalz.
Drypetes pellegrini Léandri
Elaeophorbia grandifolia (Haw.) Croizat
Erythrococca africana (Baill.) Prain
Erythrococca anomala (Juss. ex Poir.) Prain
Macaranga barteri Müll. Arg.
Macaranga cf. sp. A., FWTA t.1, p. 408 sub 10
Macaranga heterophylla (Müll. Arg.) Müll. Arg.
Macaranga heudelotii Baill.
Macaranga hurifolia Beille
Maesobotrya barteri (Baill.) Hutch.
Mallotus oppositifolius (Geisel.) Müll. Arg.
Mareya micrantha (Benth.) Müll. Arg.
Microdesmis puberula Hook.f. ex Planch.
Mildbraedia paniculata Pax
Oldfieldia africana Benth. & Hook.f.
Protomegabaria stapfiana (Beille) Hutch.
Pycnocoma macrophylla Benth.
Ricinodendron heudelotii (Baill.) Pierre ex Pax
Spondianthus preussii Engl.
Tetrorchidium didymostemon (Baill.) Pax & Hoffm.
Tetrorchidium oppositifolium (Pax) Pax & Hoffm.
Thecacoris stenopetala (Müll. Arg.) Müll. Arg.
Tragia benthami Bak.
Tragia vogelii Keay
Uapaca esculenta A. Chev. ex Aubr.& Léandri
Uapaca guineensis Müll. Arg.
Uapaca heudelotii Baill.
Uapaca paludosa Aubr. & Léandri

FLACOURTIACEAE
Caloncoba brevipes (Stapf) Gilg
Oncoba spinosa Forsk.

FLAGELLARIACEAE
Flagellaria guineensis K. Schum.

GRAMINEAE
Guaduella oblonga Hutch.

GUTTIFEREAE
Allanblackia floribunda Oliv.
Garcinia afzelii Engl.
Garcinia kola Heckel
Garcinia sp. 1
Garcinia smeathmannii (Planch. & Triana) Oliv.
Garcinia gnetoides Hutch. & Dalz.
Mammea africana Sabine
Pentadesma butyracea Sabine
Symphonia globulifera Linn.f.

HUMERIACEAE
Sacoglottis gabonensis (Baill.) Urb.

HYPERICACEAE
Harungana madagascariensis Lam. ex Poir.

ICACINACEAE
Alsodeiopsis staudtii Engl.
Chlamydocarya macrocarpa (A. Chev.) Hutch. & Dalz.
Icacina mannii Oliv.
Iodes liberica Stapf

Pyrenacantha vogeliana Baill.
Rhaphiostylis beninensis (Hook.f. ex Planch.) Planch. ex Benth.
Rhaphiostylis cordifolia Hutch. & Dalz.

IRVINGIACEAE
Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill.
Klainedoxa gabonensis Pierre ex Engl.

IXONANTHACEAE
Ochthocosmus africanus Hook.f.

LAURACEAE
Beilschmidia bitehi Aubr.
Beilschmidia mannii (Meisn.) Benth. & Hook.f.

LECYTHIDACEAE
Combretodendron macrocarpum (P. Beauv.) Keay
Napoleona leonensis Hutch. & Dalz.

LINACEAE
Hugonia platysepala Welw.ex Oliv.
Hugonia rufopilis A. Chev.ex Hutch. & Dalz.

LOGANIACEAE
Anthocleista djalonensis A. Chev.
Anthocleista nobilis G. Don
Anthocleista vogelii Planch.
Strychnos aculeata Solered.
Strychnos cuminodora Leeuwenberg.
Strychnos ngouniensis Pellegr.
Strychnos usambarensis Gilg

MALPIGHIACEAE
Acridocarpus longifolius (G. Don) Hook.f.
Acridocarpus smeathmannii (DC.) Guill. & Perr.
Heteropteris leona (Cav.) Exell

MALVACEAE
Hibiscus surattensis L.

MARANTACEAE
Ataenidia conferta (Benth.) Milne-Redhead
Halopegia azurea K. Schum.
Hypselodelphys poggeana (K. Schum.) Milne-Redhead
Hypselodelphys violacea (Ridl.) Milne-Redhead
Marantochloa congensis (K. Schum.) J. Léonard & Mullend.
Marantochloa filipes (Benth.) Hutch.
Marantochloa leucantha (K. Schum.) Milne-Redhead
Marantochloa purpurea (Ridl.) Milne-Redhead
Megaphrynium distans Hepper
Sarcophrynium brachystachys (Benth.) K. Schum.
Thalia welwitschii Ridl.
Thaumatococcus daniellii (Benn.) Benth.
Trachyphrynium braunianum (K. Schum.) Bak.

MEDUSANDRACEAE
Soyauxia floribunda Hutch.

MELASTOMATACEAE
Memecylon cinnamomoides G. Don
Memecylon guineense Keay
Memecylon lateriflorum (G. Don) Brem.
Memecylon membranifolia Hook.f.

MELIACEAE
Carapa procera DC.
Entandrophragma angolense (Welw.) C. DC.
Entandrophragma candollei Harms
Entandrophragma cylindricum (Sprangue) Sprangue
Guarea cedrata (A. Chev.) Pellgr.
Guarea leonensis Hutch. & Dalz.
Khaya anthotheca (Welw.) C. DC.
Lovoa trichilioides Harms
Trichilia heudelotii Planch ex Oliv.
Turraeanthus africanus (Welw. ex C. DC.) Pellegr.

MENISPERMACEAE
Epinetrum cordifolium Mangenot & Miège
Epinetrum scandens (Mangenot & Miège) Form.
Kolobopetalum chevalieri (Hutch. & Dalz.) Troupin
Kolobopetalum leonense Hutch. & Dalz.
Penianthus zenkeri (Engl.) Diels
Rhigiocarya racemifera Miers.
Sphenocentrum jollyanum Pierre
Stephania dinklagei (Engl.) Diels
Tiliacora dinklagei Engl.
Triclisia macrophylla Oliv.

MIMOSACEAE
Acacia pennata (L.) Willd.
Albizia adianthifolia (K. Schum.) W.F. Wright
Cathormion altissimum (Hook.f.) Hutch. & Dandy
Newtonia duparquetiana (Baill.) Keay
Parkia bicolor A. Chev.
Pentaclethra macrophylla Benth.
Piptadeniastrum africanum (Hook.f.) Brenan
Tetrapleura tetraptera (K. Schum. & Thonn.) Taub.

MORACEAE
Antiaris welwitschii Engl.
Chlorophora excelsa (Welw.) Benth.
Craterogyne kameruniana (Engl.) Lanjouw
Dorstenia smythei Sprague
Myrianthus arboreus P. Beauv.
Myrianthus libericus Rendle
Myrianthus serratus (Trécul.) Benth. & Hook.f.
Neosloetiopsis kamerunensis Engl.
Treculia africana Decne.

MYRISTICACEAE
Pycnanthus angolensis (Welw.) Warb.

MYRTACEAE
Eugenia calophylloides DC.
Eugenia miegeana Aké Assi

OCHNACEAE
Lophira alata Banks ex Gaertn.
Ouratea duparquetiana (Baill.) Gilg
Ouratea morsonii Hutch. & Dalz.
Ouratea reticulata (P. Beauv.) Engl. ex Gilg
Ouratea schoenleiniana (Klozch.) Gilg
Ouratea subcordata (Stapf) Engl.

OCTOKNEMATACEAE
Octoknema borealis Hutch. & Dalz.

OLACACEAE
Coula edulis Baill.
Heisteria parvifolia Sm.
Olax gambecola Baill.
Olax subscorpioidea Oliv.
Ptychopetalum anceps Oliv.
Strombosia glaucescens Engl.

OLEACEAE
Jasminium pauciflorum Benth.
Linociera mildbreadii Gilg & Schnell

ORCHIDACEAE
Corymborkis corymbosa Thou.
Oeceoclades maculata (Lindley) Lindley

PALMACEAE
Ancistrophyllum laeve (Mann & Wendl.) Drude
Ancistrophyllum opacum (Mann & Wendl.) Drude
Ancistrophyllum secundiflorum Wendl.
Calamus deëratus Mann & Wendl.
Elaeis guineensis Jacq.
Eremospatha hookeri (Mann & Wendl.) Wendl.
Eremospatha macrocarpa (Mann & Wendl.) Wendl.
Raphia hookeri Mann & Wendl.
Raphia sassandrensis A. Chev.

PANDACEAE
Panda oleosa Pierre

PANDANACEAE
Pandanus candelabrum P. Beauv.

PAPILIONACEAE
Angylocalyx oligophyllus (Bak.) Bak.f.
Baphia nitida Lodd.
Baphia polygalacea Bak.
Baphiastrum confusum (Hutch. & Dalz.) Pellegr.
Entada scelerata A. Chev.
Leptoderris fasciculata (Benth.) Dunn
Leptoderris miegei Aké Assi & Mangenot
Leucomphalos capparideus Benth.ex Planch.
Millettia chrysophylla Dunn.
Millettia rhodantha Baill.
Millettia sanagana Harms
Millettia zechiana Harms
Ormocarpum verrucosum P. Beauv.
Platysepalum hirsutum (Dunn) Hepper
Pterocarpus santalinoides t'Hérit. ex DC.

PASSIFLORACEAE
Adenia lobata (Jacq.) Engl.

PIPERACEAE
Piper guineense K. Schum. & Thonn.

POLYGALACEAE
Carpolobia lutea G. Don

POLYPODIACEAE
Asplenium africanum Desv.
Ctenitis protensa (Afz. ex Sw.) Ching
Ctenitis variabilis (Hook.) Tard.

Lomariopsis guineensis (Und.) Alst.
Lomariopsis rossii Holtt.
Pteris burtonii Bak.

RAPATACEAE
Maschalocephalus dinklagei Gilg & K. Schum.

RHAMNACEAE
Lasiodiscus fasciculiflorus Engl.
Ventilago africana Exell

RHIZOPHORACEAE
Anopyxis klaineana (Pierre) Engl.

ROSACEAE
Afrolicanea elaeosperma Mildbr.
Parinari aubrevillei Pellegr.
Parinari congensis F. Didr.
Parinari excelsa Sabine
Parinari glabra Oliv.

RUBIACEAE
Bertiera bracteolata Hiern
Bertiera racemosa (G. Don) K. Schum.
Canthium hispidum Benth.
Cephaelis abouabouensis Schnell
Cephaelis biaurita (Hutch. & Dalz.) Hepper
Cephaelis mangenotii Aké Assi
Cephaelis peduncularis Salisb.
Cephaelis yapoensis (Schnell) Schnell
Chassalia corallifera (A. Chev. ex De Wild.) Hepper
Coffea humilis A. Chev.
Corynanthe pachyceras K. Schum.
Craterispermum caudatum Hutch.
Cuviera acutiflora DC.
Geophila afzelii Hiern
Geophila hirsuta Benth.
Geophila neurodictyon (K. Schum.) Hepper
Geophila obvallata (K. Schum.) Didrichsen
Geophila repens (L.) I.M. Johnston
Heinsia crinita (Afz.) G. Tayl.
Ixora aggregata Hutch.
Ixora laxiflora Sm.
Lasiantus batangensis K. Schum.
Massularia acuminata (G. Don) Bullock ex Hoyle
Mitragyna ciliata Aubr. & Pellegr.
Morinda longiflora G. Don
Nauclea diderrichii (De Wild. & Th. Dur.) Merril
Nauclea pobeguinii (Pobéguin ex Pellegr.) Petit
Nauclea xanthoxylon (A. Chev.) Aubr.
Oxyanthus formosus Hook.f. ex Planch.
Oxyanthus pallidus Hiern
Oxyanthus subpunctatus (Hiern) Keay
Pauridiantha hirtella (Benth.) Bremek.
Pavetta staudtii Hutch. & Dalz.
Psilanthus mannii Hook.f.
Psychotria sciadephora Hiern
Psychotria subobliqua Hiern
Rothmannia whitfieldii (Lindl.) Dandy
Rutidea parviflora DC.
Sherbournia calycina (G. Don) Hua
Tarenna bipindensis (K. Schum.) Bremek.
Tricalysia macrophylla K. Schum.

Tricalysia reflexa Hutch.
Uncaria africana G. Don

RUTACEAE
Araliopsis tabouensis Aubr. & Pellegr.
Citropsis articulata (Willd. ex Spreng.) Swingle & Kellerman
Fagara macrophylla Engl.

SAPINDACEAE
Blighia welwitschii (Hiern) Radlk.
Chytranthus longiracemosus Gilg & Raldk.
Chytranthus mangenotii N. Hallé & Aké Assi
Chytranthus setosus Radlk.
Deinbollia cuneifolia Bak.
Deinbollia pinnata (Poir.) K. Schum. & Thon.
Eriocoelum kerstingii Gilg ex Engl.
Lychnodiscus reticulatus Radlk.
Pancovia bijuga De Wild.
Placodiscus pseudostipularis Radlk.

SAPOTACEAE
Afrosersalisia afzelii (Engl.) A. Chev.
Aningeria robusta (A. Chev.) Aubrev. & Pellegr.
Chrysophyllum pruniforme Pierre ex Engl.
Chrysophyllum subnudum Bak.
Chrysophyllum taiense Aubr. & Pellegr.
Gluema ivorensis Aubr. & Pellegr.
Kantou guereensis Aubr. & Pellegr.
Omphalocarpum ahia A. Chev.
Pachystela brevipes (Bak.) Baill. ex Engl.
Tieghemella heckelii Pierre ex A. Chev.

SCYTOPETALACEAE
Scytopetalum tieghemii (A. Chev.) Hutch. & Dalz.

SELAGINELLACEAE
Selaginella vogelii Spring

STERCULIACEAE
Cola caricaefolia (G. Don) K. Schum.
Cola chlamydantha K. Schum.
Cola digitata Mast.
Cola heterophylla (P. Beauv.) Schott & Endl.
Cola lateritia var. *maclaudi* (A. Chev.) Brenan & Keay
Cola nitida (Vent.) Schott & Endl.
Nesogordonia papaverifera (A. Chev.) R. Capuron
Scaphopetalum amoenum A. Chev.
Sterculia oblonga Mast.
Tarrietia utilis (Spraque) Spraque
Triplochiton scleroxylon K. Schum.

THYMELEACEAE
Dicranolepsis persei Cummins

TILIACEAE
Desplatsia chrysochlamys (Mildbr. & Burret) Mildbr. & Burret
Glypaea brevis (Spreng.) Monachino
Grewia mollis Juss.

VERBENACEAE
Clerodendrum schweinfurtii var. *bakeri* Gürke
Clerodendrum splendens G. Don
Clerodendrum umbellatum Poir.

Clerodendrum volubile P. Beauv.
Vitex micrantha Gürke

VIOLACEAE
Decorsella paradoxa A. Chev.
Rinorea elliotii Engl.
Rinorea ilicifolia (Welw. ex Oliv.) O'Ktze
Rinorea longicuspis Engl.
Rinorea oblongifolia (C.H. Wright) Marquand ex Chipp

ZINGIBERACEAE
Aframomum sceptrum (Oliv. & Hanb.) K. Schum.
Costus schlechteri Winkler
Renealmia maculata Stapf

REFERENCES

Adjanohoun,E. and Guillaumet,J.L. (1960-1961). Etudes botaniques entre Bas Sassandra et Bas Cavally. Missions militaires 1960--1961. ORSTOM, Adiopodoume, Rapport ronéot. 14 p.

Alexandre,D.Y., Guillaumet,J.L., Kahn,F. and De Namur,C. (1978). Observations sur les premiers stades de la reconstitution de la forêt dense humide (Sud-Ouest de la Côte d'Ivoire). Cah. ORSTOM, sér. Biol. **XIII** (3) : 189-270

ANAM (1987). Les normales pluviométriques 1951-1980. Abidjan

Aubreville,A. (1959). Flore forestiere de la Côte d'Ivoire, 2e éd., CTFT, Nogent-sur-Marne, 3 volumes

Avenard,J.M., Eldin,M., Girard,G., Sircoulon,J., Touchebeuf,P., Guillaumet,J.L., Adjanohoun,E., Perraud,A. (1971). Le milieu naturel de la Côte d'Ivoire. Mém. ORSTOM no 50, Paris, 391 p.

initial Bos V (1964). Rapport de fin de levé des coupures Taï 4a-4c. B.R.G.M. Abidjan, Rapport SODEMI. 58 p., 16 annexes

Budelman, A. and Zander, P.M. (1990). Land-use by immigrant Baoule farmers in the Taï region, south-west Côte d'Ivoire (Ivory Coast). Agroforestry Systems **11**: 101-123.

Chaveau,J.-P. and Richard,J. (1977). Bodiba en Côte d'Ivoire. Du terroir à l'etat: petite production paysanne et salariat agricole dans un village Gban. ORSTOM, serie Sciences Humaines **IX** (1): 1-182.

Coleman,N.T. and Thomas,G.W. (1967). The basic chemistry of soil acidity. Agron.Monogr. **12**:1-41

Collinet,J., Monteny,B. and Pouyaud,B. (1984). Le milieu physique. in: Recherches et amenagement en milieu forestier humide: le Projet Taï de Côte d'Ivoire, eds J.L.Guillaumet, G.Couturier, H.Dosso., p.35-58. Notes techniques du MAB 15, UNESCO, Paris

Commission de Pédologie et de Cartographie des Sols (CPCS). (1967). Classification des sols. Travaux CPCS 1963-1969. 96 p.

De Koning,J. (1983). La forêt de Banco. Meded. Landbouwhogeschool Wageningen, **83** (1). 921 pp.

De Rouw,A. (1986). Un campement Baoulé, region de Taï, sud-ouest de la Côte d'Ivoire. in: Recherche entomologique dans les ecosystemes forestiers africains, eds G.Couturier, J.Boussienguet, H.Dosso, p. 125-128. Rapport de l'atelier régional Abidjan et Taï, Unesco, Paris.

De Rouw,A. (1987). Tree management as part of two farming systems in the wet forest zone (Ivory Coast). Acta Oecologica / Oecologia Applicata **8**: 39-51.

De Rouw,A. (1990). The invasion of Chromolaena odorata (ex-Eupatorium odoratum) and competition with the native flora, in a rain forest zone, south-west Côte d'Ivoire. J. of Biogeography, in press.

De Rouw,A. (in preparation). Rice, weeds and shifting cultivation in a rain forest. Ph.D.thesis, Wageningen

De Rouw,A. and Van Oers,C. (1988). Seeds in a rain forest soil and their relation to shifting cultivation. Cote d'Ivoire. Weed research **28** (5):373-382

Development and Resources Corporation (DRC). (1967). Soil Survey of the South-West region. Rapport prepared for the Government of Ivory Coast. New-York

Dove,M.R. (1983). Theories of Swidden agriculture and the political economy of ignorance. Agroforestry Systems 1 (1) : 85-99

FAO (1974). FAO-Unesco Soil Map of the World, 1:5.000.000. Vol. 1, Legend. Unesco. Paris

FAO (1977). Guidelines for soil profile description. 2nd edition. FAO, Rome, 66 p.

FAO (1988). FAO-Unesco Soil map of the world. Revised legend. World Soil Resources Report 60, FAO, Rome, 109 p.

FAO (1990). Amendment to the revised legend. Draft. April 1990, Rome.

Fraters,D. (1986). A study of a catena in the Taï-forest. Ivory Coast. M.Sc.-thesis, Department of Soil Science and Geology, Agricultural University, Wageningen. 64 p., Annexes

Fritsch,E. (1980). Etude pédologique et representation cartographique au 1/15.000e d'une zone de 1.600 ha représentative de la région forestière du Sud-Ouest Ivoirien. Rapport ORSTOM, multigr., 130 p.

Fritsch,E. (1982). Evolution des sols sous recrû forestier après mise en culture traditionnelle dans le sud-ouest de la Côte d'Ivoire. ORSTOM, Adiopodoume, multigr., 74 p.

Gauch,H.G. (1982). Multivariate analysis in community ecology. Cambridge University Press, 298 p.

Gnesio Tehe,H. (1980). Compréhension et utilisation du monde végétal chez les Guérés et les Oubis, Sud-Ouest de la Côte d'Ivoire. ORSTOM. Abidjan, multigr., 23 pp.

Guillaumet,J.L. (1967). Recherches sur la végetation et la flore de la région du Bas-Cavally (Côte d'Ivoire). Mém.ORSTOM 20, 249p
Guillaumet,J.L., Couturier,G. and Dosso,H., eds (1984). Recherches et amenagement en milieu forestier humide: le Projet Taï de Côte d'Ivoire. Notes techniques du MAB 15, UNESCO, Paris, 245 p.

Hall,J.B. and Swaine,M.D. (1981). Distribution and ecology of vascular plants in a tropical rain forest. Forest vegetation in Ghana. Dr W.Junk, publishers, The Hague, 383 p.

Hallé,N. (1962). Monographie des Hippocrateacees d'Afrique Occidentale. Mém.de l'Inst.Français d'Afrique Noire, no 64, Dakar, 245 p.

Hill,M. D. (1979a). TWINSPAN, a Fortran program for arranging multivariate data in an ordered two_way table by classification of the individuals and attributes. Ecology and Systematics, Cornell University, Ithaca, New-York

Hill,M. D. (1979b). DECORANA, a Fortran program for detrended correspondence analysis and reciprocal averaging. Ecology and Systematics. Cornell University, Ithaca, New-York

Holas,B. (1957). Le paysannat africain devant le problème des cultures industrielles : l'exemple des Oubi (Côte d'Ivoire). Revue de l'Inst. de Sociologie Solvay no 2 : 219-233

Hommel,P.W.F.M. (1987). Landscape ecology of Ujung Kulon (West Java, Indonesia). Ph.D thesis, Agricultural University. Wageningen. Soil Survey Institute, Wageningen, 206 p, 1 table, 1 map

Houba,V.J.G., Van der Lee,J.J., Novozamsky,I. and Walinga,I. (1989). Soil and Plant Analysis, a series of syllabi. Part 5, Soil Analysis Procedures. 5th ed.,Agricultural University, Wageningen

Hutchinson,J. and Dalziel,J.M. (1954-1972). Flora of West Tropical Africa. 2nd ed., revised by R.W.J.Keay and F.N.Hepper, 3 Vols, Crown Agents, London

Kamprath,E.J. (1973). Soil acidity and liming. in: A review of soils research in tropical Latin America, ed P.A.Sanchez. North Carolina Agr.Exp.Sta./U.S.A.I.D., Techn.Bull. no 219: 126-137

Knecht,A. (1963). Contribution a l'etude biosystématique des représentants d'Aracées de la Côte d'Ivoire. Thèse. Phanerogamarum Monographiae tomus XVII. J.Cramer Verlag, Vaduz, 290 p.

Köppen,W. (1936). Das geographische System der Klimate. in: Handbuch der Klimatologie, eds W.Köppen and R.Geiger, Bd. I, Teil C, Berlin, p. 1-44.

Küchler,A.W. and Zonneveld,I.S. (1988). Vegetation mapping. Handbook of Vegetation Science. Vol.10. Kluwer, Dordrecht, 635 p.

Lena,P., Martinet,J., Richard,F. and Schwartz A. (1977). Le dynamisme pionnier dans le Sud-Ouest ivoirien : ses effets sur le milieu forestier. ORSTOM/Unesco/MAB "Projet Taï". Rapport final. Abidjan, 266 p. + maps

Leneuf,N. (1956). Contribution à l'étude pédologique de l'ouest de la Côte d'Ivoire (vallee du Cavally, Taï, Tabou). ORSTOM, Adiopodoumé, roneot.

Lorougnon,G. (1972. Les Cyperacées forestières de Côte d'Ivoire. Mém. ORSTOM no.58, Paris. 102 p.

Mangenot,G. (1955). Etude sur les forêts des plaines et plateaux de la Côte d'Ivoire. Etudes éburnéennes I.F.A.N. **4** : 5-61.

Mensbrugge de la,G. (1966). La germination et les plantules des essences arborées de la forêt dense humide de la Côte d'Ivoire. CTFT, Nogent-sur-Marne. France, 379 p.

Miedema,R. and Van Vuure,W. (1977). The morphological, physical and chemical properties of two mounds of Macrotermes bellicosus (Smeathman) compared with surrounding soils in Sierra Leone. J. Soil Science **28**: 112-124.

Monteny,B.A. (1983). Observations climatiques a la station écologique de Taï dans le Sud-Ouest ivoirien, 1978-1982. Importance de la superficie de la défriche sur les paramètres climatiques mesurés. ORSTOM - Ministère de la Recherche Scientifique, Abidjan, 9 p.

Noij,I.G.A.M., Janssen,B.H. and Van Reuler,H. (1987). Modeling nutrient cycling in tropical forest areas - a case study of Taï, Côte d'Ivoire. Proc. 2nd Intern.Tropenbos Seminar. p. 122-128

Odell,R.T., Dijkerman,J.C., Van Vuure,W., Melsted,S.W., Beavers,A.H., Sutton,P.M., Kurtz,L.T. and Miedema,R. (1974). Characteristics, classification and adaptation of soils in selected areas in Sierra Leone. West Africa. Bulletin of the University of Illinois, Urbana-Champaign and Njala University College, University of Sierra Leone, Freetown. Urbana, Illinois, 194 p.

Papon,A. (1973). Géologie et minéralisations du Sud-Ouest de la Côte d'Ivoire: synthese des travaux de l'operation SASCA 1962-1968, SODEMI, Abidjan, 286 p.

Parraux,A. (1971). Les sols. in: Le milieu naturel de la Côte d'Ivoire, eds J.M.Avenard, M.Eldin, G.Girrad, J.Sircoulon, P.Touchebeuf, J.L.Guillaumet, E.Adjanohoun et A.Perraud. Mém. ORSTOM 50, Paris

Riou,G. (1960). Mission militaire Soubré-Taï (S.O. Côte d'Ivoire). Notes pédologiques et géomorphologiques. ORSTOM, Adiopodoumé, Rapport ronéot. 37 p. + carte

Riou,G. (1963). Observations sur le sol du sud-ouest de la Côte d'Ivoire. ORSTOM, Adiopodoumé, Rapport ronéot., 421 p.

Ruf,F. (1984). Evolution des derniers fronts pionniers du Sud-Ouest ivorien. Tome I. Contribution de la section agr-economie-forêt. Rapport de convention IRCC/IDESSA, 93 p.

Sanchez, P.A. (1976). Properties and management of soils in the tropics. John Wiley & Sons, Inc., New York,etc., 618 p.

Schwartz,A. (1972). Immigration et developpement dans le sud-ouest ivoirien. 11è Séminaire International africain des immigrations modernes en Afrique Occidentale. Dakar 17 mars - 6 avril 1972. Tome II: 1-11 + annexes.

Schwartz,A. and Capot-Rey,P. (1971). Recensement demographique de la sous-préfecture de Taï. ORSTOM, série Sciences Humaines, IV(6), 67 p. Petit Bassam, Côte d'Ivoire

Soil Survey Staff. (1951). Soil Survey Manual. U.S.D.A. Handbook no. 18, Washington D.C., 503 p.

Soil Survey Staff. (1975). Soil Taxonomy. Soil Conserv.Serv., U.S.Dept.Agr.Handbook no 436. U.S.Govt.Printing Office,Washington D.C., 754 p.

Soil Survey Staff. (1990). Keys to Soil Taxonomy. SMSS Technical Monograph no 19, 4th ed., Blacksburg, Virginia

Tagini,B. (1979). Carte géologique de la Côte d'Ivoire au 1/1.000.000. in: Atlas de Côte d'Ivoire. ORSTOM, ITG, Abidjan, Côte d'Ivoire, A-2.

Taylor, C.J. (1954). Synecology and silviculture in Ghana. Th. Nelson & Sons Edinbourg, London, 418 p.

Touber,L., Smaling,E.M.A., Andriesse,W. and Hakkeling,R.T.A. (1989). Inventory and evaluation of tropical forest land. Guidelines for a common methodology. Tropenbos Technical Series 4, Ede, 170 p.

Thomas,M. (1974). Tropical Geomorphology. A study of weathering and landform development in warm climates. MacMillan, 332 p.

Timmerman,K.B. (1989). Land Unit Survey Taï. M.Sc.-thesis, Department of Soil Science and Geology, Agricultural University, Wageningen, 67 p.

TROPENBOS (1988). Annual report. The Tropenbos foundation, Ede, The Netherlands, 16 p.

Van der Gaag,J. (1989). De 'bas-fonds' in de Taï-regio (The 'bas-fonds' in the Taï region). M.Sc.-thesis, Department of Soil Science and Geology, Agricultural University, Wageningen, 52 p.

Van Kekem,A.J. (1984). Legende pour la carte des sols du Sud-Ouest de la Côte d'Ivoire; application de la méthode utilisée dans le programme pédologique du M.A.B. UNESCO, Paris, 32 p.

Van Reuler,H. and Janssen,B.H. (1987). Soil fertility aspects of upland rice in shifting cultivation systems in south-west Côte d'Ivoire. Proc. 2nd Intern. Tropenbos Seminar, 5-7 october 1987, Amsterdam, p.32-36

Van Reuler,H. and Janssen,B.H. (1989). Nutritional constraints in secondary vegetation and upland rice in south-west Ivory Coast. in: Mineral nutrients in tropical forest and savanna ecosystems, Spec.publ. no 9 of The British Ecological Society, ed. J.Proctor, p.371-382

Van Waveren,E.J. (1987). Guidelines for the description and coding of soil data. ISRIC Technical Paper 14. ISRIC, Wageningen

Vellema,H.C. (in preparation). A physiographic soil survey in the region around Taï, Côte d'Ivoire.

Vooren,A.P. (1986a). Nature and origin of tree and branch fall in the Taï forest (Ivory Coast). Neth. J.of Agr.Sci., **34**: 112-116

Vooren,A.P. (1986b). Perspectives écologiques pour l'agroforesterie dans la région de Taï, Côte d'Ivoire. in: Agroforesterie en Zones Forestières Humides d'Afrique, eds M.Maldague, A.Hladik and P.Posso. p.201-207. Unesco, Paris

Vooren,A.P. (1987). Development versus forest conservation: avoiding a conflict in the Taï region (Ivory Coast). in: Wise utilization of Tropical Rain Forest Lands, eds C.F.van Beusekom, C.P.van Goor and P.Schmidt. Tropenbos Scientific Series 1: 130-137. Tropenbos/Mab-Unesco, Ede

Vooren,A.P. (in press). Appropriate buffer zone management strategies for the Taï National Park (Côte d'Ivoire). in: Actes de l'Atelier sur l'Aménagement et la Conservation de l'Ecosystème Forestier Tropical Humide. MAB-Unesco/FAO/IUFRO, Cayenne

Vooren,A.P. (in preparation). Nature Analogue Forestry: ecological outlines of a silvicultural system for buffer zone management (with special reference to the Taï National Park, Côte d'Ivoire). Tropenbos Scientific Series no, 2, Ede.

Walter,H. (1964). Die Vegetation der Erde in ökophysiologischer Betrachtung, Vol. 1, 2nd ed., Gustav-Fischer, Jena.

Zeeman,M. (1989). Some aspects of soils and landscape development in the Taï region (Côte d'Ivoire). M.Sc.-thesis, Dept. of Soil Science and Geology, Agricultural University, Wageningen, 44 p.

Zonneveld, I.S. (1988). Basic principles of land evaluation using vegetation and other land attributes. in: Vegetation mapping. Handbook of Vegetation Science. eds A.W.Küchler and I.S.Zonneveld, p. 499-517. Kluwer, vol. 10, Chapter 6A. p. 635 a.f. Dordrecht.

Zonneveld,I.S. (1990). The land unit: a fundamental concept in landscape ecology and its applications. Landscape Ecology **3**: 67-87

LIST OF PHOTOGRAPHS - Land Unit Survey Taï 8/11/90

(the numbering follows the texte reference)

Photo 1: Outer boundary of buffer zone. Taï National Park

Photo 2: Taï National Park, east of Zagne

Photo 3: Field party on the Meno river

Photo 4: Migmatite, exposed on inselberg crest in land unit UI2 (ruler is 10 cm)

Photo 5: Saprolite of schist/gneiss (near the white 10 cm ruler) with quartz veins (near the cut-lass): road cut 500 m east of Meno river, between Allakofikro and Para

Photo 6: View from crest to valley bottom along footpath in land unit UI2

Photo 7: Rock-floored inselberg crest in land unit UI1

Photo 8: Typical vegetation of small tree Mallotus oppositifolius on inselberg crest in land unit UI1

Photo 9: Cavally river in the dry season; near Gouleako, view towards North

Photo 10: Soil catena in the Taï Biosphere Reserve near field station of I.E.T., as described by Fritsch (1980); soil monoliths in the collection of the International Soil Reference and Information Centre (ISRIC), Wageningen. From right to left: crest, upper slope, middle slope, lower slope and valley bottom (photograph ISRIC)

Photo 11: Crest site of migmatite catena west of field station I.E.T. Clay loam to sandy clay with much ironstone gravel

Photo 12: Middle slope site of migmatite catena west of field station I.E.T. Slightly gravelly sandy loam overlying very gravelly clay loam; gravel is ironstone (ruler is 10 cm)

Photo 13: Middle slope site of migmatite catena. The surface and subsurface soil contain much ironstone gravel, the subsoil is free of gravel and contains plinthite

Photo 14: Lower slope site of the migmatite catena west of field station I.E.T. Sandy loam overlying sandy clay loam: the subsoil contains plinthite mottles (ruler is 10 cm)

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Photo 17: Parinari excelsa, with epiphytes. P. excelsa is a frequently recorded species that does not show a preference for any of the sociological species groups

Photo 18: Field with 'Ferreclao'(Millettia rhodantha)

Photo 19: The large tree on the right is Piptadeniastrum africanum belonging to the sociological species group 22, the smaller tree left of it is Gymnostemon zaizou. Both species produce timber for export. Piptadeniastrum has a wide flat crown that appears as a distinct red spot on the satellite image. Crest site in land unit Usy2.

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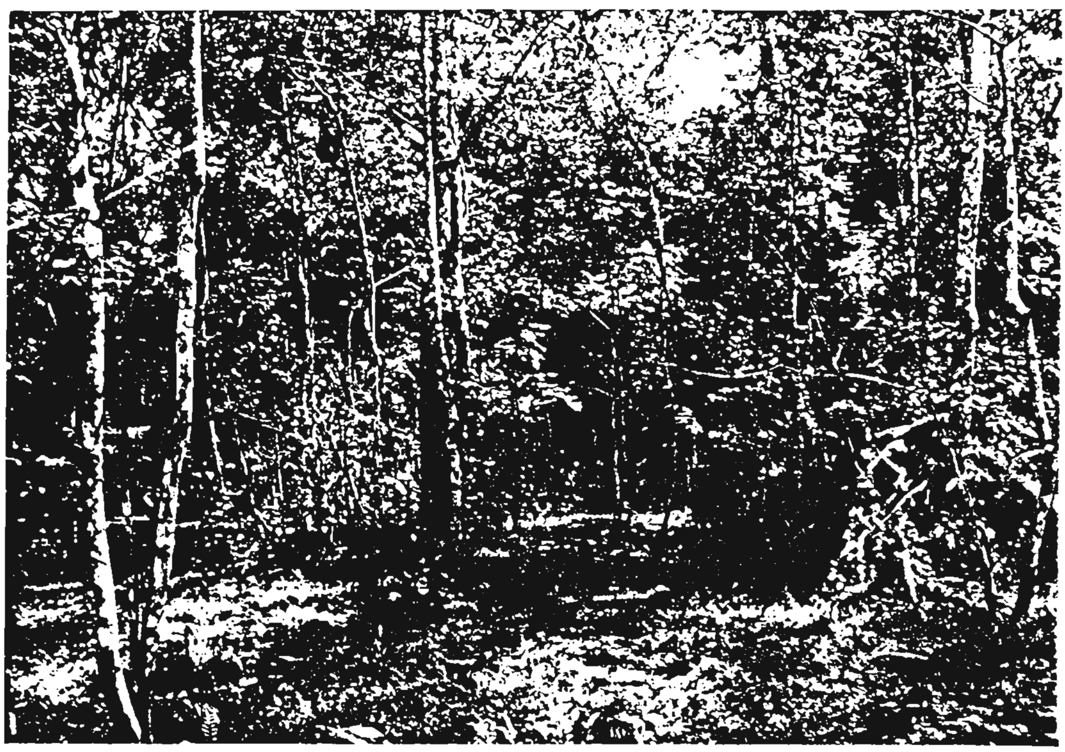

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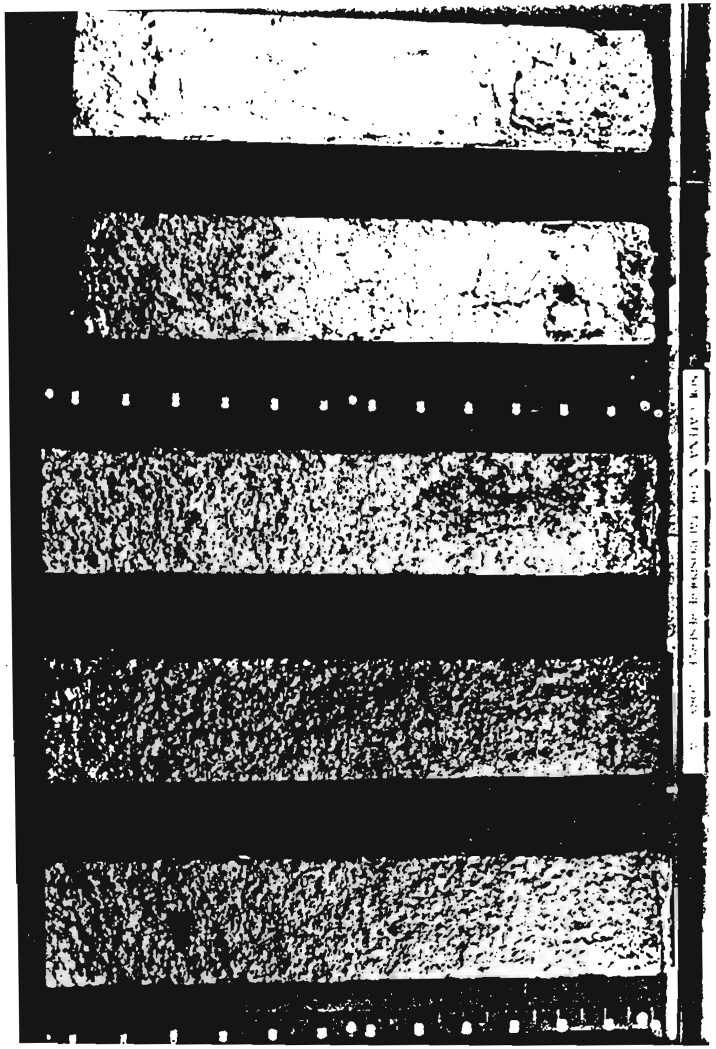

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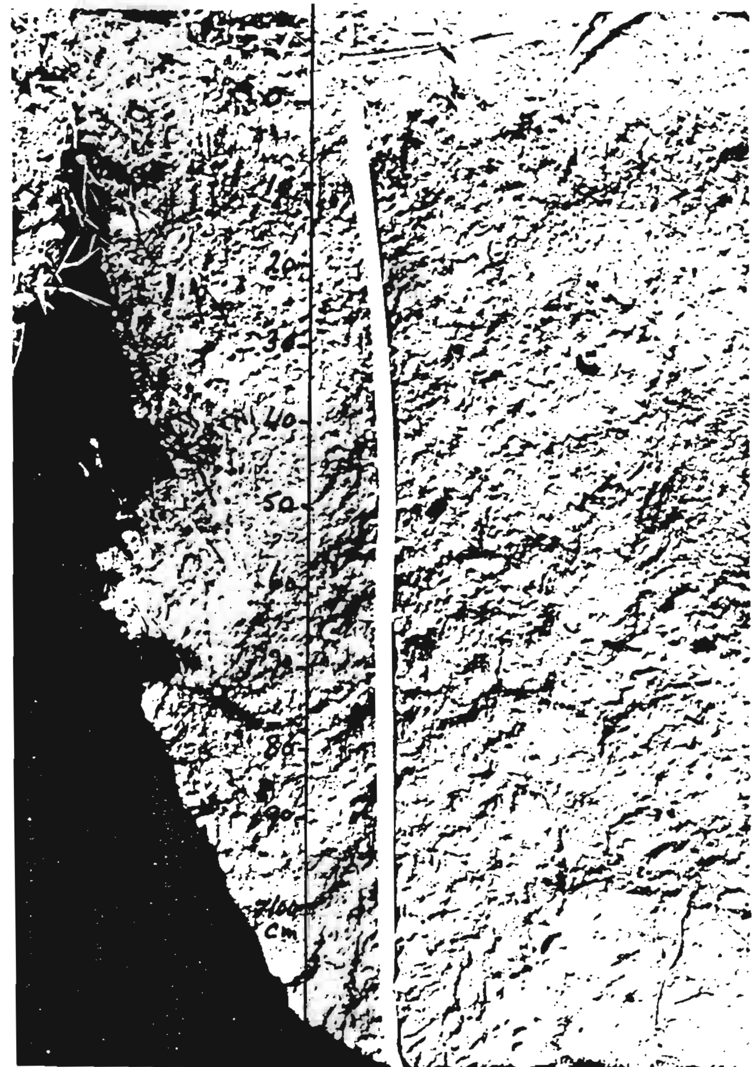

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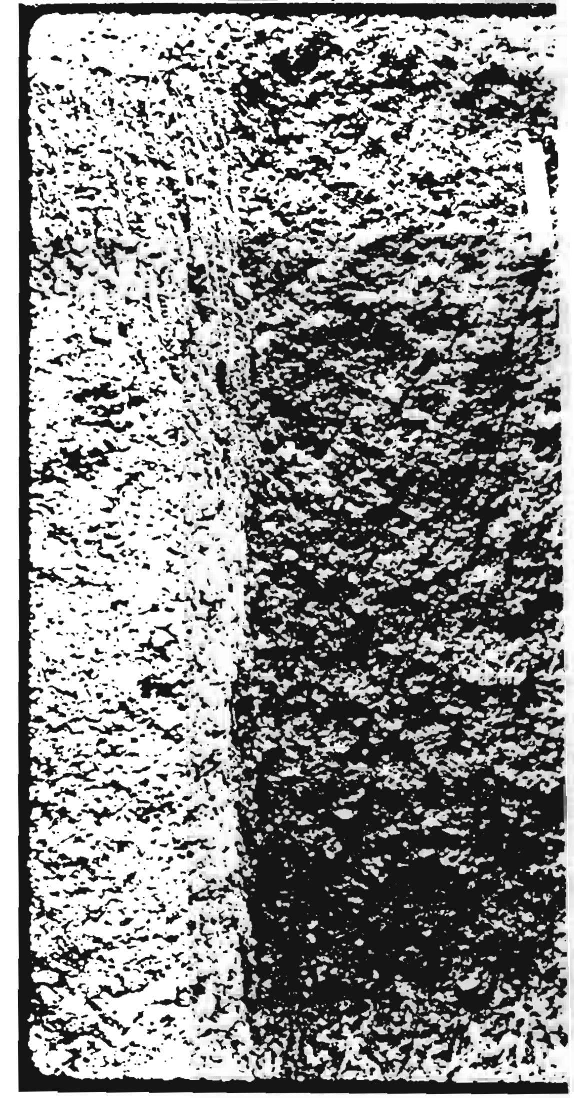

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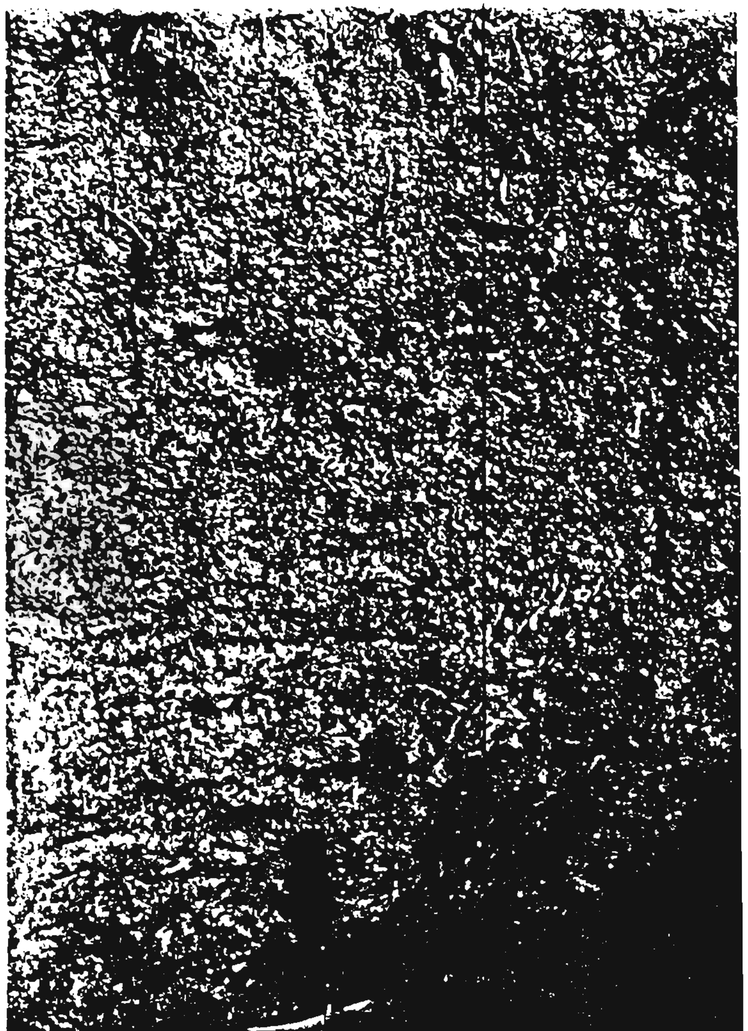

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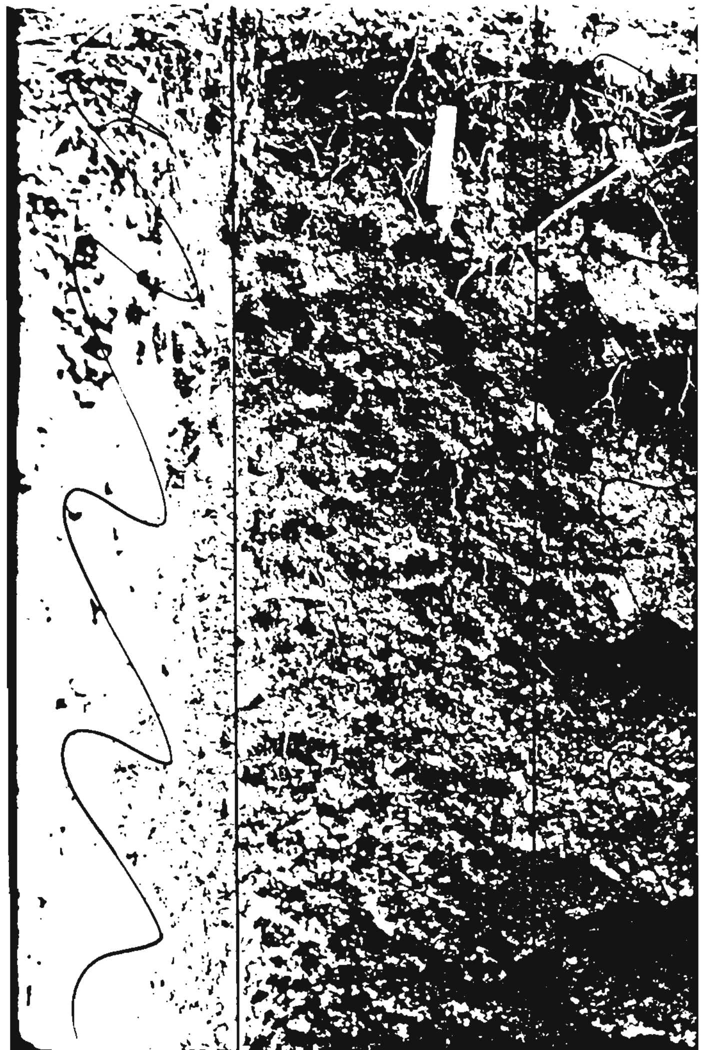

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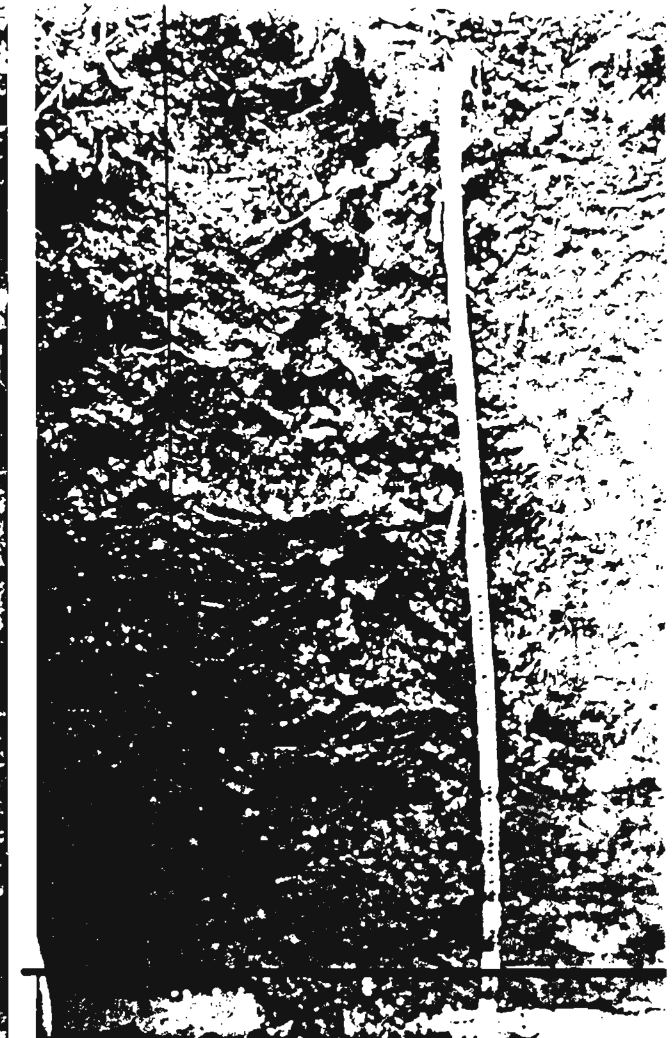

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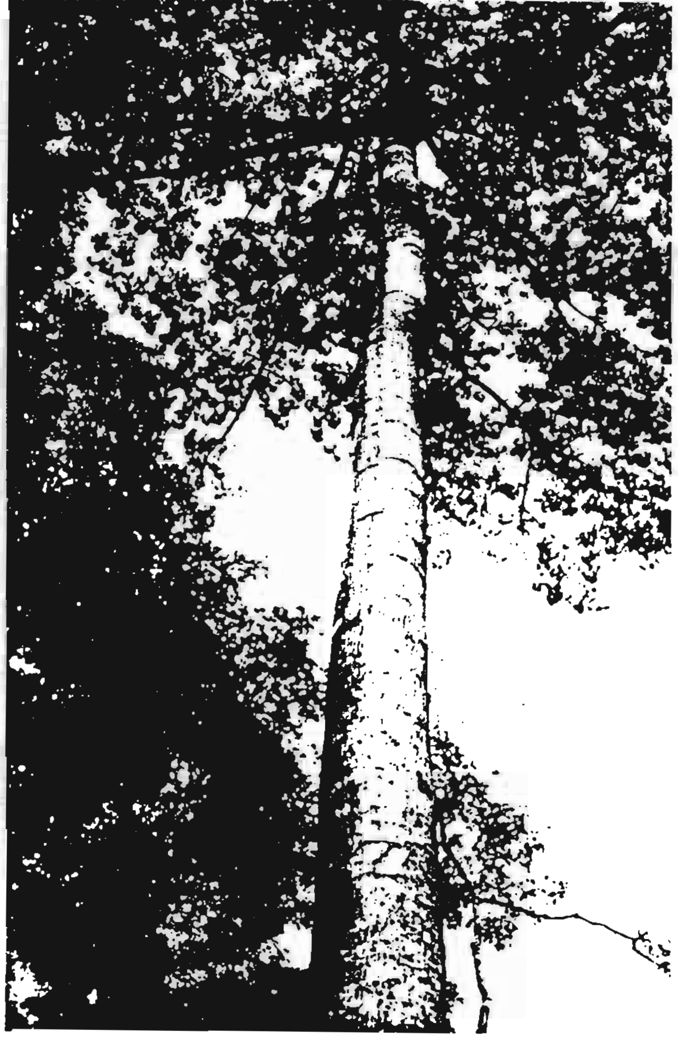

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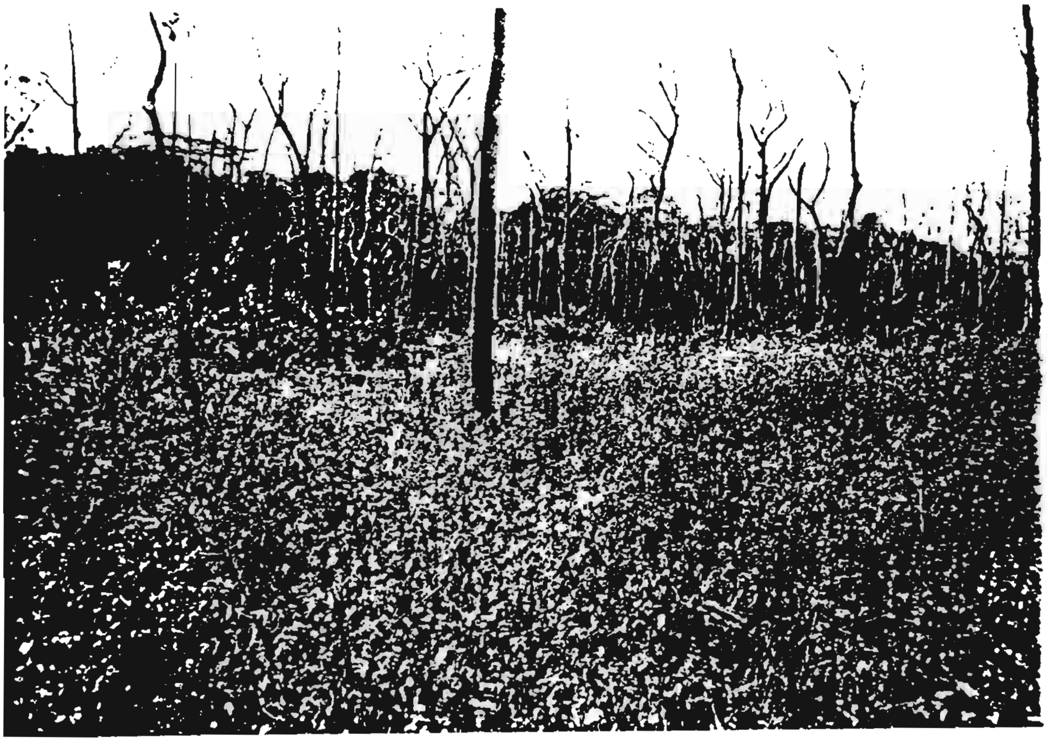

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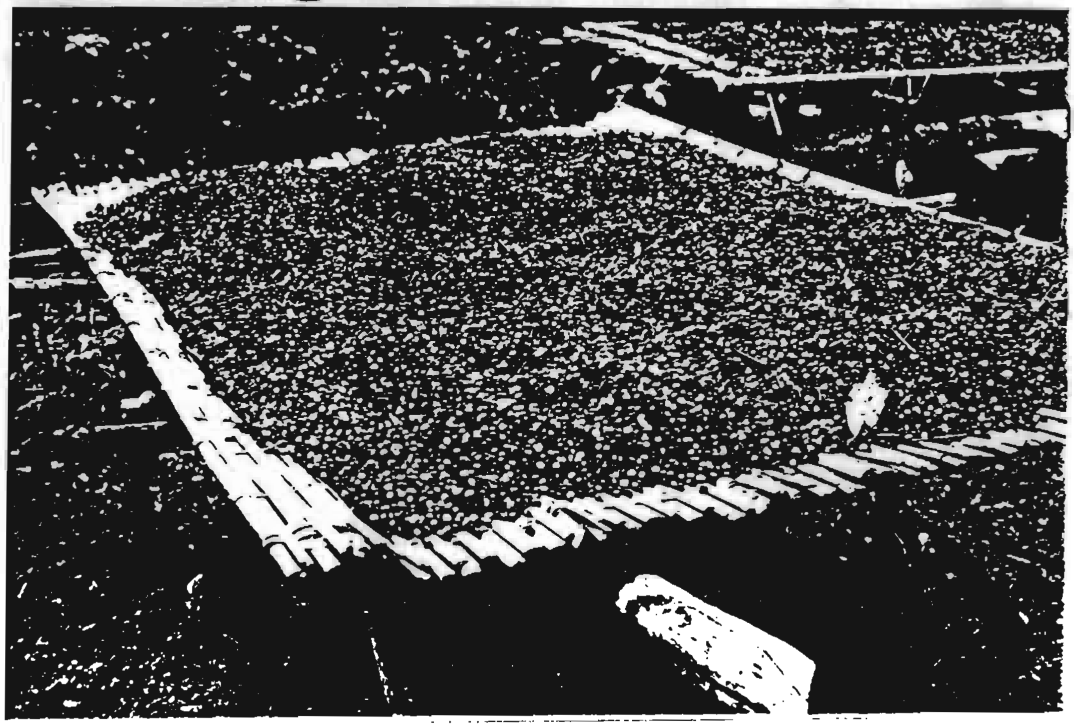

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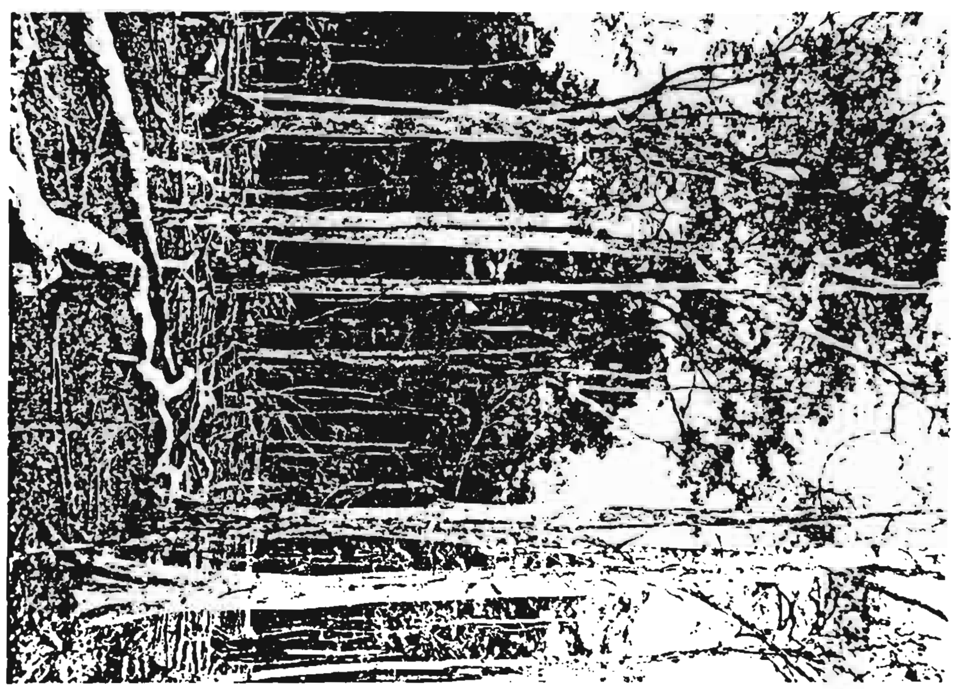

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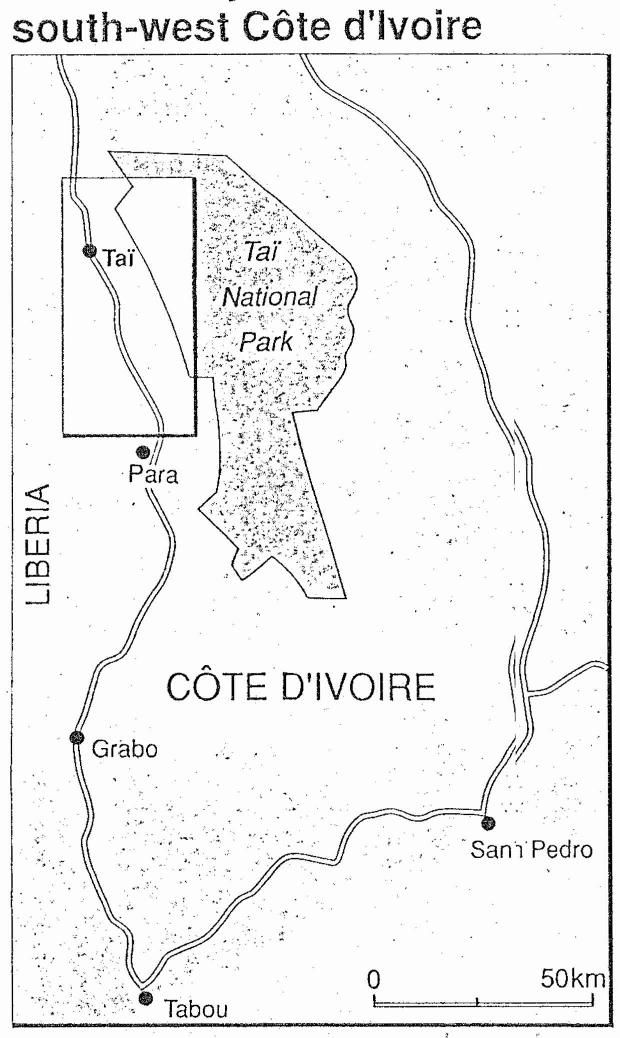
TECHNICAL SERIES

TROPENBOS

Land Unit Survey of the Taï region, south-west Côte d'Ivoire

LAND UNIT MAP



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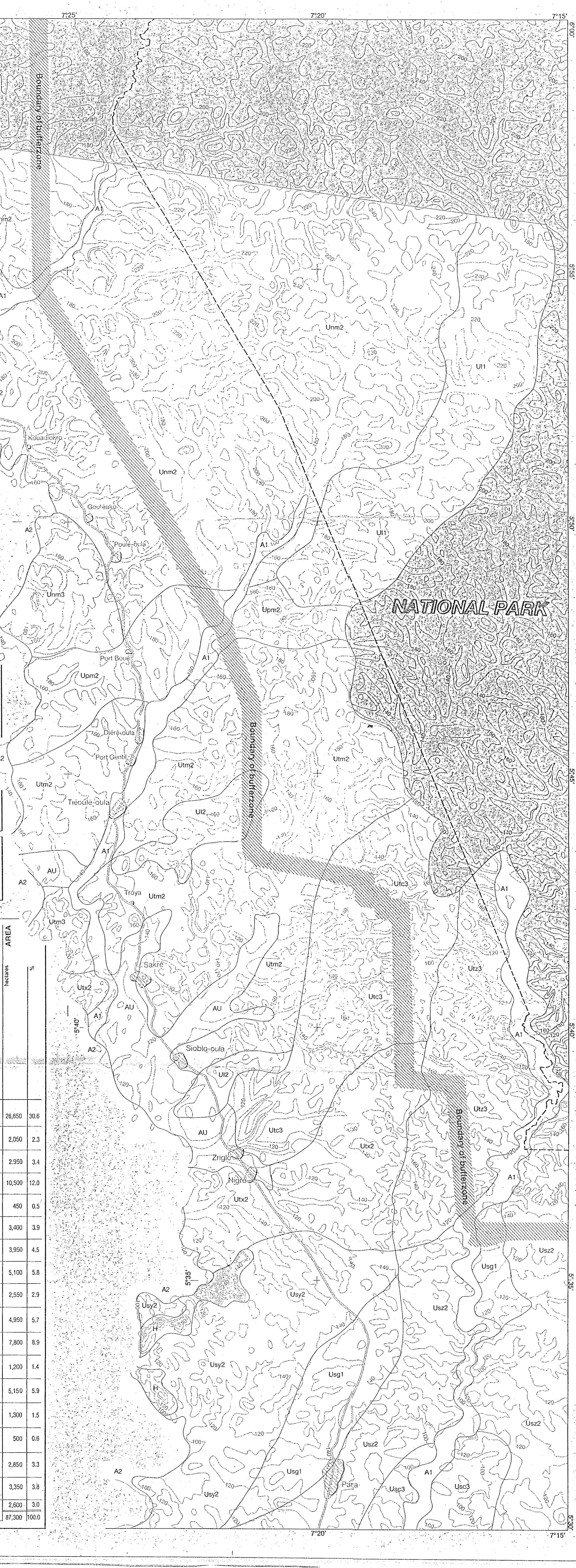

Topography

- track
- built-up area
- contour line
- permanent river/stream
- seasonal river/stream
- National Park boundary

NOTES ON LEGEND

*1 **Land Unit symbol** for Uplands U n m 2 — drainage density; lithology; rainfall/vegetation zone; major geomorphic unit

*2 **Drainage density Legend:**

weakly dissected	0
weakly to moderately dissected	1
moderately dissected	2
moderately to strongly dissected	3

Classes:

weakly dissected	< 0.4 km/km^2
moderately dissected	0.4 - 0.6 km/km^2
strongly dissected	> 0.6 km/km^2

*3 **Physiography classes** *(cf. FAO, 1977, slightly amended)*:

flat or almost flat: slopes not steeper than 2%
undulating: steepest slopes 2-8%
rolling: steepest slopes 8-16%
hilly: steepest slopes 16-30%
steep: steepest slopes > 30%

*4 **Main soil associations and soil complexes:**

Migmatite catena: brownish or reddish clayey soils, with ironstone gravel;
Schist variant: reddish clayey soils, with or without ironstone gravel;
Granite catena: yellowish-brown loamy soils, with quartz gravel;
Granite-gneiss catena: yellowish-brown loamy soils, with hardening plinthite;
Inselberg variant: shallow soils over acid to intermediate igneous rock;
Hill catena: shallow soils over basic igneous rock;
Upland-alluvium association: imperfectly to poorly drained soils with redox mottles below 50 cm;
Alluvial complex: imperfectly to very poorly drained soils with redox mottles at shallow depth.

Remark: Specific characteristics of a catena are most clearly expressed on the crest and upper slope sites. The middle and lower slope, and valley bottom positions are more alike between catenas. Crest and upper slope soils cover 25 to 50% of the surface area; the soils of middle slope, lower slope and valley bottom each between 15 and 25%.

*5 **Relative coverage of soil association and vegetation community per land unit** (vegetation communities are indicated separately for primary forest, forest fallow and plantations)

◔ 10-25%　◑ 25-50%　◕ 50-75%　● >75%

Landuse 1988, summarized from Land Use map

- primary forest
- food crops and some tree crops by indigenous farmers
- food crops and tree crops by indigenous farmers and immigrants
- tree crops by immigrants (cocoa)

Map authors: A. de Rouw, H.C. Vellema.
Publication: Land Unit Survey of the Taï region, south-west Côte d'Ivoire. Tropenbos Technical Series 7, 1990.
Authors: A. de Rouw, H.C. Vellema, W.A. Blokhuis.
Topographic data: République de la Côte d'Ivoire (IGN, Paris, 1961) Sheet: NB-29-XI-4a/4c (Taï 4a, Taï 4c), scale 1: 50,000.
Cartography: W. Feringa, A.M. Mank, J. van den Worm.

*1 LAND UNIT SYMBOL	MAJOR GEOMORPHIC UNIT	RAINFALL / VEGETATION ZONE	LITHOLOGY	*2 DRAINAGE DENSITY	*3 SLOPE CLASS	*4 SOILS *5: migmatite catena	schist variant	granite catena	granite-gneiss catena	inselberg variant	hill catena	upland alluvium association	alluvial complex	VEGETATION *5 primary vegetation: Hunteria simii & Chidlowia sanguinea A	Uapaca spp.& Mendoncia combretoides B	'Vaa' (Gilbertiodendron preussii) & Tarrietia utilis C	'Ferreclao' (Milletia rhodantha) & Parinari aubrevillei D	Strychnos ngouniensis & Chytranthus spp. E	Spiropetalum heterophyllum & 'Gnahin' (Ancistrophyllum laeve) F	Citropsis articulata & Stereospermum acuminatissimum G	Hypselodelphys poggeana & Pandanus candelabrum H	'Sahe' & Thecacoris stenopetala J	'Sahé' & Pancovia bijuga K	Psilanthus mannii & Hunteria spp L	secondary veg. *5 % in forest fallow: Rutidea parviflora & Secamone afzelii I	Cleistopholis patens & Adenia lobata II	'Kari' (Hypselodelphys violacea) & Marantochloa leucantha III	*5 % in plantations: Morinda longiflora & Clerodendrum spp. IV	Alstonia boonei & Funtumia elastica V	AREA hectares	%
Unm2	Uplands	north (n)	migmatite/gneiss (m)	2	undulating to rolling	●								●											●	◔		●		26,650	30.6
Unm3				3	rolling to hilly	●								●											●	◔		●		2,050	2.3
Upm2		intermediate (p)		2	undulating to rolling	●									●										◔	●		●		2.950	3.4
Utm2		transitional (t)		2	undulating to rolling	●										●									◑	◑	◕	●		10,500	12.0
Utm3				3	rolling to hilly	●										●									◑	◑	◕	●		450	0.5
Utx2			granitic gneiss with schist inclusions (x)	2	undulating to rolling	◑	◔		◑							●									◑	◑	◕	●		3,400	3.9
Utz3			association gneiss-granite-schist (z)	3	rolling	◕	◔	◑								●												●		3,950	4.5
Utc3			complex (c)	3	undulating to hilly			●								●									◑	◑	◕	●		5,100	5.8
Usg1		south (s)	granite with schist inclusions (g)	1	undulating		◔	●										●										●		2,550	2.9
Usy2			association gneiss-granite (y)	2	undulating to rolling	●		◔										●	◔									◑	◕	4,950	5.7
Usz2			association gneiss-granite-schist (z)	2	undulating to rolling	◕	◔	◑										◕	◑									◑	◕	7,800	8.9
Usc3			complex (c)	3	rolling			●											●									●		1,200	1.4
Ul1	association of Uplands and Inselbergs		migmatite/gneiss	2	undulating to rolling, and steep	●				◔				◕						◕										5,150	5.9
Ul2	association of Uplands and Inselbergs		migmatite/gneiss with schist inclusions	2	undulating to rolling, and steep	◕	◔			◔							◕	◑			◔					◔	●	◕	◕	1,300	1.5
H	steep-sided Hills		basic rock	0	steep						●													●			●		●	500	0.6
AU	association of Alluvial landscape and low Uplands		association alluvium-migmatite/gneiss	1	almost flat to undulating	◔			◔			●																●		2,850	3.3
A1	Alluvial landscape of tributaries to Cavally		alluvium	0	almost flat								●									●						●		3,350	3.8
A2	Alluvial landscape of the Cavally		alluvium	0	almost flat								●										●					●		2,600	3.0
																														87,300	100.0