ATLANTIC ZONE PROGRAMME

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Field Report No. 107

A GEOLOGICAL/GEOMORPHOLOGICAL AND SOIL TRANSECT STUDY OF THE CHIRRIPO MASSIF AND ADJACENT AREAS, CORDILLERA DE TALAMANCA, COSTA RICA

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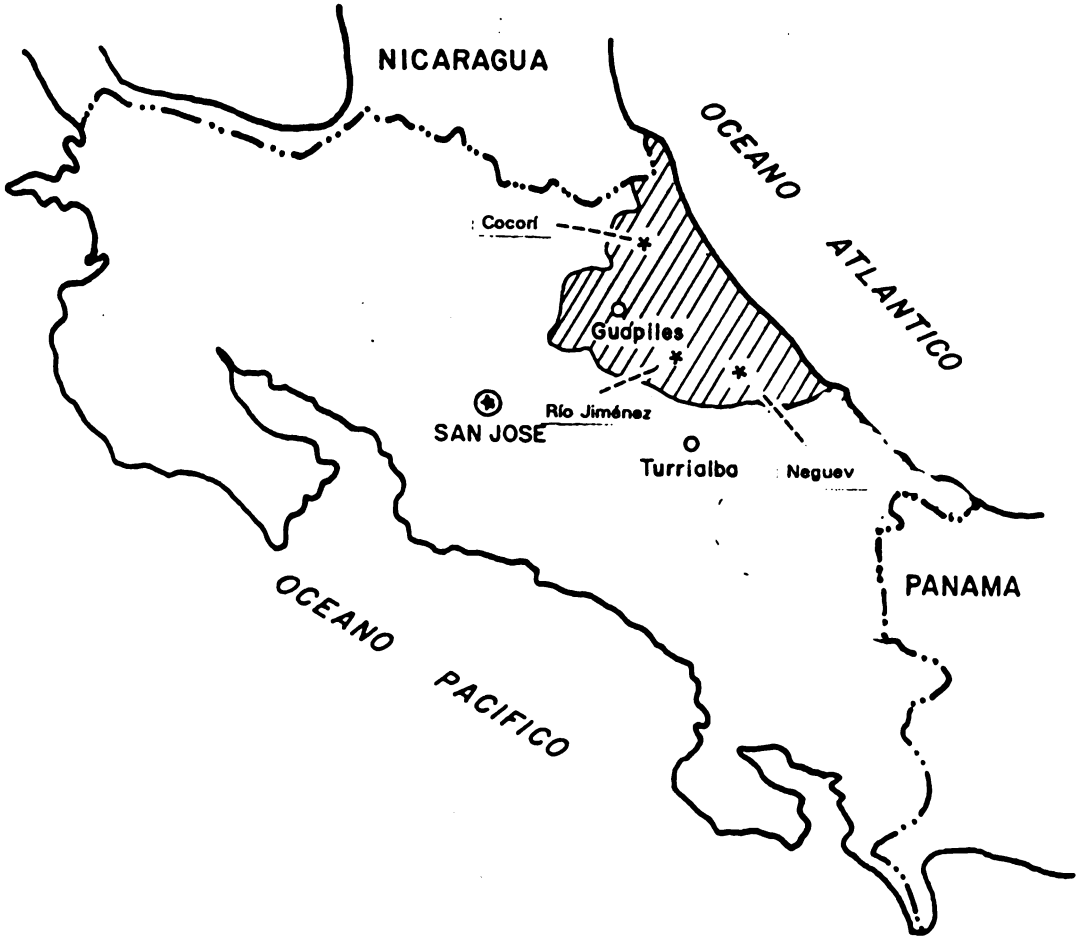

Figure 1. Location of the study area.

PREFACE

General description of the research programme on sustainable Landuse.

The research programme is based on the document "elaboration of the VF research programme in Costa Rica" prepared by the Working Group Costa Rica (WCR) in 1990. The document can be summarized as follows:
To develop a methodology to analyze ecologicaly sustainable and economically feasible land use, three hierarchical levels of analysis can be distinguished.
1. The Land Use System (LUS) analyses the relations between soil type and crops as well as technology and yield.
2. The Farm System (FS) analyses the decisions made at the farm household regarding the generation of income and on farm activities.
3. The Regional System (RS) analyses the agroecological and socio-economic boundary conditions and the incentives presented by development oriented activities.

Ecological aspects of the analysis comprise comparison of the effects of different crops and production techniques on the soil as ecological resource. For this comparision the chemical and physical qualities of the soil are examined as well as the polution by agrochemicals. Evaluation of the groundwater condition is included in the ecological approach. Criterions for sustainability have a relative character. The question of what is in time a more sustainable land use will be answered on the three different levels for three major soil groups and nine important land use types.

Combinations of crops and soils

	Maiz	Yuca	Platano	Piña	Palmito	Pasto	Forestal I	Forestal II	Forestal III
Soil I	x	x	x		x	x		x	
Soil II						x		x	
Soil III	x			x	x	x		x	

As landuse is realized in the socio-economic context of the farm or region, feasibility criterions at corresponding levels are to be taken in consideration. MGP models on farm scale and regional scale are developed to evaluate the different ecological criterions in economical terms or visa-versa.

Different scenarios will be tested in close cooperation with the counter parts.

The Atlantic Zone Programme (CATIE-AUW-MAG) is the result of an agreement for technical cooperation between the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), the Agricultural University Wageningen (AUW). The Netherlands and the Ministerio de Agricultura y Ganadería (MAG) of Costa Rica. The Programme, that was started in April 1986, has a long-term objective multidisciplinary research aimed at rational use of the natural resources in the Atlantic Zone of Costa Rica with emphasis on the small landowner.

PREFACE

This study is the result of close cooperation between two participants of two different programmes.

The main programme, under which responsibility this study was realized, is the "Agricultural Research Programme in the Atlantic Zone of Costa Rica". This programme is a long term cooperation between the "Tropical Agricultural Research and Training Center" (CATIE) in Turrialba, Costa Rica, and the "Agricultural University Wageningen" (AUW), the Netherlands. Its long term objective is to contribute to stable socio-economic and ecological development and increased wellbeing of the population of the Atlantic Zones of Central America and Panama.

The other programme is the 'Ecologia y Manejo de Vegetación de montañas altas en Costa Rica' (ECOMA) of the 'Escuela de Ciencias Ambientales' (EDECA) of the 'Universidad Nacional', Heredia, Costa Rica. The principal aim of this project is to achieve a profound insight in the ecology of the Talamanca high mountains, including forested and non forested areas.

Ecology, the impact of human activity ('forested and non forested areas'), and therefore socio-economic interests are, more or less, a common interest of both programmes.

This study was realized in fulfilment of the requirements for a 3 months MSc thesis on geomorphology and for a 5 months practical stage in tropical soil science at the Wageningen Agricultural University.

Jan Gerrit van Uffelen

ACKNOWLEDGEMENT

I owe special gratitude to the 'Agricultural Research Program' in the Atlantic Zone of Costa Rica and the 'University of Amsterdam' for funds to carry out the fieldwork. To M.Sc. Adelaida Chaverri, biologist and director of the research program 'Ecologia y Manejo de Vegetación de momtañas altas en Costa Rica' (ECOMA) at the 'Universidad Nacional' in Heredia, Costa Rica. And to the 'Servicio de Parques Nacionales' for their willingness to give a permit to work within their 'Parque Nacional Chirripó'.

Together with Maarten Kappelle two small expeditions were prepared to the 'Cordillera de Talamanca'. Together we spend a lot of time in the mountains as well as in Heredia. It must be considered very surprising that an "Amsterdammer" and a "Twent" grew on frienly terms with each other. Grateful thanks are also due to Mario Monge Fallas and his Doña Elisa for their friendship and the honour to be a 'member' of their family. Also thanks to Victor Monge, Rafael Fonseca, Antonio and all the other people of 'San Gerardo de Rivas'. I will remember them all.

I also like to thank Dr. W.G. Wielemaker, Prof. dr. S. B. Kroonenberg and Dr. P. Oosterom for their help as supervisors of the 'Atlantic Zone Program'.

Furthermore I wish to express my thanks to Guillermo Valverde for his support during the handling of the soil samples. To M.Sc. Julio Fraile, biologist, for his help to determine the collected soil fauna. To Dr. Rodrigo Saenz and Dr. Jorge Barquero of the 'Observatorio Vulcanologico-Sismologico de Costa Rica' for their help with the determination of the rock samples collected. And to Dr. A.M. Cleef, connected as a biologist to the University of Amsterdam, with whom I spend some interesting days in the field.

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1 INTRODUCTION

As in many countries of the tropics deforestation accelerated in Central America's Costa Rica. Covering more than two thirds of the country some fifty years ago, today scarcely one third is left.

This study concentrates on the virtually untouched 'Parque Nacional Chirripó' ("Chirripó Nacional Parque"). Due to the difficult access of the study area (very steep slopes and a dense primary vegetation) there is insufficient fundamental information of the parque and adjacent areas to develop proper managements plans. Attention of this study is focussed on geology, geomorphology and soils while vegetation was studied by the participating vegetation scientist (KAPPELLE, 1990).

Colonization in the foothills of the 'Cordillera de Talamanca' has caused logging of valuable timber species, strong immigration from other parts of Costa Rica and expansion of farmland for extensive grazing. However, human activity was not restricted to the foothills but extended also to the higher and steeper parts of the 'Cordillera de Talamanca' endangering nature and natural resources (destruction of potentially renewable resources is already apparent at some places). This was one of the reasons that most parts of the forested 'Cordillera de Talamanca' are declared "Legal Forested Areas" and for this reason enjoy a certain status of conservation (BONILLA, 1983). However this is not a guarantee that these areas are sacred from negative human impacts. This was shown in march 1976 when undiscriminate use of fire destroyed a large part of the primary vegetation of this "Legal Forested Area" in the 'Parque Nacional Chirripó' (CHAVERRI, 1976).

Studies on geology and geomorphology already have been carried out in the 'Cordillera de Talamanca'. But they mainly concentrate on those parts of the 'Cordillera de Talamanca' which are relative easy to access. Studies of the alpine stage (WEYL, 1956a and 1956b; HASTENRATH, 1973; BERGOEING, 1978; BARQUERO & ELLENBERG, 1986; CALVO, 1987) and descriptions of road cuts of the Inter American Hihgway (WEYL, 1957; HARRIS, 1971) resulted in basic knowledge of geology and geomorphology in the 'Cordillera de Talamanca'. However few examples are known of studies carried out in the more inaccessible parts of the Cordillera de Talamanca (BALLMANN, 1976).

Particularly important for geomorphology, and for the origin of fluvial parent materials in the coastal zone of the lower Talamanca area, is the possible occurence of Quaternary volcanism in the study area which is an important geomorphological theme in this report.

Except for some individual studies on soils (OTAROLA & ALVARADO) no systematical soil studies have been carried out in the 'Cordillera de Talamanca'.

The relation between soil characteristics and altitudinal changes of climate and vegetation is an important pedological theme.

Due to the difficult access of most parts of the study area interpretation of aerial photographs was of great value in establishing geomorphological units. The main part of the field work

took place along altitudinal transects and included examination and description of rock outcrops and other geomorphological features, description of soil profiles and the collection of soil fauna.

By integrating geological, geomorphological and soil data a reconnaissance soil map is produced at a scale of 1:80,000 based on aerial photograph interpretation and field survey. Together with the research results of the vegetation scientist this fundamental information is a prerequisite to develop proper managements plans.

After this introduction chapter 2 deals with the methods that are applied in this study. Chapter 3 deals with the physical setting of the study area, while in chapter 4 and 5 the results of this study are presented. First the geology and geomorphology are discussed (chapter 4) followed by the soils found in the study area. Geomorphology and soils are both discussed acoording to the subsequent mapping units of the reconnaissance soil map presented in this study. Summary and conclusions are found in chapter 6.

2 METHODS

2.1 Introduction

This chapter provides information on methods that have been applied to obtain information about geology, geomorphology and soils.

2.2 Office

Prior to fieldwork available maps, aerial photographs and literature were collected and studied.

The study area is covered by topographic maps provided by the 'Instituto Geografico Nacional' (IGN) at a scale of 1:50,000. Sheets of interest are 'Cuericí' (edition 2, 1969), 'Dúrika' (edition 2, 1970), 'Matama' (edition 1, 1968) and 'San Isidro' (edition 2, 1982). A geological map covering the study area is available at a scale of 1:200,000 (IGN, 1982).

Aerial photographs cover the area at a scale of approximately 1:80,000. Runs of interest are CR2CM8, Talamanca, run 3a photographs 30 to 33 and run 4 photographs 20 to 24. Both runs fall within block 'Cordillera Central' (B55) and photographs were taken in april 1984.

Aerial photographs served to determine the main physiographic units whereas the topographic maps served as a base map for the reconnaissance soil map provided for in this study. However the topographic maps are not very accurate, therefore the aerial photograph interpretations are added to this report and can be found in appendix 3:

2.3 Field

In September-October 1988 and March-April 1989 fieldwork took place along two altitudinal transects, in the paramó belt and, to a lesser degree, along a reconnaissance route through the valley of the 'Río Chirripó (Duchí)'.

Geological and geomorphological observations were done along the transects, in the páramo belt and along the reconnaissance route (see appendix 2a). Some 35 rock outcrops and other geomorphological features were examined and described (appendix 2c). A reference collection of some 50 rock samples were classified macroscopically and are available for futher research (appendix 2b). Location of the geological and geomorphological observations can be found in appendix 2a.

At representative spots within the páramo belt and at every 200 m of altitude increase along the transects, to less than 200 meters altitude increase at higher altitudes (see appendix 2b), soil profiles where described. Soil profiles along the transects are situated within the relevés as studied by the participating vegetation scientist following the BRAUN-BLANQUET methodology (1951). Some routine augerings were made with an Edelman soil auger to determine representative spots, within the párqamo belt, to describe soil profiles.

Description of soil profiles is according to FAO (1977) while for the morphological description of humus use was made of the system as recommended by MUELLER-DOMBOIS et al. (1988). This system is based on the amount of mixing of the organic matter and mineral soil and the degree of decomposition of the organic matter (appendix 6).

Soil temperature classes are after SOIL SURVEY STAFF (1975). Effective soil depth (the depth to which roots can grow without major problems) classes applied are: very shallow (<25 cm), shallow (25-50 cm), moderately deep (50-100 cm) and deep (>100 cm). These soil depth classes fall within the outline for the soil depth classes as recommended by the Soil Survey Manual (SOIL SURVEY STAFF, 1951). For the description of the soil colours (both moist or wet, and dry) use was made of the MUNSELL SOIL COLOR CHARTS (1954).

Appendix 2a shows the location of the soil profiles in the páramo belt and along the two altitudinal transects. Description of the soil profiles can be found in the separate appendices (appendix 9).

2.4 Laboratory

Both chemical and physical determinations were done as part of the soil survey (see the separate appendix 10 on chemical and physical analyses). Biological determinations were done to provide indications on the functioning of the soil system (appendix 8).

All soil profiles were sampled for chemical analysis. Some 130 fragmental or loose samples of one and a half kilo were taken from individual mineral and some organic horizons. Samples were taken in a vertical section of the soil pit one directly beneath the other and uniformly from the entire horizon.

Soil samples were air dried, passed through a 2 mm sieve and were homogenized before analyzing. Chemical analyses took place at the 'Ministerio de Agricultura y Ganaderia de Costa Rica' (MAG) laboratory at Guadalupe.

Texture was determined by a hydrometer after the modified Bouyoucos method (Bouyoucos, 1950). Clay was determined with the hydrometer method after treatment with H_2O_2 and dispersion with NaOH at pH 10. Organic carbon was measured using the Walkley-Black wet combustion method (Van Reewijk, 1987). Incomplete recovery was compensated for with a multiplication factor of 1.3. Percentage of organic matter is obtained by multiplying the percentage of organic carbon by a factor 1,72. pH H_2O and pH KCl were determined in 1:2.5 soil solution ratio. pH NaF and P retention percentages are according to Van Reeuwijk (1987). CEC was determined by measuring the absorbed Na after saturating with 1 M NaAc at pH 7.0 and leaching with 1 M NH_4Ac at pH 7.0 (Van Reewijk, 1987). Exchangeable bases (Ca, Mg, K and Na) were determined in the leachate of the soil treated with 1 M NH_4Ac at pH 7.0. Extractable acidity (Al, H) was determined with 1 M KCl. Base saturation was determined as a quotient of the exchangeable bases and the CEC. Al, Ca and Mg were determined in a KCL extract. K, P, Zn, Mn, Cu, and F were determined in a modified Olsen extract and B and S were determined in a calciummonophosphate extract.

Some soil profiles were sampled for physical analyses which included

the determination of the dry bulk density, the percentage of organic and mineral material and the soil temperature.

Undisturbed horizontal core samples were taken from some individual horizons to determine the dry bulk density (two repititions). Drying took place at a temperature of 105°C during 24 hours. Percentage of organic material was determined by the loss-on-ignition method. Samples were freed from big living roots, homogenized by means of a maize mill and dried for 48 hours at 75°C. Dry combustion took place in a furnace at 850°C during two and a half hours.

Soil temperature was measured within each soil profile at intervals of 10 cm starting at the soil surface and covering the total soil profile depth (appendix 7). Use was made of a digital apparatus with a resolution of 0.1°C and with an accuracy of 1% ± 1°C (model Consort, T550).

A thorough study of soil biology was not realistic from a logistic point of view. That is why no standardized methods were applied to obtain biological data. However, it is relatively easy to obtain certain data on bioactivity in the soil which might give important indications on the functioning of the soil system. In this study soil fauna, both macro and meso, was collected by hand (with the aid of a pair of tweezers) by carefully checking the mineral hole dugs of the soil pits. Superficie of the soil pits is approximately one square meter. Organic soil material was checked in the same way in the direct neighbourhood of the soil pit. The collected soil fauna was preserved in a diluted formaline solution. Determination took place with the aid of a binocular microscope.

Sampling for future research was done in the form of an extra amount of mineral soil material collected. On top of that steel boxes (2x2x50 cm) were used to sample soil material from the entire soil profile. After sampling these boxes were sealed carefully with plastic bags and tape. The in this way obtained monoliths are particularly interesting for further research in the field of paleontology.

3 THE PHYSICAL SETTING

3.1 Geography

Costa Rica occupies part of the isthmus of Central America and lies between 8° and 10° north of the Equator bordered by Nicaragua in the north and Panama in the south. Four mountain chains traverse the entire country from the northwest to the southeast: the 'Cordillera de Guanacaste', the 'Cordillera Tilaran', the 'Cordillera Central' and the 'Cordillera de Talamanca'. The 'Cordillera de Talamanca' is the largest and highest mountain range in Costa Rica and it extends from the 'Valle Central' into western Panama. The Talamanca Range in Costa Rica is situated in four different Provinces: San José, Cartago, Limón and Puntarenas.

Fieldwork took place in the provinces Cartago and Limón. More exactly the study area is located in the highest massif found in the westernmost part of the 'Cordillera de Talamanca': The "Chirripó Massif", including the highest point of Costa Rica's territory ('Cerro Chirripó', 3819 m). This area roughly corresponds with the 'Parque Nacional Chirripó' ("Chirripó Nacional Park"). Figure 1 shows the location of the 'Parque Nacional Chirripó' and the two transects along which the major part of the fieldwork took place.

The first altitudinal transect is located at the Pacific side of the Chirripó Massif and corresponds with the touristic footh path leading to the 'Cerro Chirripó' (3819 m), locally known as the 'Fila Cementerio de la Maquina'. This transect covers the altitudinal range between 1700 and 3400 m altitude. The second transect follows the so called 'Fila Palmito Morado' up to the watershed (continental divide), just one kilometer west of the 'Cerro Urán'. It covers the altitudinal range between 2100 and 3300 m altitude at the Pacific side. The second part of this transect goes down at the Atlantic side of the "Chirripó Massif" following an indian path ('Camino de los Indios') up to the bed of the 'Río Chirripó (Duchí)' which is found at an altitude of 1300 m.

The 'Cordillera de Talamanca' slopes away sharply at faults to the southwest down to the 'Valle del General', while the slopes to the northeast are much flatter (WEYL, 1980). The watershed is therefore clearly shifted to the southwest and drains into the Pacific Ocean (e.g. 'Río Chirripó Pacifico') while the rivers of the northeastern watershed drains into the Atlantic Ocean (e.g. 'Río Chirripó Duchí').

Construction of the Interamerican Highway opened the western part of the range to traffic and thus to settlement. However, large areas of the eastern part are still unexplored territory in which 2,500 to 3,000 indians live today (HARTSHORN et al., 1982).

3.2 Climate

It is apparent that the Atlantic and Pacific sides of Costa Rica have different rainfall regimes (see figure 2). Particularly important for the Atlantic side are the strong tradewinds, coming from the Caribbean,

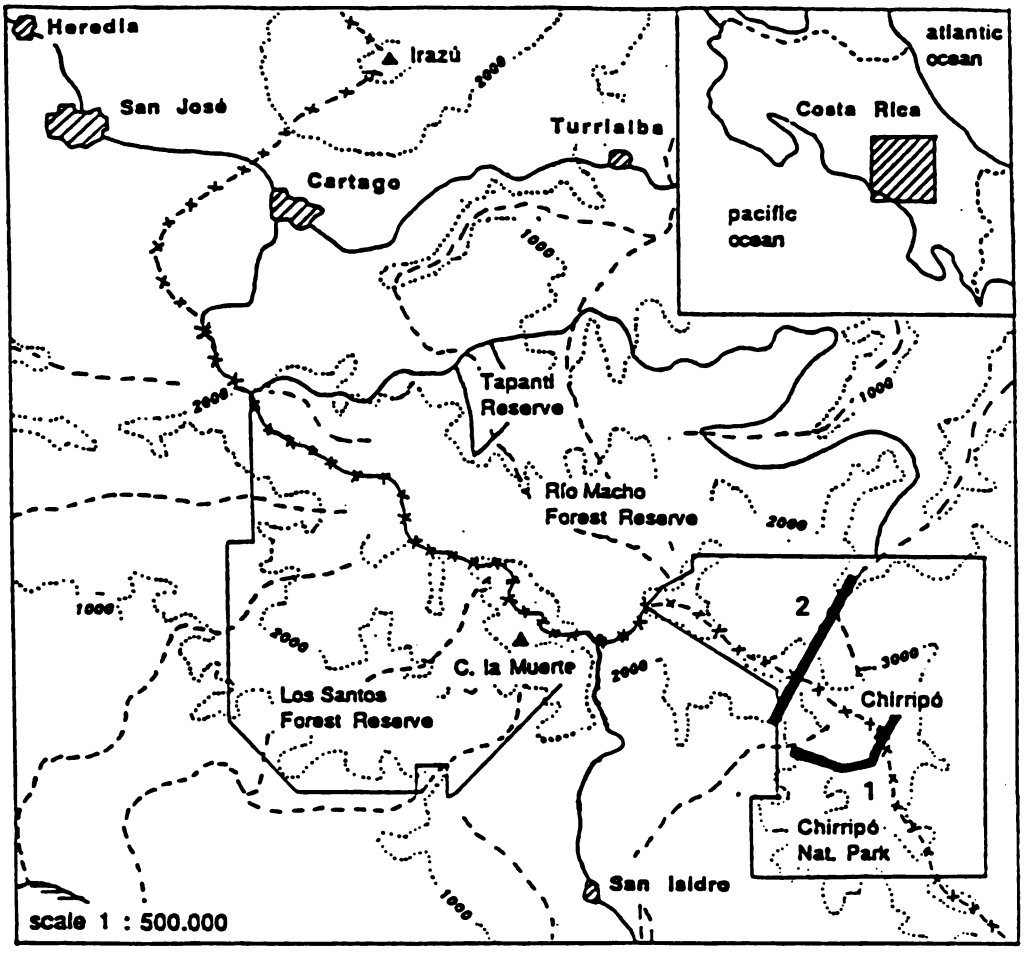

Figure 1. Map of the study area showing the location of the 'Parque Nacional Chirripó' and the two transects along which the major part of the fieldwork took place.

from which heavy rains occur. For this reason the Atlantic side receives more precipitation than its Pacific counterpart which has a pronounced dry season. Another important orographic feature, for both Atlantic and Pacific sides, is the formation of condensation belts, above some 2000 m altitude, during morning hours.

Precise information about rainfall is not at hand for the study area. HERRERA (1985) mentions an mean annual precipitation between 3,400 and 6,300 mm for the higher parts of the 'Cordillera de Talamanca' and a potential evapotranspiration of some 850 to 1,150 mm. Although there is no pronounced dry season a very small water deficit may occur in march.

The mean average temperature in Costa Rica oscillates between 26°C at the Atlantic coast and 28°C at the Pacific coast to 4.5°C at the 'Cerro Chirripó' (3819 m) in the 'Cordillera de Talamanca' (HARTSHORN et al., 1982). Major diurnal temperature differences are found at the higher altitudes and vary between 9°C in the rainy season to 14°C in the dry

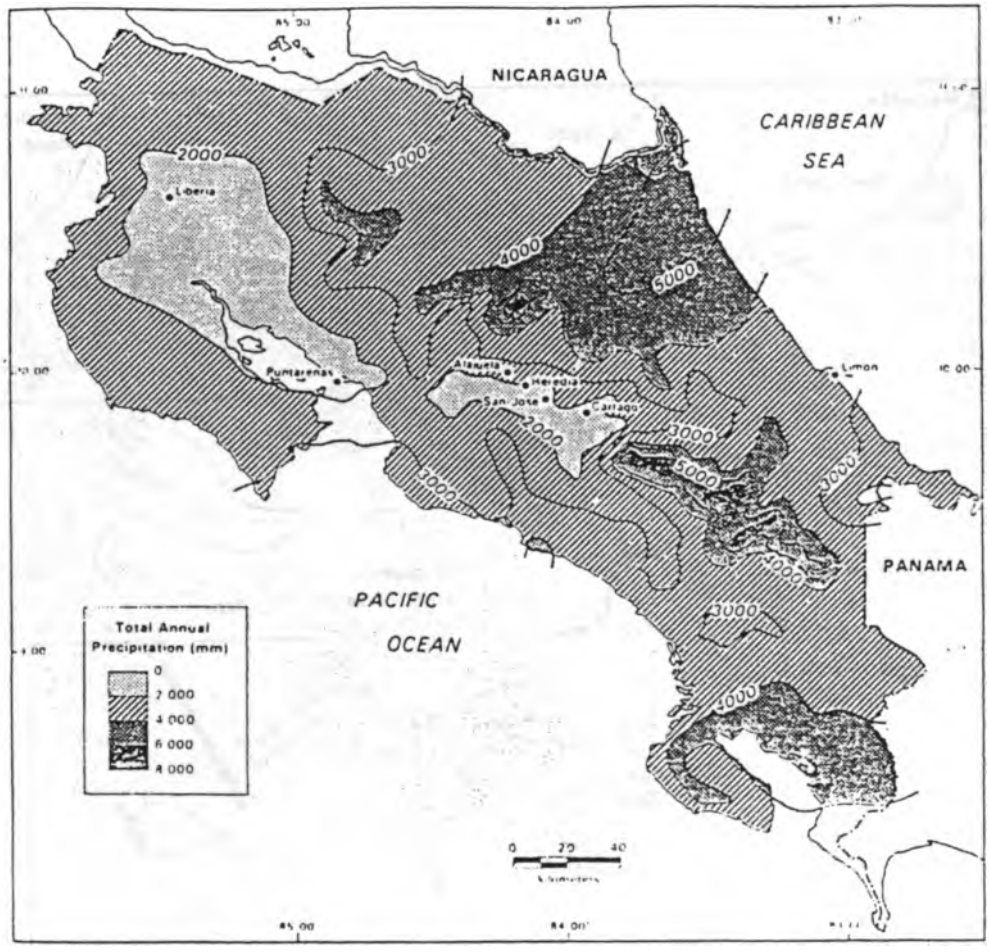

Figure 2. Mean annual precipitation in Costa Rica (HALL, 1985; from INSTITUTO PANAMERICANO DE GEOGRAFICO E HISTORIA, 1976).

season (HARTSHORN et al., 1982). Below 2500 m altitude frost is absent or rarely observed while above 1500 m altitude a sufficient amount of hours of critical low temperature inhibits the growth of frost sensitive species (HARTSHORN et al., 1982).

3.3 Life zones and vegetation

HOLDRIDGE (1967) incorporated the concept of altitudinal temperature zones into a precise and sophisticated system of live zones defined by heat, precipitation and moisture. From the twelve life zones present in Costa Rica four can be found within the study area (NUHN, 1978): subalpine rain páramo, montane, lower montane and premontane rain forest (see figure 3).

In contrast with the logging of valuable timber species and expansion of farmland, e.g. for extensive grazing, that affected large parts of the 'Cordillera de Talamanca', the study area is left virtually untouched. According to KAPPELLE (1990), the following zonification of primary vegetation of the 'Parque Nacional Chirripó' can be

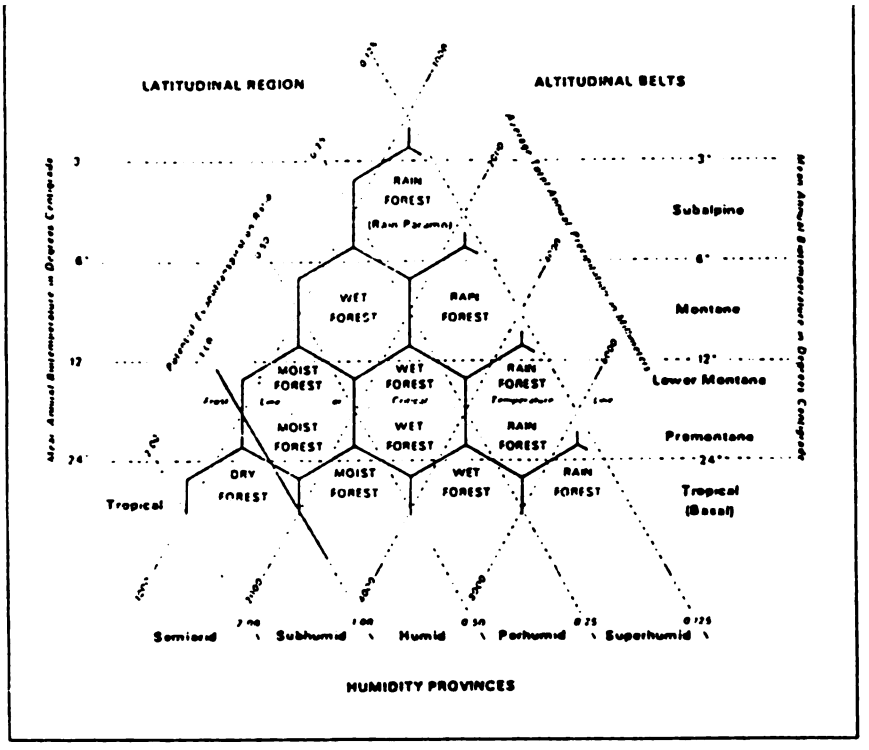

Figure 3. Chart of life zones in Costa Rica. (HALL, 1985; adapted from HOLDRIDGE, 1967).

distinguished (see figure 4):

- a bamboo-páramo which is caracterized by the following dominant species: Chusquea sp., Escallonia sp., Clethra sp., and Pernettya sp.
- the transition between bamboo páramo and montane pure oak forest (high montane dwarf forest) can be characterized by the following dominant species: Chusquea spp., Weinmannia sp., Comarostaphylis sp., and Vaccinium sp.
- the montane pure oak forest is caracterized by the dominant species: Quercus spp., and Chusquea spp.
- the transition between montane pure oak forest and submontane mixed forest can be caracterized by the following dominant species: Quercus spp., Clusia spp., Styrax sp., Ardisia spp., and Prunus sp.
- the submontane oak-lauraceous forest by: Quercus spp., Ocotea spp., Guarea sp., Billia sp., Mollinedia sp., and Nectamdra sp.

The study of the submontane pure lauraceous forest is underway (KAPPELLE, in prep.) and provisionally might be characterized by Nectandra spp. and Ocotea spp. (pers.comm. drs. KAPPELLE). Secondary submontane forest and pastures are found at lower altitudes on the Pacific side, but they fall beyond the scope of this study.

For further information on the primary vegetation in the montane belt of the western part of the 'Cordillera de Talamanca' reference is made to KAPPELLE et al. (1989).

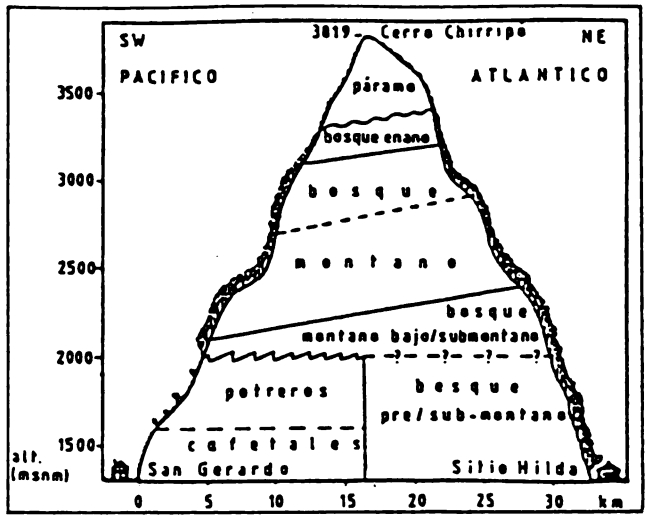

Figure 4. Schematic altitudinal zonation of the primary vegetation of the Parque Nacional Chirripó (KAPPELLE, 1990).

3.4 Geology and geomorphology

3.4.1 Southern Central America and Costa Rica

The deepest stockwork of Southern Central America is formed by oceanic sediments and volcanic rocks dating chiefly from the Cretaceous. This stockwork was formed as a result of the rifting of the Cocos and Caribbean plates (WEYL, 1980; SEYFRIED et al., 1987). From the Albian to the Campanian a ridge of primitive tholeiites developed which only in places emerged above sealevel. From the Maestrichtian to the Eocene, an andesitic island formed behind this tholeiitic ridge. From the Oligocene onwards this island arc gradually transformed into a continental landbridge. Formation of the island arc and its continentalization in northern Costa Rica are shown schematically in figure 5 (after SEYFRIED et al., 1987).

A present-day simplified geological map of Costa Rica is shown in figure 6.

3.4.2 Cordillera de Talamanca

RIVIER (1973) assumes that during the Paleozoic era to the Middle Eocene in the Cenozoic era an ocean basin extended throughout the region of the present 'Cordillera de Talamanca' in a northwest direction and that large masses of sediments built up in this bassin. The Upper Eocene is regarded as a period of low volcanic activity and mainly neritic sedimentation (WEYL, 1980). In the middle Oligocene initil uplift starts in the region of the 'Cordillera de Talamanca' followed by a strong uplift in the Middle Miocene. This means the end of the formation of marine sedimentation in the area of the 'Cordillera de Talamanca'. This strong uplift contrasts with the considerable subsidence of the Limon Basin more to the northeast. According to

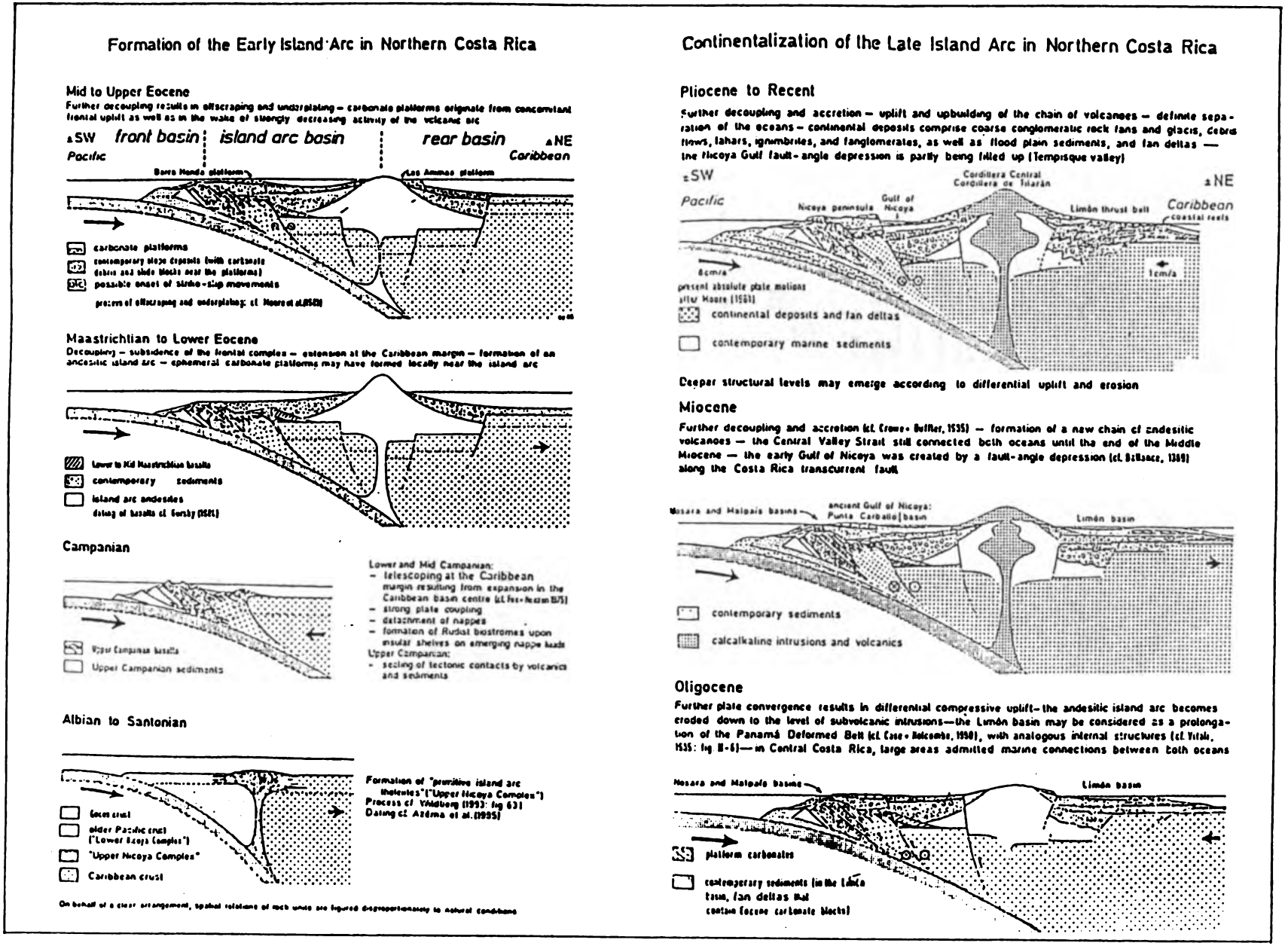

Figure 5. Formation of the island arc in northern Costa Rica and its continentalization. Structural evolution and basin development from the Albian to the present (SEYFRIED et al., 1987; accretion and offscraping according to SHIPLEY & MOORE, 1986).

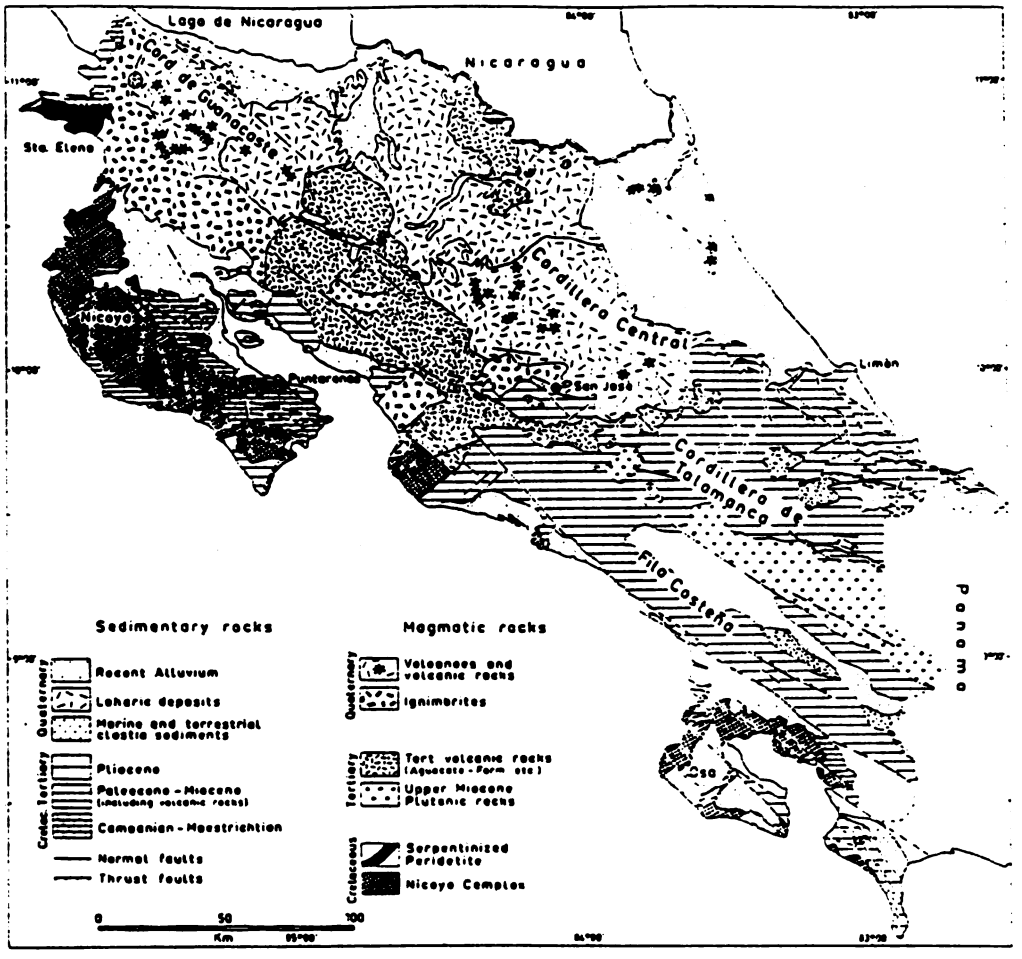

Figure 6. Geological map of Costa Rica (WEYL, 1980; simplified redrawing from 'Mapa Geológico de Costa Rica 1:700,000').

BALLMAN (1976) and WEYL (1957) Miocene plutonism played a major role in the structure of the 'Cordillera de Talamanca'.

DENGO (1962) gave a schematic cross section through southeastern Costa Rica including the 'Cordillera de Talamanca' (figure 7).

According to WEYL (1980), the 'Cordillera de Talamanca' is built up of Tertiary sediments with a thickness of probably in the order of several thousands of meters, with intercalated volcanic and Upper Miocenic plutonic rocks. In the western part of the range, and in particular on the northern flank, Tertiary sediments and intercalated volcanics predominate. WEYL (1980) concluded from the survey of BALLMAN (1976) carried out along a traverse, that in the eastern part of the 'Cordillera de Talamanca' by and large only horizontal strata or strata distorted by faults were found. This induced WEYL to remark that plutonic rocks are obviously much more in evidence in the eastern part of the range than in the western and northern parts.

The morphology of the 'Cordillera de Talamanca' is dominated by the contrast between steeply dissected valleys and extensive remains of

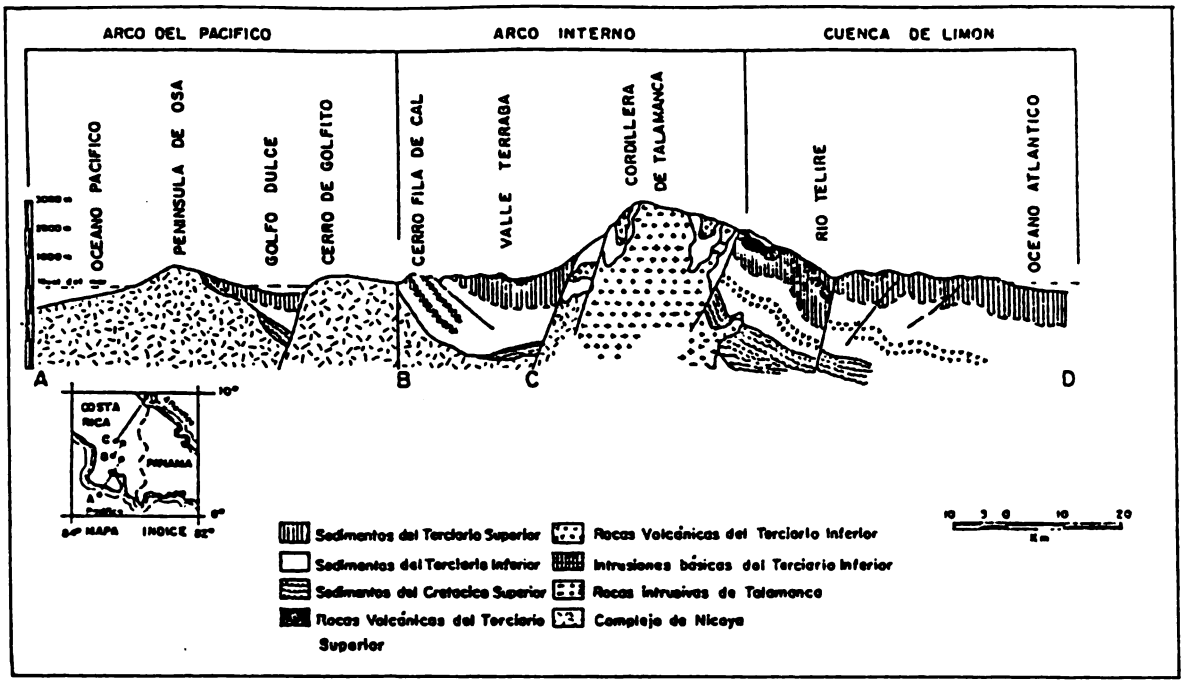

Figure 7. Schematic cross section of the southeastern part of Costa Rica (DENGO 1962).

flattish Pliocenic forms at the crest; the result of the violent young uplift of the range (WEYL, 1956a). Ultimately Pleistocene glaciation influenced the 'Cordillera de Talamanca' and glacial erosion gave shape to the highest regions around the 'Cerro Chirripó' (3819 m) and the 3554 m high 'Cerro Kamuk' (WEYL, 1956a and 1956b; HASTENRATH, 1973; BERGOEING, 1978).

3.5 Soils

The general soil map of Costa Rica shows only two soil types on the steeply dissected to mountainous relief in the 'Cordillera de Talamanca' (VASQUES, 1983). According to this general soil map one finds soils developed from volcanic ash deposits situated on slopes of 30 to 80% on the peaks of the Talamanca range ('Cerro Las Vueltas', the 'Cerro Buena Vista'/'Cerro de la Muerte' and the 'Cerro Chirripó'). These soils are dark, deep, rich in organic matter, medium textured, moderately fertile and excessively drained (mainly Andepts). The other type of soil is residual and is situated on slopes of 40 to 80% or more. These soils have an excessive external drainage, are deep to very shallow, reddish, heavily textured and they have a low fertility (mainly Tropepts).

Soil research studies are scarce in the 'Cordillera de Talamanca'. However of importance is the soil study carried out by OTAROLA & ALVARADO at the 'Cerro Buena Vista' ('Cerro de la Muerte') between 2000 and 3400 meters altitude. According to these authors Lithic Tropofolists form the major soil type at higher altitudes, Dystrandepts occur at lower altitudes, Tropohumods and Dystrandepts at intermediate altitudes. In general very low pH values were encountered.

4 GEOLOGY AND GEOMORPHOLOGY

4.1 Introduction

The geomorphological interpretation of aerial photographs is rooted in the study of landforms (a characteristic of relief) which reflects the various geomorphological processes and can be interpretated in a genetic and/or environmental sense (VERSTAPPEN, 1977).

Based on this definition of landforms three main physiographic units (areas) have been defined. Each of them represents a specific landform: a glacial area representing forms of glacial origin, a volcanic area representing forms of volcanic origin and a steeply fluvially dissected area representing predominantly forms of denudational origin, and to lesser degree forms of fluviatile origin. The ultimate criteria to classify a phenomena within one of these three areas is the morphogenesis which has left the most significant traces.

In the glacial area a nearly unchanged glacial stage is to be found in which, compared with the glacial processes of Pleistocenic age, denudational and fluviatile processes play only a secondary role today (BARQUERO & ELLENBERG, 1986). Although it is believed that no Quaternary volcanism took place volcanic forms are still clearly recognizable today. However denudational processes play an important role. The steeply fluvially dissected area is predominantly charaterized by denudational processes while depositional features are much more limited.

In the following a general overview will be given of the geology in the study area (paragraph 4.2). With regard to geomorphology first of all an introduction will be given of each of the three main physiographic units (areas), as discussed above, in the form of a literature review (paragraph 4.3 to 4.5). After this introduction the physiographic units, the physiographic subunits (only for the volcanic area), the parent material and the dominant rock particle size classes (only for the glacial area) are introduced and subsequently discussed following the legend of the reconnaissance soil map (see appendix 1a and 1b).

4.2 Geology

Figure 8 shows part of the geological map covering the study area at a scale of 1:200,000. Upper Miocene intrusions (granodioritic, dioritic and granitic rock, unit Tmi), Eocene and Upper Oligocene sediments (units Tep respectively Tom) are the main rock types found in the study area. According to the geological map some vulcanites (unit Tpq(v)) are found in the southeastern part of the study area and in the northeastern part just outside the study area.

CALVO (1987) studied the geology in the direct neighbourhood of the 'Cerro Chirripó'. She defined five lithological units in an area of some twelve square kilometers, viz lavas (Paleocene - Lower Miocene), pyroclastic deposits (Paleocene - Lower Miocene), marine deposits mainly derived from piroclasts (Middle Miocene - Lower Pliocene ?),

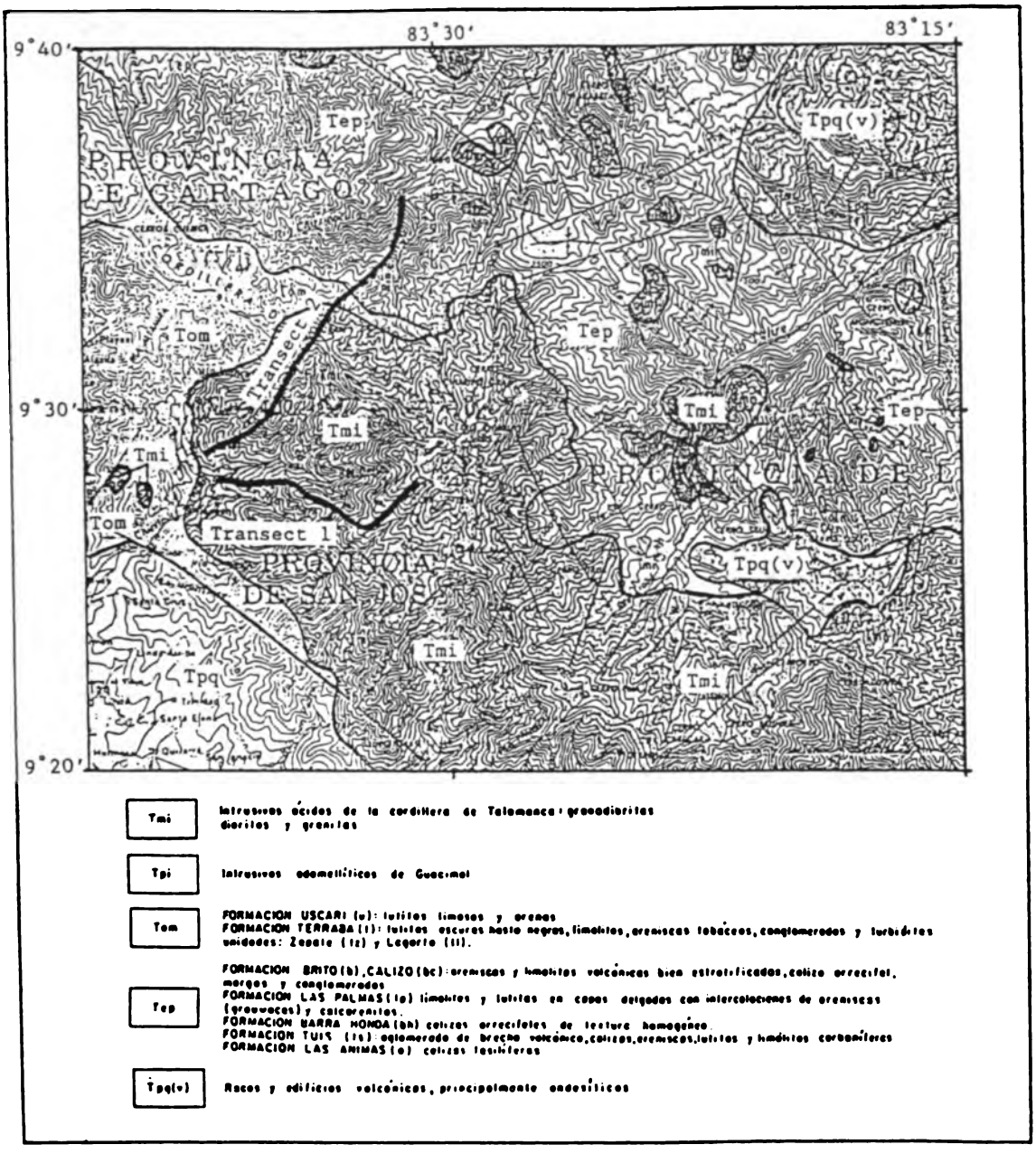

Figure 8. Part of the geological map, covering the study area at a scale of 1:200,000 and showing the two transects (IGN, 1982; scaled down).

intrusive rocks and metamorphic rocks.

During fieldwork intrusive igneous rocks (mainly granodiorites, diorites and granites), extrusive igneous rocks (vulcanites), sedimentary rock (mainly very fine siltstones) and some metamorphic

rocks were encountered in the glacial area (appendix 2a and 2b). Partly in contrast with the geological map both extrusive and intrusive igneous rock seem to be the major rock types found in the glacial area. At some places in the glacial area rocks showing hydrothermal alteration are found as well as rocks with layers of silicic filling. The plucking out and/or the rasping away of these different rock types during Pleistocene glaciation provided the material deposited as drift. For this reason drift varies in composition both in rock fragent size as well as in rock type. Relation between rock fragment size and rock type is not prominent.

The volcanic skeleton (see paragraph 4.4.1) as determined within the volcanic area probably consists of hard rock (lavas) interbedded in soft materials (pyroclasts). The volcanic remnants (paragraph 4.4.2) will be build up by vulcanites.

Apart from the rocks sampled along the two transects it is hard to say something in general about the rock types found in the steeply fluvially dissected area. Rock types encountered along transect one are mainly intrusive igneous rocks (granites and granodiorites) at lower altitudes and vulcanites (lavas) at higher altitudes (appendix 2a, 2b, 4a). Along transect two vulcanites are prominent with some sedimentary rock (very fine sandstones with a calcareous cement) found near the bed of the 'Río Chirripó' (appendix 2a, 2b, 4b). Sediment load of the 'Río Chirripó', as determined along the reconnaissance route, consists predominantly of vulcanites. From aerial photograph interpretation it is clear that landslides are particularly common in the northwestern part of the study area (appendix 1a). This possibly indicates the presence of fine grained sedimentary rock, or fine grained metamorphic rock of sedimentary origin, which have a relative low resistance to mass movements.

Generally speaking vulcanites are quite prominent in the study area which is in clear contrast with the geological map as presented above. On the other hand sediments, and to a lesser degree intrusives seem to be of a less widespread occurrence as is indicated at the geological map.

4.3 Glacial area

From the freshness of forms the age of the glaciation in the Chirripó Massif was thought to be equivalent to Würm-Wisconsin and ended some 50,000 years ago (WEYL, 1956a, 1956b; HASTENRATH, 1973). However, by now it is generally believed that the epoch of glaciation in the Würm-Wisconsin ended some 30,000 to 20,000 years ago (pers. comm. prof. dr. S.B. Kroonenberg).

According to BARQUERO & ELLENBERG (1986) the relief features of this alpine stage have been formed by three different generations of geomorphological processes.

The valleys and watersheds were initiated during the first generation of geomorphological processes: the preglacial.

The second generation of geomorphological processes was of a glacial character thus giving rise to a number of glacial features such as U-valleys, glacial lakes, terraces, cirques, moraines etc. These are

mapped very well by BARQUERO & ELLENBERG (1986). Pre-existing rock structure (e.g. dip of layers) is believed to be a major factor for the asymmetry of the glaciation, giving preference to the valleys directed towards the western and northern quadrants (WEYL 1956a, 1956b; HASTENRATH, 1973). Another important factor for this asymmetry might be the smaller amount of snow accumulation at the windward side because of the strong trade winds. The Pleistocene snow line elevation is set at about 3500 m altitude related to the base of the major cirques (WEYL, 1956 a, b; HASTENRATH 1973). The major glacial valleys have wide basins in their upper portion at 3450-3550 m. The largest glaciers reached to an altitude of some 3300 m (BARQUERO & ELLENBERG, 1986). The glacial lakes, mainly of the cirque type, constitute the most numerous group of tropical high mountain lakes within Central America (LOFFLER, 1972) with a maximum depth up to 22 m in the biggest lake, the 'Laguna Grande' (GOCKE et al., 1981). HASTENRATH (1973) identified two distinct sets of moraines. A comparatively old complex of moraines with up to three separate ridges is found near the valley exits and a complex of smaller and presumably appreciably younger moraines is found at the upper portion of the valleys. This induced him to say that the large moraines at the lower portion of the valleys belongs to the main glaciation and that the smaller moraines near the valley exits reflect later, possibly recessional stages.

The third generation of geomorphological processes distinguished by BARQUERO & ELLENBERG (1986) can be characterized by presently acting processes. Of the periglacial phenomena only block streams do occur quite commonly, mainly above 3600 m altitude (BARQUERO & ELLENBERG, 1986; HASTENRATH, 1973). Other phenomena described by BARQUERO & ELLENBERG are the undermining of the U-valleys by small streams and the filling up of cirques by soil materials. Some solifluidal effects are apparent, for example in the 'Valle de los Conejos' (HASTENRATH, 1973).

The glacial area is subclassed in two physiographic units which are interfluves and valley floors.

The interfluves are relatively undissected uplands or ridges between two adjacent valleys containing streams in the same general direction (BATES & JACKSON, 1980).

Valley floors are the comparatively broad, flat bottoms of a valley (BATES & JACKSON, 1980).

Glaciation involves scraping of weathered rock and soil, plucking out of bedrock and rasping away of firm rock. The load of sediment in this way obtained is carried away and deposited. Deposits of active ice are moraines, both ground and end moraines (terminal and lateral moraines) and meltwater deposits (outwash). Deposits itself are called drift which can be non sorted and directly deposited from the ice (till) or sorted and stratified (stratified drift).

The relationship between the physiographic units and both glacier and non glacier induced erosional features together with deposits of active ice is shown in table 1.

Study of the glacial area is based on interpretation of aerial photographs and on fieldwork within the páramo belt and along the upper parts of the transects.

Table 1. Relationship between the physiographic units of the glacial area, and both glacier and non glacier induced erosional features together with deposits of active ice.

			Physiographic units	
			inter-fluves	valley floors
erosive features		non abraded rock	*	
	glacier	abraded rock	*	*
deposits	glacier	ground moraine (drift)	*	*
	glacier	lateral moraine (till)	*	
	glacier	outwash (stratified drift)		*

4.3.1 Interfluves

Non abraded and abraded rock

The abrasive working of ice has left abraded rock outcrops at many sites (geomorphological observations 4, 6, 11, 18, appendix 2c). Extended abraded rock outcrops are most notably exposed at the northwestern flank of the 'Valle de los Conejos'. Here an abraded rock outcrop (pyroclastic rock partly overlaying sedimentary rock)) extends for more then 1 km showing very clear glacial striations. In other parts large structurally instable abraded rock outcrops were left behind. This has induced instable faces which caused heaps of fresh angular rock parts accumulated at the foot of these faces (g.o. 5). At some places abraded rock outcrops are found on steep slopes. Physical erosion (frost weathering) of these outcrops caused the occurrence of fresh angular boulders.

The upper limit of glaciation is clearly shown at places where smooth abraded mountain slopes pass more or less abruptly into rugged frost shattered mountain crests or peaks. A good example of such a mountain crest is 'Crestones' which lower parts (below some 3600 m) are smoothly abraded while its higher parts (above some 3600 m) are more rugged (figure 9 and g.o. 2). At other places crests are overriden by small glaciers (g.o. 3). The peak of the 'Cerro Chirripó' is the most notable sharp peak bounded by the intersecting walls of three cirques (g.o. 10). For this reason the 'Cerro Chirripó' must have been a horn during glaciation.

Ground moraine

In general drift blankets the landscape and may reach a thickness of 10 m or more as is shown at some margins of the glacial area and at some

river incisions (g.o. 9, 21). Based on the predominant rock fragment size three types of drift are distinguished within the physiographic unit of the interfluves, viz gravelly/stony drift, stony and stony/-bouldery drift.

Gravelly/stony drift is found on the relatively high solitary parts of the glacial area where glacial erosion was the prominent proces and supply of boulders from higher situated areas was limited. Large areas are only covered with a relative thin layer of gravelly drift directly overlying rock or rotten rock. These areas are

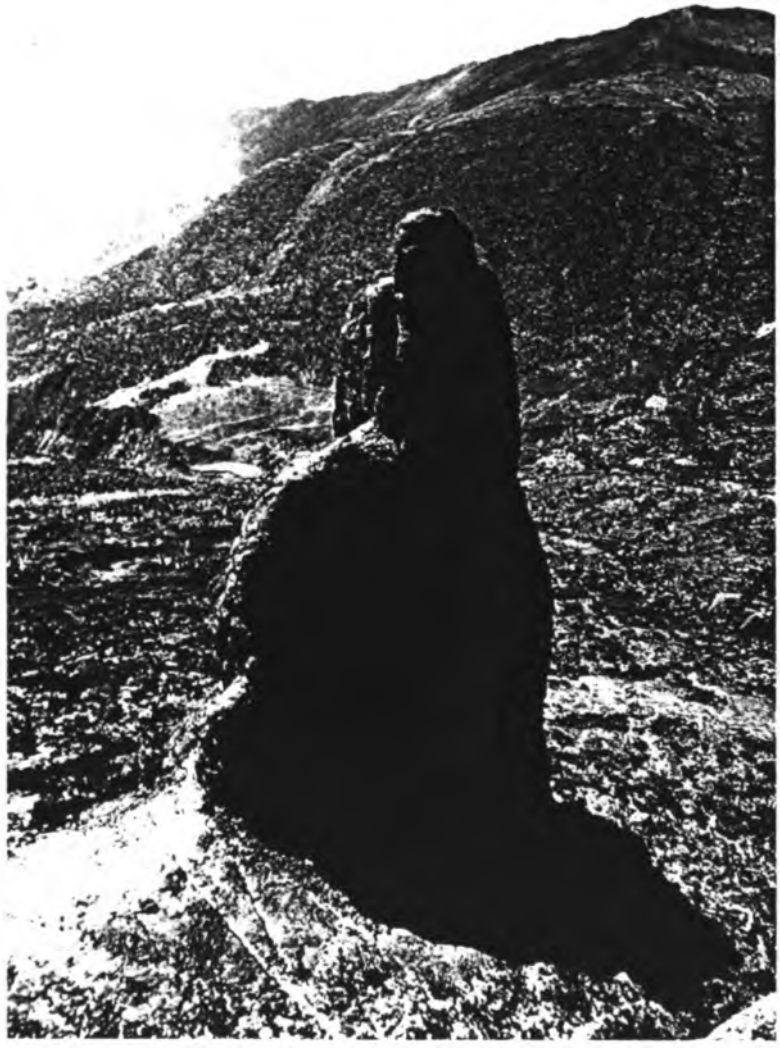

Figure 9. The lower smooth abraded pillar shaped part of the 'Crestones' with a height of some 60 m. Note the lateral moraine at the background with a second crest and the undermining of moraine material by the 'Río Talari' seen outermost left.

characterized by a strikingly smooth surface. A good example for such an area is the area east of the 'Cerro Urán' (g.o. 21). Particularly common on relative flat areas or depressions are small swampy areas and shallow lakes which dry up in periods short of rain.

At the other end of the range is bouldery drift which is most notable in areas whenever the distance to the source of these boulders (in general nowadays existing rock outcrops) is short. This situation can be found especially at or near the valley heads (g.o. 12). Signs of frostworking are recognizable near some crests (g.o. 17). Solifluidal processes might have been quite strong at some places (g.o. 17).

Stony/bouldery drift can be found in intermediate areas and is therefore most common. Particular common in this area are small cirque stairways and perpendicular ablong shaped lakes which dry up in periods short of rain (g.o. 13). Erosion, due to river incision, shows that the thickness of stony/bouldery drift may reach up to tens of meters in the area directly bordering the steeply fluvially dissected area.

Lateral moraines

Within the glacial area a great variety of end moraines (both terminal and lateral) of different age can be found. Because major terminal end moraines occupy a restricted area, only major lateral end moraines are dealt with. As both glacial (subsequent glacier advances and retreats) and past glacial erosion had their influence, minor terminal end moraine remnants, if at all, are left (g.o. 14, 19, 20).

Lateral end moraines are low ridge like moraines carried on or deposited at or near the side margin of a mountain glacier. As lateral moraines are chiefly composed of rock fragments loosened from the valley walls by glacial abrasion and plucking, or fallen on the ice from the bordering slopes, it is composed of both unsorted and unstratified drift (till). Thickness of lateral moraines range from a few meters to tens of meters as is shown by strong river incision near the entrance of the U-shaped valleys. Undermining of till by river incision results in debris slides exposing the moraine material (g.o. 9). Slopes are quite uniform and steep to very steep while some lateral moraines extend for more than 1 km. In some valleys lateral moraines are limited to one site and are less developed or complete absent at the other side of the valley (g.o. 15). Some major lateral moraines have a second crest at approximately half the height of the lateral moraine. This induces a strikingly depression almost parallel with the upper limit of the moraine (g.o. 8). It possibly refers to a persistent period of reduced thickness of the glacial body. Above the maximum level of the moraines and in the depressions as mentioned above one finds creeks and small lakes draining water.

The age of the major lateral moraines might be more or less the same, seen the soil development (profile description 3 and 6). Their location near the exits of the U-shaped valleys refer to the maximum extension of the glaciers.

4.3.2 Valley floors

Ground moraine

Based on the predominant rock fragment size two types of drift are distinguished within the unit of the valley floors, viz gravelly drift and stony/bouldery drift.

Gravelly drift is found at valley floors whenever the supply of coarse fragments by glaciers from up-glacier areas was limited resulting in a very small sediment load at the base of the glacier. Valley floors covered with gravelly drift are relatively flat and situated at the upper part of the valley indicating that plucking of rock parts out of the bedrock was restricted. Upstream areas of valley floors covered with gravelly drift are characterized by prominent abrasive forms. Large areas are only covered with thin layers of gravelly drift directly overlying abraded rock or rotten rock. Particular common at the valley floors covered with gravelly drift are swampy areas and relative large areas showing abraded rock, or rotten rock, surfaces. Of the periglacial phenomenas gelifluction played an important role in the 'Valle de los Leones' (g.o. 1).

Stony/bouldery drift is especially common in areas whenever supply of coarse fragments by glaciars from up-glacier areas was abundant. Nowadays these upstream areas are characterized by many rock outcrops which are not abraded (rugged crests and peaks) to more or less abraded rock outcrops (figure 10). Abraded rock outcrops showing clear striations are found at some places.

Figure 10. The upper portion of the 'Valle de las Morenas', covered with stony to stony/bouldery drift, showing more or less abraded rock outcrops at the highest part of the inter fluves, and a groundmoraine belonging to a small glacier at the valley floor (view from the top of the major lateral end moraine).

Outwash

One of the deposits of active ice is stratified drift which is deposited by streams of meltwater. Stratified drift can be expected in front of the lateral moraines. Within the study area meltwater streams occurring during the maximum extension of the glaciers surely led to the deposition of stratified drift. Except from some remnants of outwash deposits at the backside of the lateral moraine (up glacier side) in the 'Valle de los Conejos', existence of these deposits could not be determined because of the restricted visibility due to the dense vegetation. But seen the erosion of the major lateral moraines the erosion and removal of these deposits is obvious.

Within the U shaped valleys river incision exposes layers of both compacted drift and stratified drift (g.o. 7, 16) and sometimes include a layer of compacted fibric soil material (g.o. 7): remnants earmarking different glacial stadia.

4.4 Volcanic area

It is generally believed that no Quaternary volcanism took place in the Cordillera de Talamanca (CASTILLO, 1984; WEYL, 1980).

HARRIS (1971) described up to six buried soils, each of them developed in a layer of ash, in a single section found in a road cut near 'El Empalme' in the 'Cordillera de Talamanca'. By investigating the age of the ash layers HARRIS came to the conclusion that there appeared to be evidence that volcanic activity took place between 17,000 (main extrusive phase) and 8,400 radiocarbon years before present across the 'Cordillera de Talamanca'. Failure to identify the Quaternary vulcanicity induced him to say that the activity might have been produced by fissures. However, such eruptions are characteristically associated with fluid basaltic magmas whose lavas tend to spread widely and build up flat plains (SKINNER & PORTER, 1987). Absence of these features and the fact that ashes tend to be deposited in an elliptical zone to the east of each volcano, makes it more presumable that Harris had to do with ash depositions originating from vulcanicity in the 'Cordillera Central'.

More recent BARQUERO & SAENZ (1987) depicted in their map of volcanic structures in Costa Rica two volcanic skeletons in the 'Cordillera de Talamanca': 'Piedra del Fuego' (longitude 83°21'10'', latitude 09°36'46'', altitude 2206 m) and 'Sinsal' (longitude 83°19'55'', latitude 09°39'46'', altitude 2394 m). Data about their age are not at hand.

The volcanic area is subclassed in two physiographic units which are volcanic skeletons and volcanic remnants.

A volcanic skeleton is defined as the last stage of destruction of a volcano, the cone shape being destroyed while an arrangement of radial ridges on a centrifugal pattern of consequent valleys may survive (VISSER, 1980). In the northwestern part of the study area

remnants of a steep conical mount can be identified from the aerial photographs. This volcanic skeleton is the 'Piedra del Fuego' as depicted by Barquero and Ellenberg in their map of volcanic structures in Costa Rica. Steep conical mounts are build up by either pyroclasts or pyroclasts and viscous lava. Conical mounts build up by pyroclasts will not last long because of the climate in the study area (heavy rainfall). For this reason the volcanic skeleton may be classified as a former stratovolcano that emitted both pyroclasts and viscous lava of which the latter one can be identified from the aerial photographs.

Within the context of this report volcanic remnants are features of volcanic origin which can not be tracked to easily recognizable volcanic structures. These features are concentrated in the southwestern part of the study area.

It is important to realize that the study of the volcanic area is almost entirely based on the interpretation of aerial photographs.

4.4.1 Volcanic skeleton

Infacing cone slope

The infacing slope of the cone remnant is possibly filled up with volcanic debris forming concave slopes to the lowest point covering the former crater pit. Back cutting erosion of a river ('Río Securí') broke part of the broadly circular crest of the infacing slope and started to erode the infacing cone slope.

Cone slopes

Only part of the cone slope remnants can be identified clearly at the western side of the infacing cone slope. The cone slope remnant is deeply cut by back cutting erosion of rivers (strongly gully and ravine erosion) resulting in a radial drainage pattern. Summit of the cone slope remnants are steep while slopes flatten to the base. Near its base, in the eastern part of the study area, part of the less eroded cone slope can be identified. Most probably the cone remnant consists of hard rock (lavas) interbedded in soft material (pyroclasts).

lava flow

In the western section of the volcanic skeleton the cone slope has collapsed leaving a steep walled bassin with a diameter of some 2 km. The bottom of this bassin is filled by low viscosity lava showing a flattish topography. This obviously more effusive eruption took probably place at the southwestern point of the lava flow. More to the northeast a solitary lava flow can be identified which exact origin could not be tracked. Lava has flown downwards over a distance of some 5 km and blocked the valley of the 'Rio Chirripó' (g.o. 34). Both lava flows presented the last phase of the eruption history. Associated with the volcanism is the thermal spring found in the valley of the 'Río Chirripó (Duchí)' (g.o. 32). Some springs are rich in mineral matter dissolved from rock (g.o. 29).

4.4.2 Volcanic remnants

slopes

Very steep to moderately steep slopes which are steeply dissected. Some volcanic remnants (almost directly bordering the glacial area to the east) show signs of possibly explosive forms. Radial drainage pattern within these remnants end in only one outlet draining these remnants. Within this physiographic subunit small wall like ridges produced by differential erosion (dikes) are common.

talus fan

Talus fans are classified as volcanic remnants since no other source could be identified to be causally related to the occurrence of talus fans within this particular part of the study area. It is charaterized by a strikingly uniform slope in which slumps occur. Most striking however is the obvious high sediment load resulting in a more braided pattern of the river which drains the area, striking because other rivers show strong incision. The talus fan is build up of unconsolidated material in which mass-wasting occur (slumps) resulting in a high sediment load.

lava infill

Lava infills are the outcome of low viscosity lava resulting in a strikingly relative flat area bounded by steep slopes. River incision is strong and erosion is notable.

crest

Strikingly are the nearly flat topped crests bordered by very steep slopes. Width of these crests ranges from tens of meters to hundreds of meters. Vegetation is sparse, if at all, which gives rise to the idea that consolidated rock is near the surface.

lava flow

Old eroded lava flows can be identified from the aerial photographs. The old flows form the higher parts of the surrounding country thus indicating an inversion of the volcanic relief. Volcanic structures from which these flows originate could not be determined.

4.5 Steeply fluvially dissected area

Due to its hard access and the remote location no scientific research has been carried out in this area yet.

The area is subclassed in two physiographic units which are crests and slopes, and terraces.

Crests are the highest points or lines of a landform from which the surface slopes downward in opposite direction (BATES & JACKSON, 1980).

A terrace is any long, narrow, relatively level or gently inclined surface bounded along one edge by a steeper descending slope and along the other by a steeper ascending slope (BATES & JACKSON, 1980). This unit is subclassed into two physiographic subunits, viz river terraces and volcanic dam lake remnants. River terraces are terraces occurring along the margin of rivers. Volcanic damlake remnants are remnants of terraces originating from an expanded part of a river, induced by a dam formed by a volcanic flow, forming a lake.

Study of the steeply fluvially dissected area is based on the interpretation of aerial photographs, fieldwork along the transects and along the reconnaissance route.

4.5.1 Crest and slopes

Rugged crests and steeply dissected slopes characterize the steeply fluvially dissected area. Slopes can be relatively flat to very steep. The drainage pattern is dendritic although river beds are structurally controlled by faults at some places.
Landslides do occur in the upstream area of the 'Río Chirripó (Duchí)'.

4.5.2 Terraces

River terraces are only found in areas with a huge supply of debris and extensive in areas filled up with debris like in former lava-dam lakes. Denudational processes play a major role today and river incision in own sediments amounts to a few meters in some years (g.o. 28, 35). Rivers show a more or less braided pattern with many rapids. Along the reconnaissance route abandoned channels (g.o. 35) are easily to determine. The most extended river terraces are found near the indian villages of 'Sitio Hilda' and 'Chirripó Abajo'.

Volcanic dam-lake remnants are found in the uppermost part of the valley of the 'Río Chirripó (Duchí)' (figure 11) which was blocked by a lava flow as described in section 4.4.1. This has led to the formation of a lava-dam lake in which debris were deposited. Seen the relatively level valley bottom near 'Sitio Hilda' thickness of this (alluvial) fill probably amounts to tens of meters. Probable relicts of this former lava-dam lake are found along the transect just before one reaches the bed of the 'Río Chirripó (Duchí)'. In a steeply dissected surrounding country very well preserved small remnants of a few terraces are found up to some 70 meters above the actual bed of the 'Río Chirripó' (g.o. 24, 33). On the way to 'Sitio Hilda' and in 'Sitio Hilda' itself one finds the very well preserved remnants of several terraces (g.o. 31). The lava flow that blocked the valley shows today a huge face of some 100 m almost straight down to the actual bed of the 'Río Chirripó (Duchí)'. Blocking of valleys by lava flows are of more widespread occurrence as can be seen in the valley of the 'Río Telire'.

Figure 11. Volcanic dam lake remnants near 'Sitio Hilda' in the uppermost part of the valley of the 'Río Chirripó (Duchí)'.

5 The Soils

5.1 Introduction

In the second paragraph of this chapter a literature review of available soil information is given. In paragraph 5.3 the physiographic legend of the reconnaissance soil map is introduced and reference is made to the legend and the reconaissance soil map itself. In the next paragraph a short account on systematics and nomenclature introduces the description of the subsequent soil mapping units according to the legend. The last paragraph of this chapter deals with soil genesis and classification.

5.2 The physiographic legend of the reconnaissance soil map

The mapping units of the reconnaissance soil map are mainly based on interpretation of aerial photographs and correspond with the physiographic units as described in chapter 4. Thus the highest category of the legend groups soils according to physiography: soils of the glacial area, soils of the volcanic area and soils of the steeply fluvially dissected area. These areas were then subdivided in physiographic units, physiographic subunits (only for the volcanic area) and further by parent material and dominant rock particle size classes (only for the glacial area).

The soil mapping units are defined in terms of soil associations. Proportions of the different members of the soil associations are expressed as percentages. These percentages are based on rough field estimates and for this reason can only be indicative.

The range of characteristics of the members of the soil associations are given in the legend and are defined in terms of Soil Taxonomy (SOIL SURVEY STAFF, 1975). Most of the terms used in the legend are based on FAO (1977). The effective soil depth classes applied are very shallow (< 25 cm), shallow (25-50 cm), moderately deep (50-100 cm) and deep (> 100 cm). These soil depth classes fall within the outline of soil depth classes as recommended by the SOIL SURVEY STAFF (1951). Reference is made to the reconnaissance soil map and its legend which can be found in the loose appendices 1a and 1b.

Accuracy of the reconnaissance soil map is not that of a detailed soil map because soil associations are based only on the profile descriptions and some routine soil augerings along transects and in the páramo belt. However the reconnaissance soil map allows a better appraisal for the developement of proper management plans.

5.3 Description of the soil mapping units

5.3.1 Systematics and nomenclature

The members of the soil associations are described according to the legend of the reconnaissance soil map. Each soil association is

introduced by the nomenclature of its taxonomic units using the nomenclature of the SOIL SURVEY STAFF (1975). In this study use was made of the work of the International Committee on the Classification of Andisols (ICOMAND, 1987). This means that in the Key to the Soil Orders (SOIL SURVEY STAFF, 1975) Andisols will key out after the Histosols.

To classify a soil as an Andisol it has to meet the following properties and diagnostic horizons:

1 Have andic soil properties
  a Throughout all subhorizons, whether buried or not, which make up to a thickness of 35 cm or more within 60 cm of the mineral soil surface, or
  b Throughout 60% or more of the total soil thickness if a lithic or paralithic contact occurs within 60 cm of the mineral soil surface, and
2 Do not have an albic horizon, or remnants of an albic horizon, with an associated spodic horizon, unless it occurs below the depth of the total thickness required in 1.

To have andic soil properties, the soil material must meet the requirements given in ICOMAND (1987). From these three reguirements only the first one is of interest for the study area:

1 a Acid oxalate extractable aluminium plus 1/2 acid-oxalate extractable iron is 2.0% or more, and
  b Bulk density of the <2 mm fraction, measured at 1/3 bar water retention, is 0.90 g/cm^3 or less, and
  c Phosphate retention is more than 85%.

Acid oxalate extractable Al and Fe were not determined. The bulk density of the <2 mm fraction was not determined because of the rock particles in most profiles. For this reason a field criterion of pH NaF over 10 together with the required phosphate retention strongly support the classification of soil material having andic properties (pers. comm. dr. W. Wielemaker).

Most of the terms used in the description of the soil mapping units (soil associations) are based on FAO (1977). The members of the soil associations are defined in terms of Soil Taxonomy in which the andic integrate to the great groups is defined, in this study, by andic soil properties (as defined above) within 60 cm of the mineral soil surface. Nomenclature after both Soil Taxonomy (SOIL SURVEY STAFF, 1951) and FAO (1988) for the 36 profiles can be found in appendix 5. Soil colours (moist) are after the MUNSELL SOIL COLOR CHARTS (1950) and have a hue of 10 YR unless otherwise mentioned. Soil acidity (pH H^2O) is expressed in soil acidity classes according to the Soil Survey Manual (SOIL SURVEY STAFF, 1951).

Soil profile descriptions and chemical and physical analyses of the soil profiles are both given in the separate appendices (appendix 9 respectively 10).

5.3.2 Soils of the glacial area

5.3.2.1 Interfluves

Mapping unit: GIri, GIrv and GIrs

Parent material: debris derived from granodioritic-, dioritic-and granitic rock (GIrv), volcanic rock (GIrv) or sedimentary rock (GIrs)
Topography: mountainous
Vegetation: sparse bamboo-páramo

Soils and their setting

1 (20%) Lithic Troporthents

Occurring at almost flat to sloping positions protected from erosion

Soil characteristics:
Horizons: none or slight evidence of development of pedogenetic horizons, slight accumulation of organic soil materials
Surface stoniness: rubble land

2 (80%) Rock outcrops

Mapping unit: GIgl

Parent material: mainly thin layers of gravelly to stony drift mainly derived from igneous rock (ground moraine)
Topography: almost flat to hilly
Vegetation: bamboo-páramo

Soils and their setting

1 (30%) Lithic Placudand, Lithic Humitropept (Profile 23; 25, see figure 12)

Occurring on sloping positions near strongly abraded convex crests, developed in thin layers of drift over consolidated rock

Soil characteristics:
Horizons:
-O, up to 15 cm thick layer of sapric soil material, black
-histic epipedon
-Ah, some 10% organic matter, dark gray to very dark brown
-E, not visible, no signs of bleaching visible, supposingly E is being formed within A
-Bw, very pale brown (10YR)
-placic horizon, some 10 mm thick, formed over lithic or saprolitic substratum
Drainage: imperfectly to moderately well drained
Depth: shallow
Texture: sandy loam, 15 to 50% stones
Surface stoniness: stony to exceedingly stony
Structure: weak subangular
Chemical properties:
-very strongly acid (pH 4.5-5.0) to strongly acid (pH 5.1-5.5) soils, base saturation <10%
-Lithic Humitropept does not meet required thickness soil material having andic properties

Figure 12. Lithic Humitropept showing a thin iron pan (Placic horizon) formed over rotten rock (profile 25).

2 (30%) Lithic Troposaprist (Profile 1, 24)

Occurring on almost flat positions, in depressions and other poorly drained positions, especially on thin layers of gravelly drift

Soil characteristics:

Horizons:

- **-O, up to 40 cm thick layer of sapric soil material, up to 60% organic matter, black to very dark brown sometimes dark reddish brown (5YR)**
- **-Ah, 10 to 20% organic matter, black to brown**
- **-Bw, light yellowish brown to brownish yellow**
- **-lithic or saprolithic substratum over which mostly a placic horizon has been formed**

Drainage: poorly drained to imperfectly drained

Depth: very shallow to shallow
Particles within the soil: from 0% in shallow soils to 50% in very shallow soils
Surface stoniness: exceedingly stony (very shallow soils) to no stones (shallow soils)
Structure: weak angular to subangular
Chemical properties:
-extremely acid (pH <4.5) in the O horizon to strongly acid (pH 5.1-5.5) in the Bw horizon, base saturation <10%

3 (40%) Rock outcrops, abraded and normally paved with stones

Mapping unit: GIg2

Parent material: mainly thick layers of stony drift mainly derived from igneous rock (ground moraine)
Topography: hilly to mountainous
Vegetation: bamboo-páramo with spots of high montane dwarf forest found at lateral moraine remnants, high montane dwarf forest near the borders with the steeply fluvially dissected area

Soils and their setting

1 (75%) Acric Hapludand, Typic Hapludand (Profile 2; 5)

Occurring on moderately steep to very steep positions

Soil characteristics:
Horizons:
-O, up to 5 cm thick layer of hemic soil material, up to 50% organic matter, black
-sometimes histic epipedon
-Ah, 5 to 10% organic matter, black to dark brown or reddish dark brown
-Bw, brownish yellow to dark brown
Drainage: moderately well drained
Depth: moderately deep
Texture: sandy loam, 15 (in shallow soils) to 90% (in very shallow soils) stones
Surface stoniness: exceedingly stony
Structure: weak subangular
Chemical properties:
-medium acid (pH 5.6-6.0) to slightly acid (pH 6.1-6.5) soils, base saturation <50%

2 (20%) Lithic Troposaprist (Profile 26, 27, 28)

Occurring at depressions, on almost flat or other poorly drained positions, especially on relatively thin layers of drift overlying rotten rock at the Atlantic side.

Similar soil as Lithic Troposaprist in unit GIg1, except for
Horizons:
-O, up to 65 cm thick layer of sapric soil material
Depth: moderately deep
Particles within the soil: slightly gravelly at lower part of the soil
Surface stones: none

3 (5%) Rock outcrops

Mapping unit: GIg3

Parent material: bouldery drift mainly derived from igneous rock (ground moraine)
Topography: mountainous
Vegetation: bamboo-páramo

Soils and their setting

1 (85%) Acric Hapludand, Typic Hapludand

Occurring on very steep slopes found near valley heads with more or less rugged crests

Similar soils as Acric and Typic Hapludand in unit GIg2

2 (15%) Rock outcrops

Mapping unit: Gil

Parent material: thick layer of bouldery till mainly derived from igneous rock, and sometimes also rich in sedimentary rock (lateral moraine)
Topography: mountainous
Vegetation: high montane dwarf forest

Soils and their setting

1 Andic Dystropept and Eutropept, Typic Hapludand (Profile 3; 6, 8; 7)

Occurring on very steep positions

Soil characteristics:
Horizons:
- -O, to a few cm thick layer of hemic soil material
- -no histic epipedon
- -Ah, some 15% organic matter, black
- -Bw, relatively thick and well developed, strong brown (7.5YR) to pink (5YR)

Drainage: well drained
Depth: moderately deep to deep
Texture: loamy sand to sandy loam
Surface stoniness: very stony
Structure: weak very fine subangular blocky
Chemical properties:
- -slightly acid (pH 6.1-6.5) soils, base saturation <15%
- -Typic Hapludand meets required thickness andic soil material
- -Andic Eutropept has base saturation > 50%

5.3.2.2 Valley floors

Mapping unit: GFgl

Parent material: thin layer of gravelly drift, mainly derived from igneous rock deposited over consolidated substratum (ground moraine)
Topography: flat to undulating
Vegetation: bamboo-páramo

Soils and their setting

1 (70%) Lithic Placaquand (Profile 4)

Occurrence on flat to sloping positions at valley head

Soil characteristics:
Horizons:

-O, none or slightly developed
-no histic epipedon
-Ah, up to 20% organic matter, black to dark yellowish brown
-E, not visible, no signs of bleaching visible, supposingly E is being formed within A
-placic horizon, up to 10 mm thick, formed over abraded rock or rotten rock

Drainage: very poorly drained
Depth: very shallow
Texture: sandy loam, 15 to 50% stones
Surface stoniness: stony
Structure: weak subangular blocky
Chemical properties:
-medium acid (pH 5.6-6.0) to slightly acid (pH 6.1-6.5), base saturation < 15%

2 (30%) Rock outcrops

Mapping unit: GFg2

Parent material: relatively thin to thick layers of mainly stony to bouldery drift mainly derived from igneous rock (ground moraine)
Topography: almost flat to rolling
Vegetation: bamboo-páramo

Soils and their setting

1 (85%) Acric Hapludand, Typic Hapludand

Occurrence on almost flat to sloping positions

Similar soils as Acric and Typic Hapludand in unit GIg2

2 (10%) Lithic Troposaprist

Occurring at depressions and on other poorly drained positions

Similar soil as Lithic Tropofolist in unit GIg1

3 (5%) Rock outcrops

5.3.3 Soils of the volcanic area (exploratory)

5.3.3.1 Volcanic skeleton

Mapping unit: VSC(i)

Parent material: unconsolidated material derived from lava's and pyroclasts
Topography: steep slopes at top to sloping at bottom
Vegetation: densely forested
Soils: well developed moderately deep soils may be expected (erosion is limited)

Mapping unit: VSC

Parent material: hard rock (lava's) interbedded in soft material (pyroclasts)
Topography: steep to very steep slopes
Vegetation: forested

Soils: old volcanoes in the humid tropics may display thick soils, however erosion is strong and therefore moderately well developed shallow soils may be expected

Mapping unit: VSF

Parent material: lava
Topography: almost flat to moderately steep slopes
Vegetation: densely forested
Soils: well developed deep soils may be expected (erosion is very limited)

5.3.3.2 Volcanic remnants

Mapping unit: VRS

Parent material: residual and colluvial material derived from volcanic rock
Topography: moderately steep to very steep slopes
Vegetation: forested
Soils: moderately well developed shallow soils may be expected (strong erosion)

Mapping unit: VRF

Parent material: unconsolidated material, debris
Topography: gentle to moderately steep slopes
Vegetation: sparsely, no forest
Soils: slightly developed very shallow soils, if at all, may be expected (active mass wasting)

Mapping unit: VRI

Parent material: lava
Topography: gentle to moderately steep slopes
Vegetation: densily forested
Soils: well developed deep soils may be expected

Mapping unit: VRC

Parent material: residual, colluvial volcanic rock
Topography: almost flat to moderately steep slopes
Vegetation: sparsely vegetated, at certain places no vegetation
Soils: moderately well developed shallow soils may be expected, at non vegetated places consolidated rock is near the surface (erosion)

Mapping unit: VRF

Parent material: lava
Topography: gentle to moderately steep slopes
Vegetation: densily forested
Soils: well developed deep soils may be expected (erosion is limited)

5.3.4 Soils of the steeply fluvially dissected area

5.3.4.1 Crest and slopes

Mapping unit: FSrc

Parent material: residual and colluvial material derived from various rock types
Topography: steeply dissected
Vegetation: montane forest at higher altitudes to submontane forest at lower altitudes

Soils and their setting

1 (30%) Pacific phase: Typic, Alic and Acric Hapludand, Andic Humitropept, Andic Haplumbrept (Profile 11, 12, 17, 20, 22; 9, 13; 14, 18, 19; 10, 15, 21; 16)

Occurring on moderately steep to very steep positions over both unconsolidated and consolidated substratum

Soil characteristics:
Horizons:
- -O, up to 20 cm thick layer of fibric to sapric soil material, 35 to 60% organic matter, very dark brown, dark reddish brown (5YR) or dark yellowish brown, abundant very fine to coarse roots
- -histic epipedon
- -Ah, 10 to 20% organic matter, black to dark yellowish brown
- -E, sometimes visible, color value is one unit lighter than the Ah (profile 9,11,12,13,17,20), E being formed within Ah, sometimes some grains are covered with cracked coatings, loamy sand
- -Bw, yellowish brown to brownish yellow
- -sometimes lithic contact, otherwise unconsolidated substratum

Drainage: moderately well to well drained
Depth: moderately deep
Texture: loamy sand to loam, up to 50% stones on steep slopes
Surface stones: none
Structure: weak to moderate subangular blocky, at altitudes lower than 2100 m weak to moderate crumb
Chemical properties:
- -extremely acid (pH <4.5) to strongly acid (pH 5.1-5.5), base saturation <15, if derived from intrusive rock or volcanic rock
- -andic properties of Andic Humitropept and Andic Haplumbrept are less pronounced

2 (65%) Atlantic phase: Typic Hapludand, Acric Hapludand, Andic Humitropept, Typic Humitropept (Profile 32, 34; 33; 31; 35, 36)

Occurring on moderately steep to very steep positions over both unconsolidated and consolidated substratum

Same soils as Pacific phase, except for;
Horizons:
- -O horizon up to 40 cm thick
- -E horizon not visible

Chemical properties:
- -medium acid (pH 5.6-6.0) and higher base saturation if derived from sedimentary rock

-andic properties of Andic and Typic Humitropept are less pronounced

3 (5%) Atlantic phase: Typic Placudand, Placic Humitropept (Profile 29; 30)

Occurring on gently sloping to moderately steep positions mainly at the Atlantic side, placic horizon formed over consolidated substratum of mainly volcanic rock

Soil characteristics:
Horizons:
-O, 25 cm thick layer of fibric to sapric soil material, up to 65% organic matter, black to very dark grayish brown, abundant very fine to coarse roots
-histic epipedon
-Ah, some 10% organic matter, dark grey to very dark grayish brown
-E, is being formed within Ah, colour value is at least one unit lighter than the Ah, sandy loam to clay loam (rich in kaolinite?)
-placic horizon, up to 2 mm thick, formed over unconsolidated substratum
-Bw, yellowish red (5YR)
Drainage: imperfectly drained
Depth: shallow
Texture: sandy loam to loam, 2 to 15% very weathered stones
Surface stoniness: none
Structure: weak subangular blocky
Chemical properties:
-extremely acid (pH <4.5) to very strongly acid (pH 4.5-5.0), base saturation <10%
-Lithic Humitropept lacks andic properties

5.3.4.2 Terraces

Mapping unit: FTRs

Parent material: sediments mainly derived from igneous rock
Topography: flat or almost flat
Vegetation: forest and at certain places shifting cultivation by indians.
Soils: moderately well developed, moderately deep soils

Mapping unit: FTDs

Parent material: sediments mainly derived from igneous rock
Topography: almost flat
Vegetation: forest and shifting cultivation by indians or permanent pasture especially near 'Sitio Hilda'
Soils: moderately well developed, moderate deep soils

5.4 Soil genesis and classification

5.4.1 Introduction

The soils in the study area are classified according to Soil Taxonomy (SOIL SURVEY STAFF, 1975) and FAO (1988). Major chemical

characteristics of the soils are represented by their soil names and therefore can be directly understood.

As background to classification the following soil forming factors will be shortly discussed: parent material and topography, climate and vegetation, soil fauna and man.

5.4.2 Parent material and topography

Glacial area

The glacial area is covered with drift derived from various rock types. Thickness of these deposits range from a few centimeters to tens of meters. Both thickness and position of drift define the soil drainage and together they strongly determine the kind of soil found (see table 2).

Table 2. Relationship between thickness of drift deposits, physiography, drainage and the kind of soil found in the glacial area.

	Drift	Thickness	Position	Drainage	Soil (Soil Taxonomy)
Interfluves	(non abraded and abraded rock)				
	-	-	flat to very steep	-	rock outcrops
	-	thin layers	flat to very steep	-	Lithic Troporthent
	ground moraine				
	none	-	-	-	rock outcrops
	gravelly/stony drift	thin layers	sloping	imperfectly to moderately well	Lithic Placudand Lithic Humitropept
			flat, other poorly drained positions	poorly to imperfectly	Lithic troposaprist
	stony to bouldery drift	thick layers	moderately steep to very steep	moderately well	Acric and Typic Hapludand
	lateral (end) moraine				
	bouldery drift	thick layers	very steep	well	Andic Dystropept and Eutropept, Typic Hapludand
Valley floors	ground moraine				
	none	-	-	-	rock outcrops
	gravelly drift	thin layers	flat to sloping (valley heads)	very poorly	Lithic Placaquand
	stony to bouldery drift	thin layers	poorly drained positions	poorly to imperfectly	Lithic Troposaprist
		thick layers	almost flat to sloping	moderately well	Acric and Typic Hapludand

Abrasion by glaciers removed soil material thus leaving bare, partly or totally abraded rock outcrops. These rock outcrops are commonly found at the valley heads and the upper portion of the flanks of some valleys. Initial soil formation and the accumulation of organic soil material between the interstices of rock particles led to the formation of Lithic Troporthents.

Thin layers drift can be found over abraded rock outcrops at the interfluves and valley floors thus inducing very shallow soils. Quite commonly a thin iron pan has been formed over a lithic or saprolithic substratum. When found at depressions, on flat and other poorly to imperfectly drained positions organic soils are found (Lithic Troposaprist). At very poorly drained positions at the valley floors (at the valley heads) one finds Lithic Placaquands. Well drained very shallow soils are found at sloping positions at the interfluves (Lithic Placudand, Lithic Humitropept). Figure 13 shows the schematized relative position of soils developed in thin layers of drift.

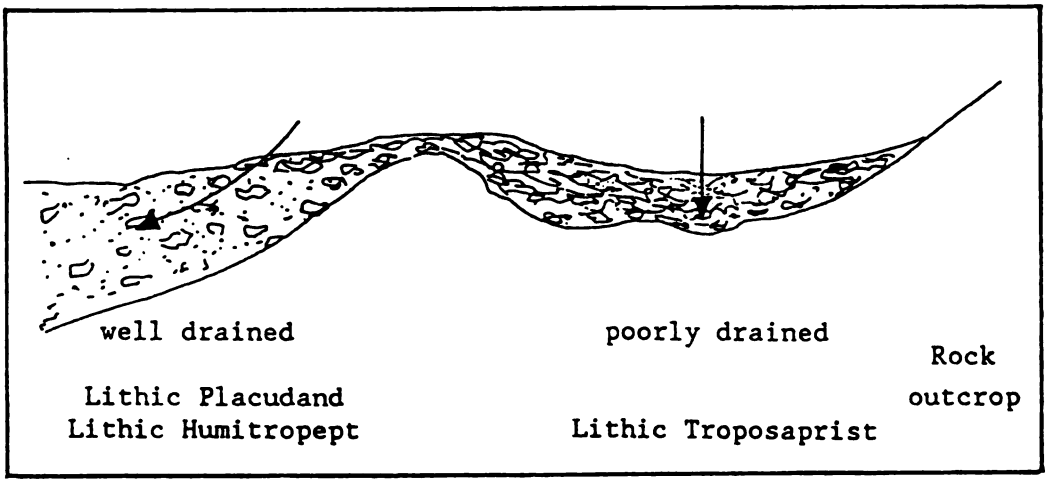

Figure 13. Schematized relative position of soils developed in thin layers of drift.

Thick layers of drift are found at both interfluves and valley floors and are commonly moderately well drained (Acric and Typic Hapludand, Andic Dystropept and Eutropept). Moderately deep to deep soils are developed over the lateral moraines.

Because of the well developed andic properties of the soils in the glacial area admixture with volcanic ash is obvious.

The influence of parent material as a soil forming factor is weak from a pedogenetic point of view. Important for fertility however is the fact that soils formed in drift relatively rich in basic rock have relatively high pH H_2O values of 5.5 to 6.5 throughout the entire soil profile. When drift is composed of acid rock types pH H_2O ranges from 4.0 to 5.0. When sedimentary rock forms a substantial contribution to the composition of drift the base saturation is more than 50%, otherwise it is less than 10%.

The volcanic area

For the soils in the volcanic area it is important to remark that soils found on volcanic crests may locally restrict tree growth as can be seen on the aerial photographs. This is possibly due to poorly soil drainage and/or limited soil depth.

The steeply fluvially dissected area

As most soils in the steeply fluvially dissected area are found on steep to very steep positions the differentiating role of topography as a soil forming factor is much less pronounced than in the glacial area.

Generally speaking altitude and climate dominate the soil forming processes in most tropical highlands.

At gently sloping imperfectly drained positions at the Atlantic side a thin iron pan has been formed in unconsolidated soil material derived from volcanic rock (Typic Placudand and Placic Humitropept). Organic matter accumulation is higher at the Atlantic side (see next section). Otherwise soils are quite uniform and andic properties are well developed at most places (Typic, Alic and Acric Hapludand). Admixture of volcanic ash in these soils is obvious.

As in the glacial area influence of parent material as a soil forming factor is weak from a pedogenetic point of view. Relative young soils formed over basic rock types have a relatively high pH H_2O value of 5.6 to 6.5 in the Ah horizon. Soils formed over acid rock types do have a low pH H_2O value ranging from pH H2O 4.0 to 5.0 throughout the entire soil depth. Base saturation is always lower than some 15%, for soils both formed over basic and acid rock types

5.4.3 Climate and vegetation

Temperature, precipitation and cloudiness are climatic factors significant for the development of vegetation in the study area. Vegetation itself provides organic matter to the soil, which is important for soil development.

Climate and vegetation zones

Figure 4 (paragraph 3.3) shows that the inferior boundaries of the vegetation zones and their transitions are higher at the Atlantic side than at the Pacific side.

A possible explanation for this asymmetry, especially for the páramo belt, is given by LAUER (1981). Strong tradewinds arrive on the Atlantic slopes of the Talamanca range carrying large quantities of water that cause heavy rains on slopes with a northeast exposition (Atlantic side). Abundant precipitation, and therefore reduced temperature fluctuations and a decreasing number of days with frost, facilitate continued forest growth at higher altitudes at the Atlantic side.

An important point to be made is that diagrammatic representations of climatic types that have occurred since the Ice Age indicate that páramos in Latin America, occur between the present day snow line and the ice age snowline (LAUER, 1981). The ice age snowline equals roughly

the present position of the upper timberline. This point strongly supports the differentiation of soils found in the glacial area ('páramo soils') and in the volcanic and steeply fluvially dissected area ('forest soils').

Soil temperature

It is generally accepted that soil temperature has an important influence on biological, chemical and physical processes in the soil and on the adaptation of introduced plants (SOIL SURVEY STAFF, 1975).

Figure 14 shows the relation between soil temperature, and their variation within the individual horizons, and altitude as found in the study area. Temperature variation within the individual soil profiles is generally within one degree Celcius (for the soil temperatures in the soil profiles measured at intervals of 10 cm see appendix 7). The soil temperatures in the páramo soils are higher than one would expect seen the soil temperatures in the forests near the timber line. Most possibly this is mainly due to the rainfall regime (fog and clouds stay freguently below the limits of the upper timber line, especially at mornings) and the interrelated incoming solar radiation.

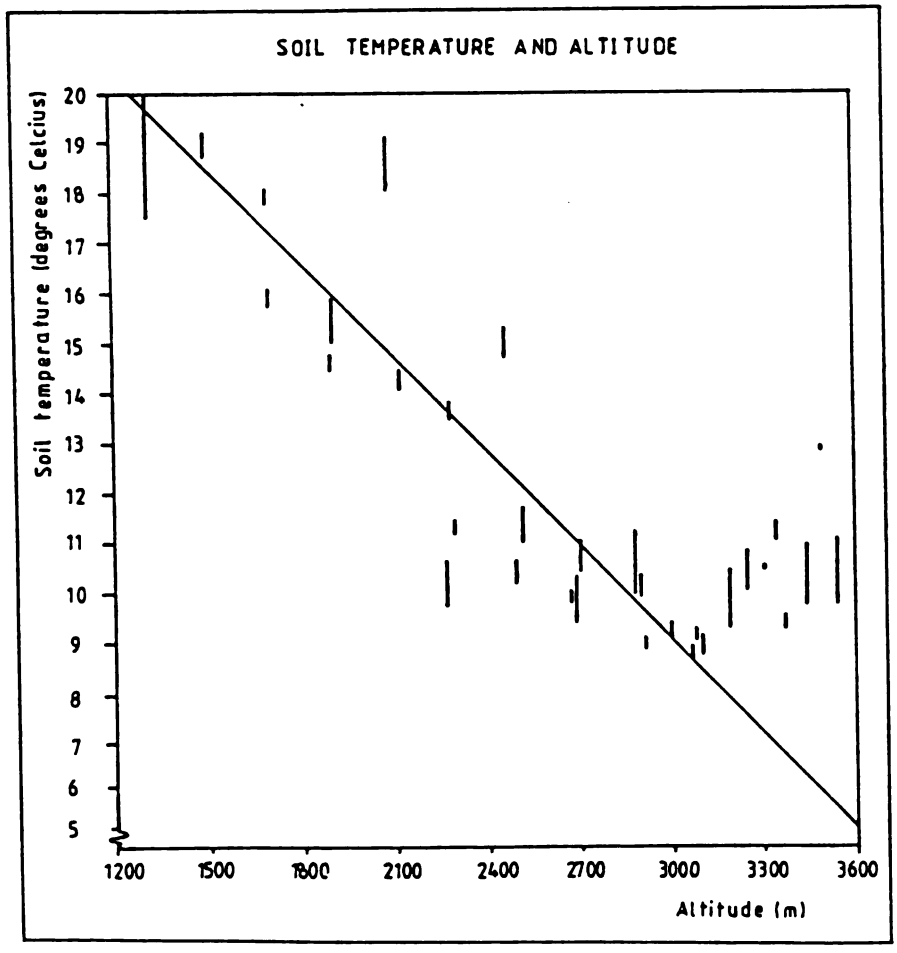

Figure 14. Relation between soil temperature, and its variation within the individual soil profiles, altitude and the (theoretical) mean annual air temperature.

Soil temperatures below 8 to 10 °C critically reduce the water absorption capacity of roots (LAUER, 1981). As one can see in figure 14 soil temperatures drop not below some 9 °C and therefore can not be (wholly) restrictive for tree growth.

From a soil temperature study in the Buritaca - La Cumbre transect in the Colombian Andes it became clear that the deeper soil temperatures in the forest belt provided a good approximation of the mean annual air temperatures (VAN DER HAMMEN, 1984). By extrapolating the soil temperature gradient of the forest soils as found in the study area one finds for the páramo belt a mean annual air temperature with a range of some 4 to 8 °C (see figure 14). As at an air temperature of 8 to 10°C tree growth ceases (LAUER, 1981), air temperature may be considered an important factor responsible for the restriction of tree growth within the páramo belt and the fixation of the upper limit of the tropical forest belt.

Organic matter

Nature and content of organic matter are important characteristics of soils. Appendix 4a and 4b show the soil profiles together with their humus profiles along the two transects. Figure 15 shows the relation between the thickness and morphology of the humus profiles and altitude, both for the Pacific and Atlantic side of the study area.

Strong accumulation of organic matter is found within the páramo belt. Humus profiles are dominantly composed of fine organic material, they are free of litter and contain some mineral soil material. These humus profiles have a thickness up to some 60 cm and are black coloured representing their high degree of decomposition.

Humus profiles of most forest soils are for about half their thickness composed of fine organic material which is free of litter fragments and contain some mineral soil material.

At the Atlantic side this well decomposed organic horizon is overlaid by a less decomposed horizon and sometimes by a litter layer, or the well decomposed organic horizon is directly overlaid by a litter layer. At the Pacific side the well decomposed organic horizon is overlaid by a horizon composed of about equal amounts of more or less fragmented litter and finely divided organic material. This horizon is overlaid by a litter layer.

The humus profiles of forest soils are commonly very dark brown. Thickness of the humus profiles ranges from some 10 cm, at low altitudes, to some 40 cm at higher altitudes at the Atlantic side. At the Pacific side thickness of the humus profiles ranges from some 10 cm, at low altitudes, to some 20 cm at higher altitudes.

The decomposition proces is strongly influenced by temperature which possibly accounts for the decrease of the humus profile thickness with decreasing altitudes. As soils are extremely acid to strongly acid at both Atlantic and Pacific side the higher moisture content at the Atlantic side (more precipitation) is a factor which possibly favours a better decomposition of the organic material at the Atlantic side.

In the well decomposed lower parts of the humus profiles of the forest

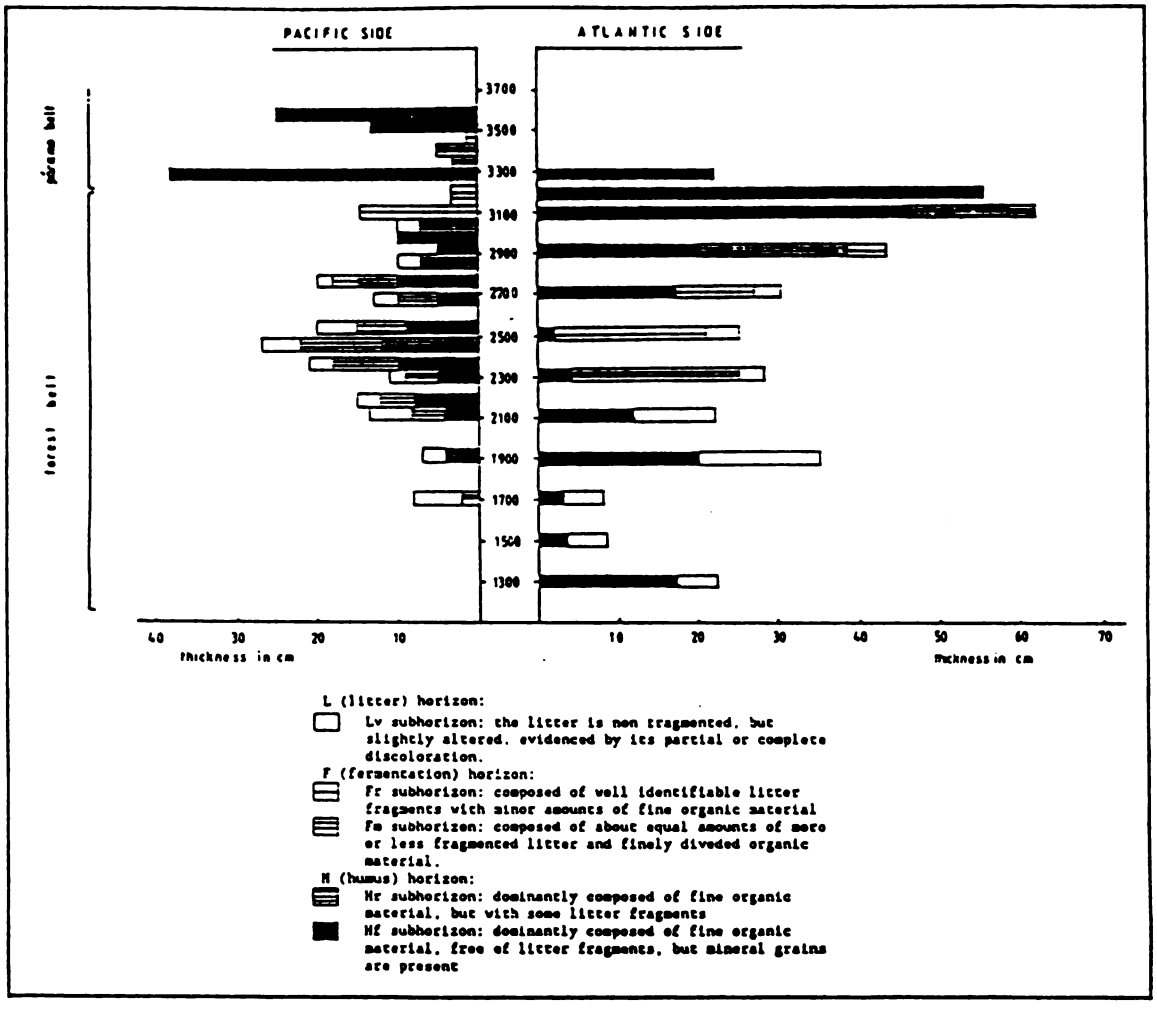

Figure 15. Relation between the thickness and the morphology of the humus profiles and altitude, both for the Atlantic and Pacific side of the study area.

soils thick superficial root mats have been developed (root distribution descriptions can be found in the soil profile descriptions): humus profiles offer both moisture and nutrients to the vegetation. Another important role of the humus profiles is the protection of the mineral soil surface against (water) erosion. This important role is highlighted by the formation of badlands in the 'Cordillera de Talamanca'. Forest clearing and the subsequent removal and depletion of organic matter, followed by water erosion and mass movements, opened the way to the formation of the badlands.

5.4.4 Soil fauna

The relation between earthworm biomass (expressed as g/m^2 or ton/ha) and altitude for both Atlantic and Pacific side is shown in figure 16.

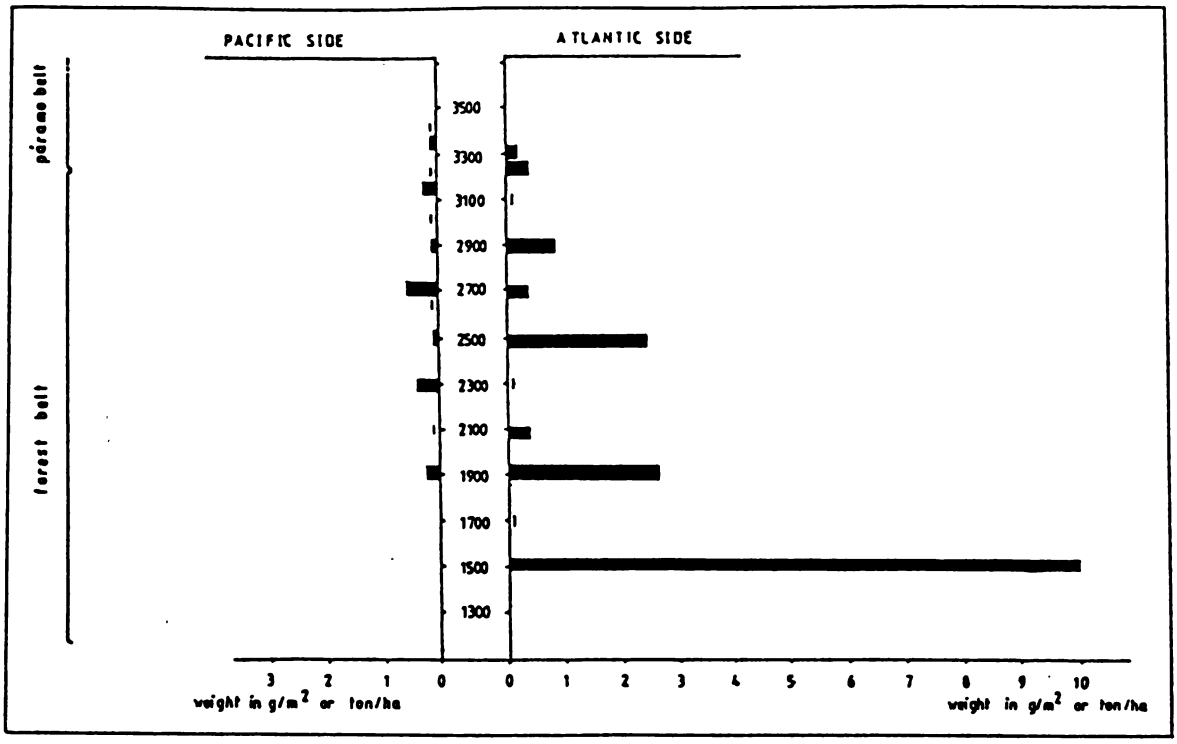

Figure 16. Relation between earthworm biomass and altitude for both Atlantic and Pacifc side.

The figure shows that the earthworm biomass tends to be higher at the Atlantic side. The major differentiating factor between Atlantic and Pacific side is the soil humidity, so the higher soil humidity at the Atlantic side possibly accounts for the higher earthworm biomass. This may be partly reflected by the better decomposition of the organic matter at the Atlantic side as was shown in figure 15.

For those interested in the soil fauna one finds in appendix 8 the classification of the collected soil fauna (major groups and orders of some major groups), expressed as percentage of total weight. Because of the sampling method, both restricted in time and place, it may only serve as a very general indication.

5.4.5 Man

Logging of valuable timber species and expansion of farmland on steep positions just southwest of the study area has resulted in a dramatic increase of landslides. On pastures with large numbers of animals compaction is a problem seen the mottling near the surface of the soil. Other negative human impacts are man made fires to clear land: in 1988 undiscriminate use of fire destroyed a large part of the forest near the village of San Gerardo.

Small numbers of Amar indians practice shifting cultivation with maize, beans and cassave in the valley of the 'Río Chirripó (Duchí) (figure 17). After two or three years these places are left and allowed to

refert to forest as can be seen along the 'Rio Chirripó (Duchí)'. In this way soil exhaustion and soil erosion are controlled. Other crops grown near their homesteads are sugar cane, bananas and citrus. Terraces found in the upper portion of the valley of the 'Río Chirripó (Duchí)' near 'Sitio Hilda' are turned into permanent pasture (figure 11 and 18).

Figure 17. Shifting cultivation with maize on a river terrace of the 'Río Chirrpó (Duchí)' near 'Sitio Hilda'.

Figure 18. Indian homestead near 'Sitio Hilda' on a terrace (volcanic damlake remnant) turned into permanent pasture, and shifting cultivation on a slope in the background.

6 SUMMARY AND CONCLUSIONS

The Chirripó Massif is the highest massif found in the westernmost part of the 'Cordillera de Talamanca' and includes the highest point of Costa Rica's territory, the 'Cerro Chirripó' (3819 m). The study area covers this Massif which corresponds roughly with the 'Parque Nacional Chirripó'. Mean annual precipitation is high and between 3,400 and 6,300 mm a year while the live zones present in the study area are subalpine rain páramo, montane, lower montane, and premontane rain forest.

In September and October 1988 and March and April 1989 fieldwork took place along two altitudinal transects, in the páramo belt and, to a lesser degree, along a reconnaissance route through the valley of the 'Río Chirripó (Duchí)'. Geological and geomorphological observations were done, soil profiles were described and soil material collected for laboratory analyses.

Three main physiographic units have been defined in the study area. Each of them represent a specific landform, viz a glacial area representing forms of glacial origin, a volcanic area representing forms of volcanic origin and a steeply fluvially dissected area representing predominantly forms of fluviatile origin. Information about these areas is for the glacial area based on fieldwork along transects and in the páramo belt, for the volcanic area on interpretation of aerial photographs, and for the steeply fluvially dissected area on fieldwork along transects and along the reconnaissance route.

The glacial area is subclassed in two physiographic units which are interfluves and valley floors. The upper limit of glaciation is clearly shown at places were smooth abraded interfluves pass more or less abruptly in frost shattered interfluves. This limit lies at some 3600 m. Most interfluves, however, are covered with ground moraine. A set of major lateral moraines is found near the exits of the U-shaped valleys referring to the maximum extension of the glaciers. On the valley floors one finds ground moraine and some abraded rock outcrops. Ground moraine is further subclassed based on the thickness of the drift deposits and the predominant rock fragment size of these deposits.

The volcanic area is subclassed in volcanic skeletons and volcanic remnants. In the northwestern part of the study area one finds the skeleton of a stratovolcano. The infacing cone slope, the cone slopes and some lava flows can be readily distinguished from aerial photographs. In the southwestern part of the study area volcanic remnants, some of them showing explosive forms, area quite prominent. Volcanic slopes, talus fans, lava infills, volcanic crests and lava flows were distinguished.

The steeply fluvially dissected area is characterized by rugged crests and steeply dissected slopes. Both river terraces as well as terraces originating from volcanic dam lake remnants are found.

Generally speaking intrusive rock and volcanic rock are quite prominent in the glacial area. Along the transects mainly vulcanites were en-

countered.

A reconnaissance soil map is provided in this report, its legend is based on physiography. The soil mapping units are defined in terms of soil associations. Proportions of the different members of the soil associations are expressed as percentages based on rough field estimates.

Soils of the glacial area are very shallow to shallow when developed in thin layers of drift and moderately deep to deep when developed in thick layers of drift. In relative thin layers of drift on nearly flat positions, at depressions and on other poorly drained positions, formation of organic soil material is strong (Lithic Troposaprist). Admixture of volcanic ash is obvious leading to the formation of Andisols. Formation of a thin iron pan over abraded rock surfaces in very shallow to shallow soils is a common phenomena (Lithic Placudand, Lithic Placaquand). In thicker layers of drift Andisols, Dystropepts and Eutropepts were found.

Soil development in the volcanic area depends theoretically on climate, age and rock type. However in the study area erosion will play an important factor determining soil depth and development.

Soils of the steeply dissected area are moderately deep and are characterized by a thick humus profiles of fibric to sapric soil material. In the lower parts of these humus profiles thick superficial root mats have been developed. Humus profiles are thicker at Atlantic side than at the Pacific side (up to 40 cm respectively 20cm) and they are better decomposed. This is most probably the result of the higher amount of precipitation at the Atlantic side of the study area and the interrelated higher activity of soil fauna (especially earthworms). Soils of the steeply fluvially dissected area show almost all strong andic properties (Hapludands and Andic Humitropepts) and admixture of volcanic ash is therefore obvious. Some soils show initial podsolization.

The glacial stage in the Chirripó Massif initiated a major soil boundary between soils of the glacial area ('páramo soils') and soils of the volcanic and steeply fluvially dissected area ('forest soils'). The air temperature is an important factor responsible for the restriction of tree growth in the glacial area (páramo belt).

The forest vegetation provides a rich supply of organic matter to the soil which has important implications for soil development. It not only provides nutrients and moisture to the vegetation (superficial root mats in the humus layer) it also plays an important role by protecting the mineral soil material against water erosion.

Clearance of the forest, and the subsequent removal and depletion of the organic matter, will facilitate the destruction of this unique natural resource. Within a few years the luxuriance of the forest will be replaced by an area with exhausted soils, showing initial signs of the formation of badlands. This can already be seen on steep slopes in the southwestern part of the study area.

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APPENDICES

LOOSE APPENDICES

1a Reconnaissance soil map of the Chirripó Massif and adjacent areas, Cordillera de Talamanca, Costa Rica
1b Legend of the reconnaissance soil map of the Chirripó Massif and adjacent areas, Cordillera de Talamanca, Costa Rica

2a Location of the geological and geomorphological observations, and the location of the soil profiles

4a Cross section of the altitudinal sequence through the Chirripó Massif: transect 1 - 'Cementerio de la Máquina'
4b Cross section of the altitudinal sequence through the Chirripó Massif: transect 2 - 'Palmito Morado' - 'Paso de los Indios'- 'Camino de los Indios'

Appendix 2b Reference collection of rocks

Glacial area

1	Extrusive igneous rock - lava (basaltic/andesitic)
2	Extrusive igneous rock - very weathered
3	Extrusive igneous rock - lava (basaltic/andesitic)
4	Intrusive igneous rock - Diabase
5	Extrusive igneous rock - lava
6	Igneous rock - hydrothermal alteration
7	Silisic filling
8	Extrusive igneous rock - lava (basaltic/andesitic)
9	Intrusive igneous rock - Granitoid
10	Extrusive igneous rock - lava (basaltic/andesitic)
11	Extrusive igneous rock - lava (basaltic/andesitic)
12	Intrusive igneous rock - Diabase
13	Intrusive igneous rock - Granitoid
14	Intrusive igneous rock - Diabase
15	Extrusive igneous rock - basaltic?
16	Intrusive igneous rock - Granitoid
17	Intrusive igneous rock - Alaskite
18	Igneous intrusive rock - Granitoid
19	Extrusive igneous rock - Dolerite
20	Metamorfic rock - Hornfels
21	Metamorfic rock - Hornfels
22	Metamorfic rock - Hornfels
23	Intrusive igneous rock - Granodiorite
24	Extrusive igneous rock - Dolerite
25	Intrusive igneous rock - Granodiorite
26	Extrusive igneous rock - lava

Transect 1: 'Fila Cementerio de la Máquina'

27	3300	Extrusive igneous rock - lava (basaltic/andesitic)
28	3160	Extrusive igneous rock - lava (basaltic/andesitic)
29	3100	Extrusive igneous rock - lava (basaltic/andesitic)
30	2910	Intrusive igneous rock - Diabase
31	2810	Intrusive igneous rock - weathered
32	2640	Intrusive igneous rock - Diabase
33	2570	Intrusive igneous rock - Granitoid
34	2470	Extrusive igneous rock - lava (weathered)
35	2100	Intrusive igneous rock - Granodiorite (weathered)
36	1630	Intrusive igneous rock - Granite
37	1400	Intrusive igneous rock - Granite containing pyrite

Transect 2: 'Fila Palmito Morado' - 'Camino de los Indios'

38	1500	Intrusive igneous rock - Granodiorite (altered)
39	1820	Intrusive igneous rock - Granodiorite (altered)
40	1920	Extrusive igneous rock - lava with phenocrists (basaltic/andesitic)
41	2600	Extrusive igneous rock - lava (basaltic/andesitic)
42	2910	Extrusive igneous rock - lava (basaltic/andesitic)
43	3100	Extrusive igneous rock - lava (basaltic/andesitic)
44	2500	Extrusive igneous rock - lava (basaltic/andesitic)
45	2100	Extrusive igneous rock - lava (basaltic/andesitic)
46	1500	Extrusive igneous rock - lava (basaltic/andesitic)
47	1300	Intrusive igneous rock - Diabase
	1270	'Río Chirripó (Duchí)', in situ
48		Sedimentary rock - very fine sandstone, calcareous cement
49		Igneous intrusive rock - Diabase
	1270	'Río Chirripó (Duchí)', sediment
50		Igneous intrusive rock - Granodiorite
51		Igneous intrusive rock - hydrothermal alteration

Reconnaissance route

52	Sedimentary rock - silicified breccia
53	Extrusive igneous rock - lava (basaltic/andesitic)
54	Intrusive igneous rock - Diabase

Appendix 2c Description of the geomorphological observations

GLACIAL AREA

'Valle de los Leones'

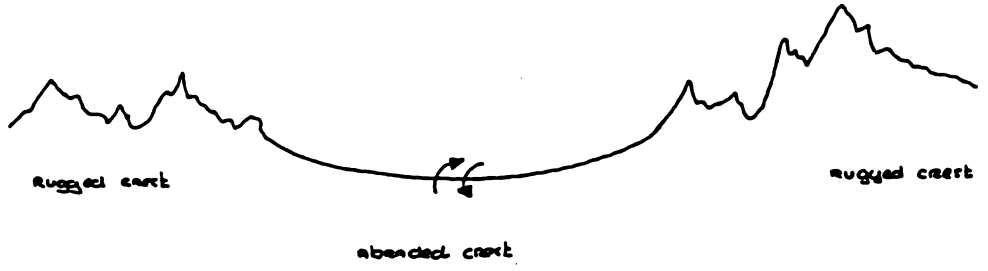
1a Gelifluction sheets have crept downslopes thus overriding the thin layers of ground moraine on the valley floor. Only slight river incision.

1b River incision (middle branch of the 'Río Talari') in the valley situated directly to the north amounts to some 3 m.

'Valle de los Conejos'

2 3700 m, crest near 'Crestones'.
Smooth abraded pillar shaped rock outcrop (pyroclastic rock, agglomerate), with a height of some 60 m, pass more or less abruptly into more rugged frost shattered crest above some 3700 m. This indicates the upper limit of the glaciation.

3 3700 m, crest near 'Ventisquiros'.
Rock outcrops below some 3700 m are abraded while higher situated rock outcrops are rugged and do clearly show signs of physical weathering.
At some places the crest between the 'Valle de los Conejos' and the 'Valle de los Lagos' (to the north) are broad and smoothed showing evidence of glacial erosion. At these places the crest was overridden by small glaciers. A cross section is given for such a crest located 1 km south of the 'Cerro Ventisquiros'.

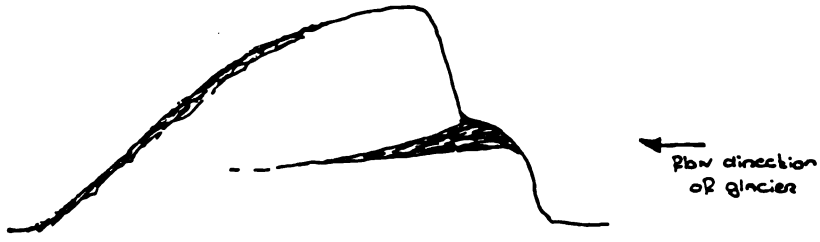


4 3700 m, near the 'Cerro Ventisquiros'.
One finds a spot of very weathered igneous rock (hydrothermal alteration) in which bands of silicified filling are more resistant thus forming sharp ridges with a superficial height of up to some 2 m.

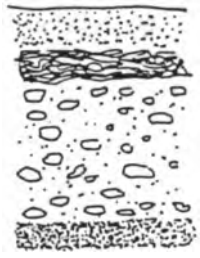
5 3600 m, valley head.
Structually instabile abraded rock outcrop (sedimentary rock) showing a nearly vertical face of some 35 m. At the foot of this face one finds a heap of fresh angular rock parts up to a diameter of some 15 m.

6 3380 m, bottom of the lower portion of the valley.
Strongly abraded rock drumlin showing striations. Front consists

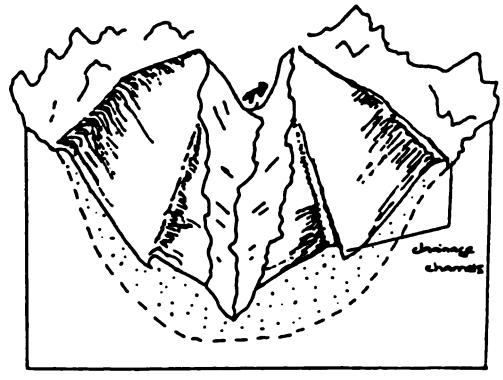
of bare rock and at the back side one finds a weak developed soil, a loamy sand overlies a loam containing gravel and stones.



7 3330 m, 'Río Talari'.
Face, caused by incision of the 'Río Talari', shows subsequent layers of compacted stratified drift, till, compacted fibric soil material and stratified drift.



8 Exit of the U-shaped valley.
Both main lateral moraines show a depression behind an extra crest at about half the height of the lateral moraine. This feature possibly reflects a persistant period of reduced thickness of the glacial body. These depressions acts as drains. At the point where these depressions drain into the 'Río Talari' incision in moraine material already amounts up to some 15 m (no bedrock feasible). Both main lateral moraines reflect the maximum extension of the glacier in the 'Valle de los Conejos'.



9 3250 m, 'Río Talari'
Near the exit of the U shaped valley the 'Río Talari' strongly undermines the lateral moraines causing debris slides. Incisions in the moraine material amounts to tens of meters.

'Cerro Chirripó'

10 This mountain top has a sharp-pointed peak which is bounded by intersecting walls of three cirques. Physical erosion produces sharp angular boulders.

'Valle de las Morrenas'

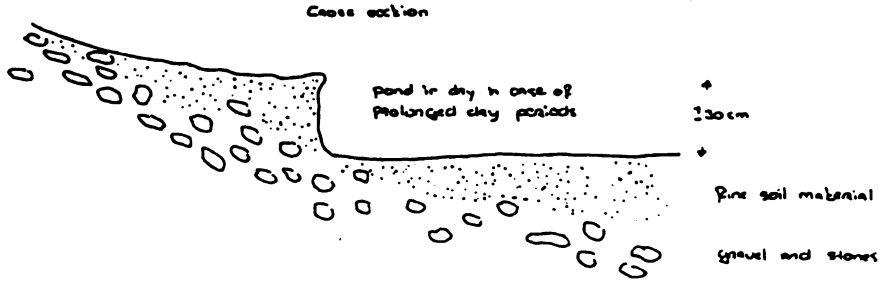
11 3550 m, crest at the valley situated to the northeast.
One finds some outcrops of metamorphic rock (of sedimentary origin) and just after crossing the crest coarse sandstone (containing foraminifers).

12 3500 m, near valley head.
One finds drift rich in angular, slightly weathered, boulders originating from non abraded to more or less abraded rock outcrops (crests) found at higher altitudes.

13 Flanks at the upper portion of the valley.
Oblong shaped pools (following the perpendiculars), with a surface from a few to some 20 square meters, are a common phenomena. They are interconnected with small streams during and after periods of excessive rain. In dry periods these small streams and most pools do not contain water. However some pools do contain water throughout the year thus serving camping investigators.
One also finds small pools just beneath one another (cirque stairways). The depth of these small pools amounts to some 40 to 100 cm. Bottoms are strikingly flat and the soil material becomes finer near the center of these pools.

14 3400 m, 300 m northwest of the cottage.
One finds a seven meter deep incision in a small lateral moraine at the valley floor. Profile shows rounded to angular gravel, stones and boulders, no layering, unsorted material.

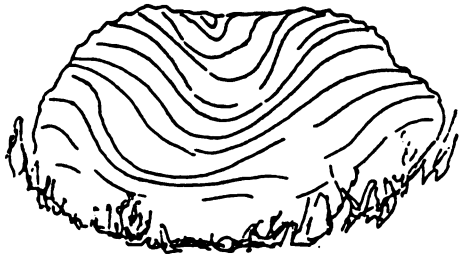
15 3400 m, western side, lower portion of the valley.
One finds a long lateral moraine with almost uniform slopes (77%). Profile 3 is situated at the higher part of this moraine. Between the highest part of this lateral moraine and the straight slope to the crest a creek, interconnected with some small pools, drains water. Bottom of the pools contain gravel and few coarse sand. The edge of the lakes show a 30 cm high face containing very fine soil material.



16 3300 m, river incision of the 'Río Chirripó (Duchí)'.
River incision caused a 4 m high face showing well defined layers. A very compacted layer of very fine material showing red, yellow and black colors (stratified drift) is overlaid by a well defined layer containing rounded stones. Straight boundary between stratified drift and moraine material.

Valley northeast of the 'Valle de las Morrenas'

17 3600 m, crest at valley head.
One finds two rows of parallel, almost vertical, oriented stones with a superficial height of some 2 m (due to frost working?).
One finds a 2.5 meter heigh pillar shaped rock outcrop (secondary quartz attached to bedrock) with a diameter of 0.5 m. Striking because it is situated in a broad and smoothed divide, probably overriden by a small glacier.
At the same altitude, a more or less continuous layer of silicified rock can be found.
One finds a few rounded granitic boulders, with a diameter of some 60 cm, with strikingly parallel ridges a few centimeters apart from each other. Amplitude in relief is about 1 cm.



18 Bottom at valley head of the valley directly situated to the northeast.
Small metamorphic rock outcrops of sedimentary origin show a pronounced surface form (small rock drumlins).

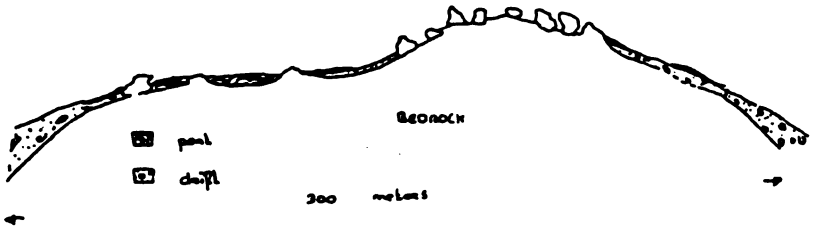
19 3600 m, valley to the east.
Remnants of a lateral moraine are visible in a V-shaped valley. Incision by the main river (most northern branch of the 'Río Ditkebi') is strong and the occurence of debris slides is obvious.

'Cerro Urán'

20 3300 m, footslope.
One finds the remnants of a lateral moraine. As in other places it is caractericed by the presence of trees which, apart from lateral moraine remnants, grow very sporadically in the glacial area.

21 3200 m, 1 km east of the 'Cerro Urán'.
Glaciers scraped of a good deal of the soil material without leaving much drift behind. In the stripped area one finds boulders (to a diameter of some 3 m) near the top of small hills which seems to be former rock outcrops. In a large area rotten rock is found at a depth of some 20 centimeters. See profile descriptions

23 to 28. Increasing amounts of drift are found near the margins of this particular area, which commonly holds for most parts of the glacial area. Looking to the west from this point one can clearly see the undermining of drift deposits near the boundaries of the steeply fluvially dissected area. Thickness of these deposits amounts to tens of meters at some places.



STEEPLY FLUVIALLY DISSECTED AREA

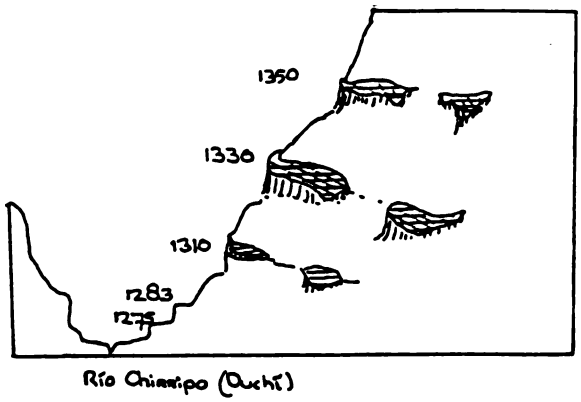
'Paso de los Indios'

22 3100 m, large rock outcrop covered with forest.
Slightly to non weathered angular material is found as a result of physical erosion of this outcrop. After passing this outcrop the slope becomes very steep except for another large volcanic rock (lava) outcrop found at an altitude of 3010 m.

23 2800 m, small rock outcrop (lava).
One finds a small rock outcrop (with a smooth surface of about 10 square meter (slope 25°, orientation 210°). Pillar shape is very clear. The slope of this outcrop corresponds with the slope of the surrounding country (a broad relative flat crest). At 2300 meter another identical rock outcrop is found, with a surface of about 6 square meter (slope 20°, orientation 200°).

24 Terraces in a steeply dissected surrounding country.
At 1350 m one finds the remnants of a locally well preserved small terrace with a width of about 20 meters and a totally smooth surface of more than 500 square meters. Soils have the following characteristics:
10 cm thick O horizon (7.5YR 3/2)
30 cm thick Ah horizon (10YR 2/2).
The soil material contains few gravel (angular gravel; 0-2 cm) in a matrix of loamy sand. Well developed trees are found on this uppermost terrace.

At 1280 m remnants of another small terrace were encountered with a width up to 10 meters. Soil development, to a depth of 40 cm, is weak.
At 1275 m remnants of a small terrace containing some fine sandy soil material, common angular blocky (0-2 cm) gravel and some stones were found.



25 1330 m, face showing some colluvial material.
Angular stones (25-50 cm) of volcanic origin are embedded in a sandy matrix. Excessively drained.

26 1310 m, face showing colluvial material.
Weathered angular gravel and stones of volcanic origin in clayey matrix. Material is compacted and slightly permeable causing superficial drainage.

27 1270 m, bed of the 'Río Chirripó (Duchí)'.
At the river bed and especially at the banks of the river one finds very dark gray very fine sandstones with calcareous cement. Weathering colours are yellow and the weathering product is a clayey soil material. A hundred meters upstreams of the 'Río Chirripó (Duchí)' one finds, besides a series of waterfalls, a lithological contact between this sandstone and intrusive rock (Diabase).

RECONNAISSANCE ROUTE

28 Following the bed of the 'Río Chirripó (Duchí) one has to walk over a small river terrace some 3 m above the bed of the river.

29 Following the 'Camino de los Indios' to Sitio Hilda, one encounters some springs which waters are rich in iron. Due to the higher oxigen pressure of the atmosphere iron precipitates and cements soil materials.

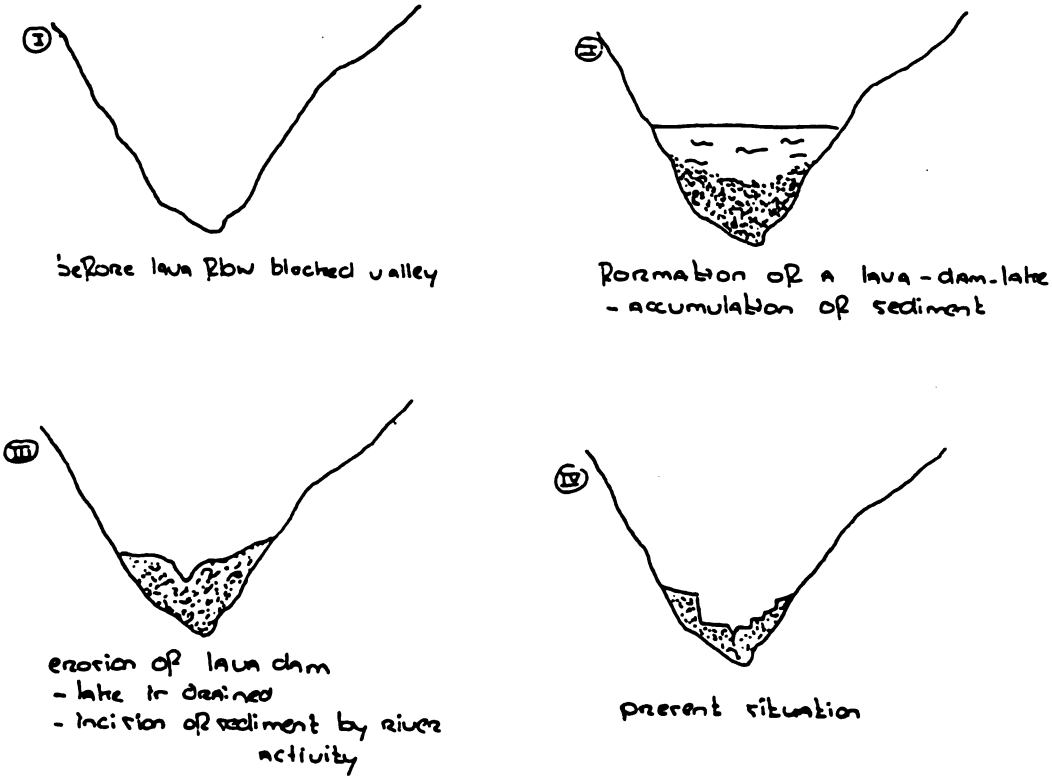
30 Bed of the 'Río Chirripó (Duchí)' becomes relatively wide at some places. River terraces at these places contain very much rounded boulders, its banks are covered with forest.

31 At 'Sitio Hilda' one can clearly see several terraces which are partly cleared by the indians and are in use as pastures. Along the reconnaissance route in 'Sitio Hilda' itself rivers which drain into the 'Río Chirripó (Duchí)' incised these terraces by some 10 m.

32 We didn't get the permission to see a small thermal spring ('termales'). According to the indians water its water is too hot for bathing.

33 After leaving 'Sitio Hilda' one has to walk over an extensive terrace which has a width of some 50 meters and is situated some 70 meters above the bed of the 'Rio Chirripó (Duchi)'. It is a very flat terrace with a few boulders on its surface originating from higher situated rock outcrops. A small drainage system has been developed in this terrace.

34 The valley becomes very narrow near a lava flow which can be seen clearly at the other side of the 'Río Chirripó (Duchi)'. This flow forms a nearly straight face of some 150 meters up to the bed of the river. The surface of the flow is very flat related to the surrounding country. The lava flow blocked the valley. The following figure gives a a schematical representation of the formation of the terraces as described in point 31 and in observation 24.



35 The incision of the 'Río Chirripó (Duchi)' in its own sediments can be a very quick proces. Near the indian settlement called 'Chirripo Arriba' (downstreams of the former lava dam) incision amounts to some four meters in eight years (pers. comm. Mario Monge). High rainfall intensities (during the so called 'temporales') are obviously important tools for this kind of erosion. The 'Río Chirripó (Duchi)' changed its bed very recently near 'Chirripó Arriba'.

'SAN GERARDO'

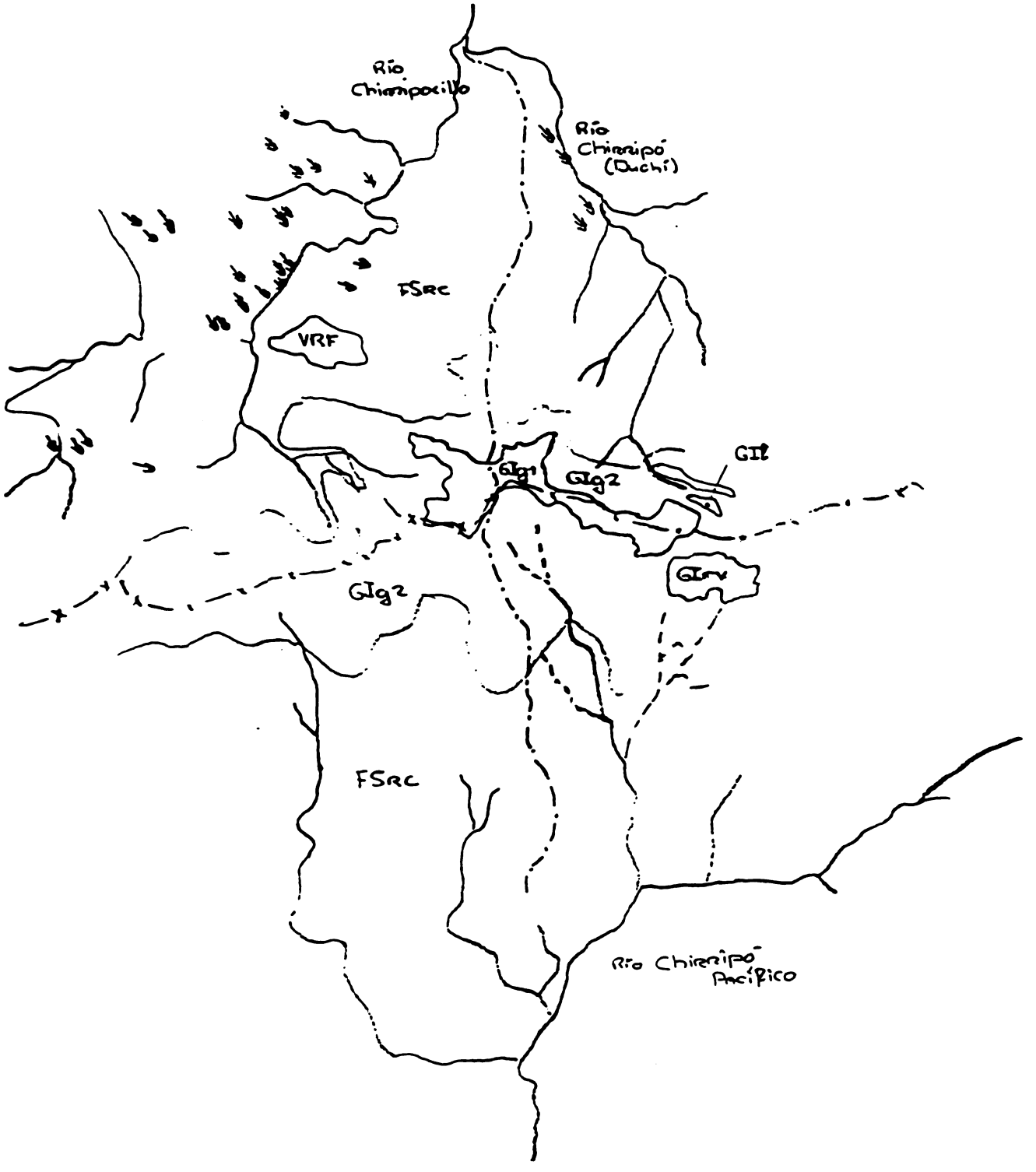
36 According to some inhabitants of the village of 'San Gerardo' the whole Chirripó area was shaken by a earthquake in july 1983. Some inhabitants remember only this one because its strenght was unusual: several houses were totally damaged.
Other impacts of this earthquake were:
- the warm water spring was dry for over a month,
- other springs dried up leaving some farmers without water, and
- in the period after the earthquake a lot of landslides took place.

Appendix 2d Altitudinal location of the soil profiles in the páramo belt and along the two transects

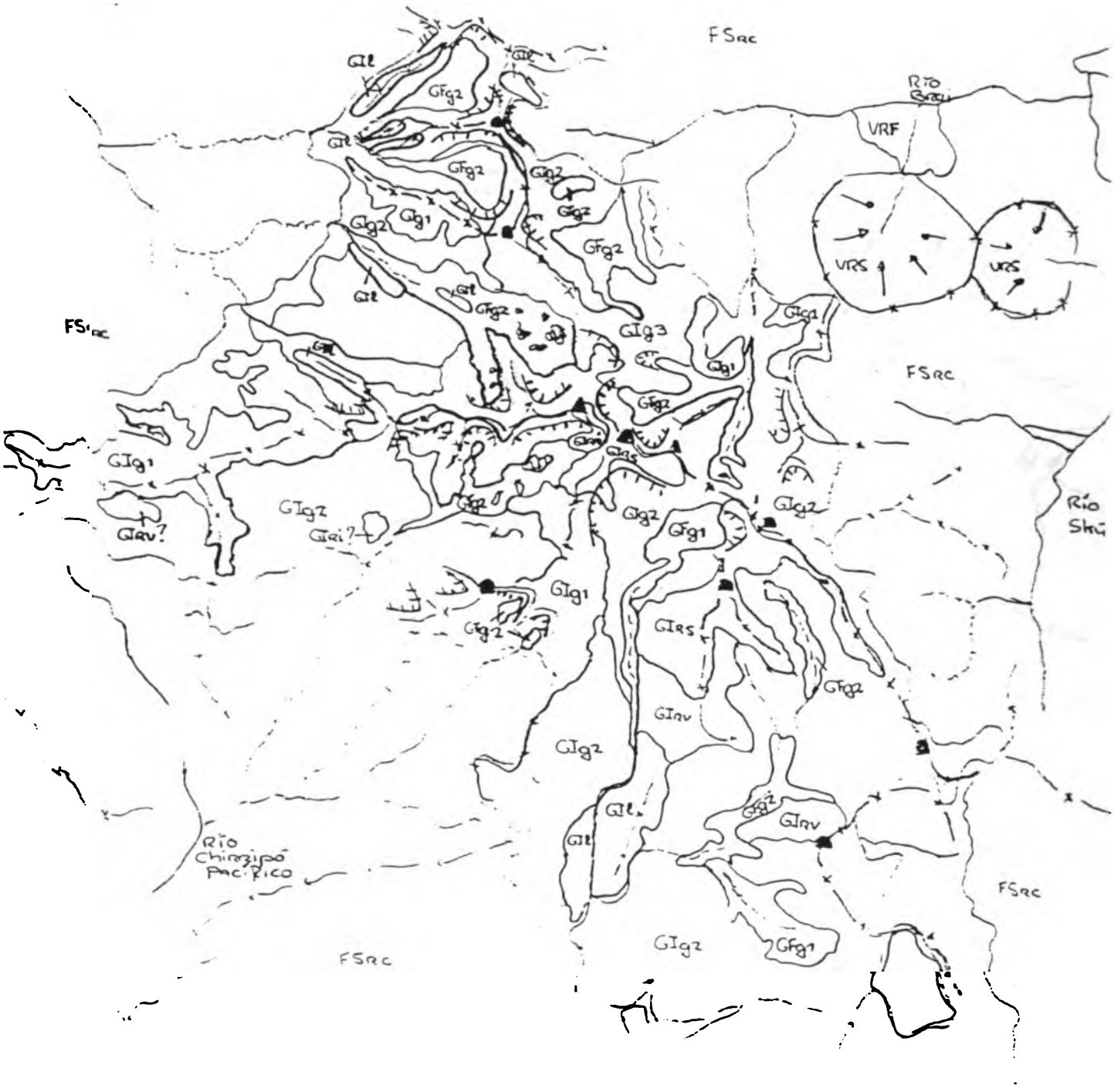
Altitude	Number	Altitude	Number
páramo belt		transect 2:'Fila	
3500	1	Palmito Morado'	
3470	2	2100	17
3365	3	2300	18
3560	4	2500	19
3390	5	2700	20
		2900	21
transect 1:'Fila		3000	22
Cementerio de		3100	23
la Maquina'		3250	24
3340	6	3300	25
3250	7	'Camino de los	
3160	8	Indios'	
3100	9	3250	26
2910	10	3100	27
2680	11	2900	28
2470	12	2700	29
2300	13	2500	30
2100	14	2300	31
1900	15	2100	32
1700	16	1900	33
		1700	34
		1500	35
		1300	36

Appendix 3 Aerial photograph interpretations (copies of overlays)

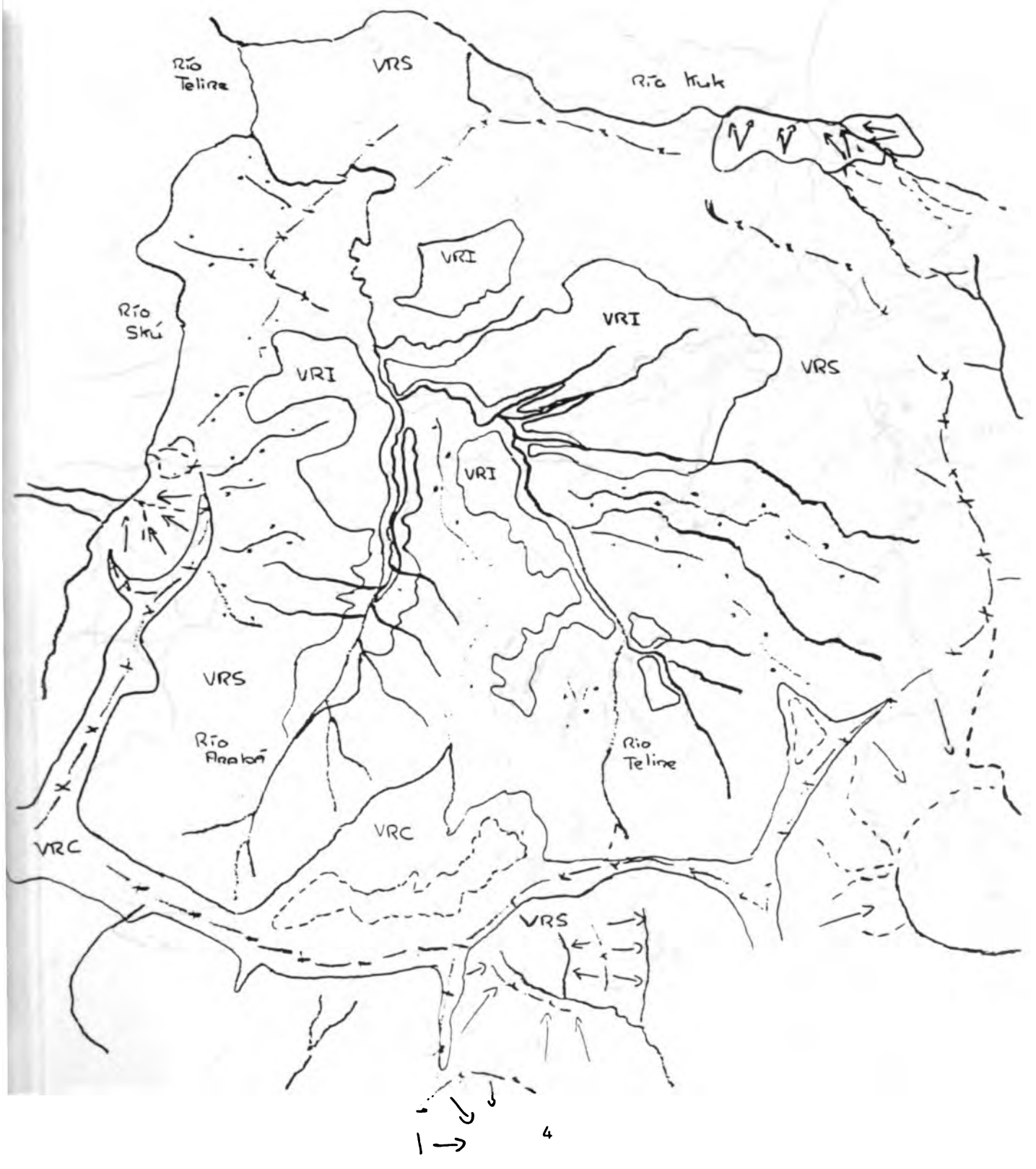
CR2CM8, Talamanca, block 'Cordillera Central' (B55), run 4, photograph 20.



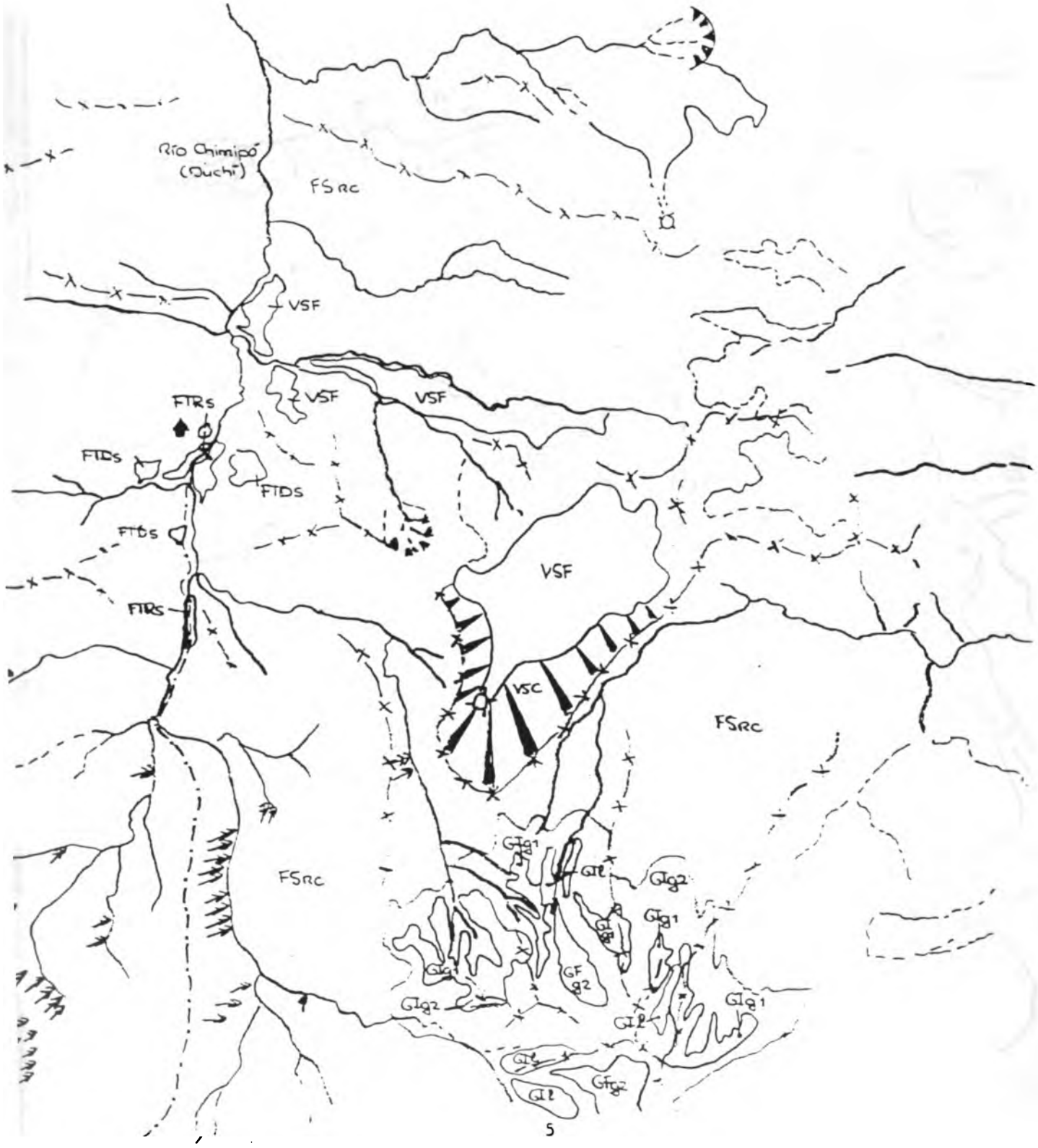
CR2CM8, Talamanca, block 'Cordillera Central' (B55), run 4, photograph 21.



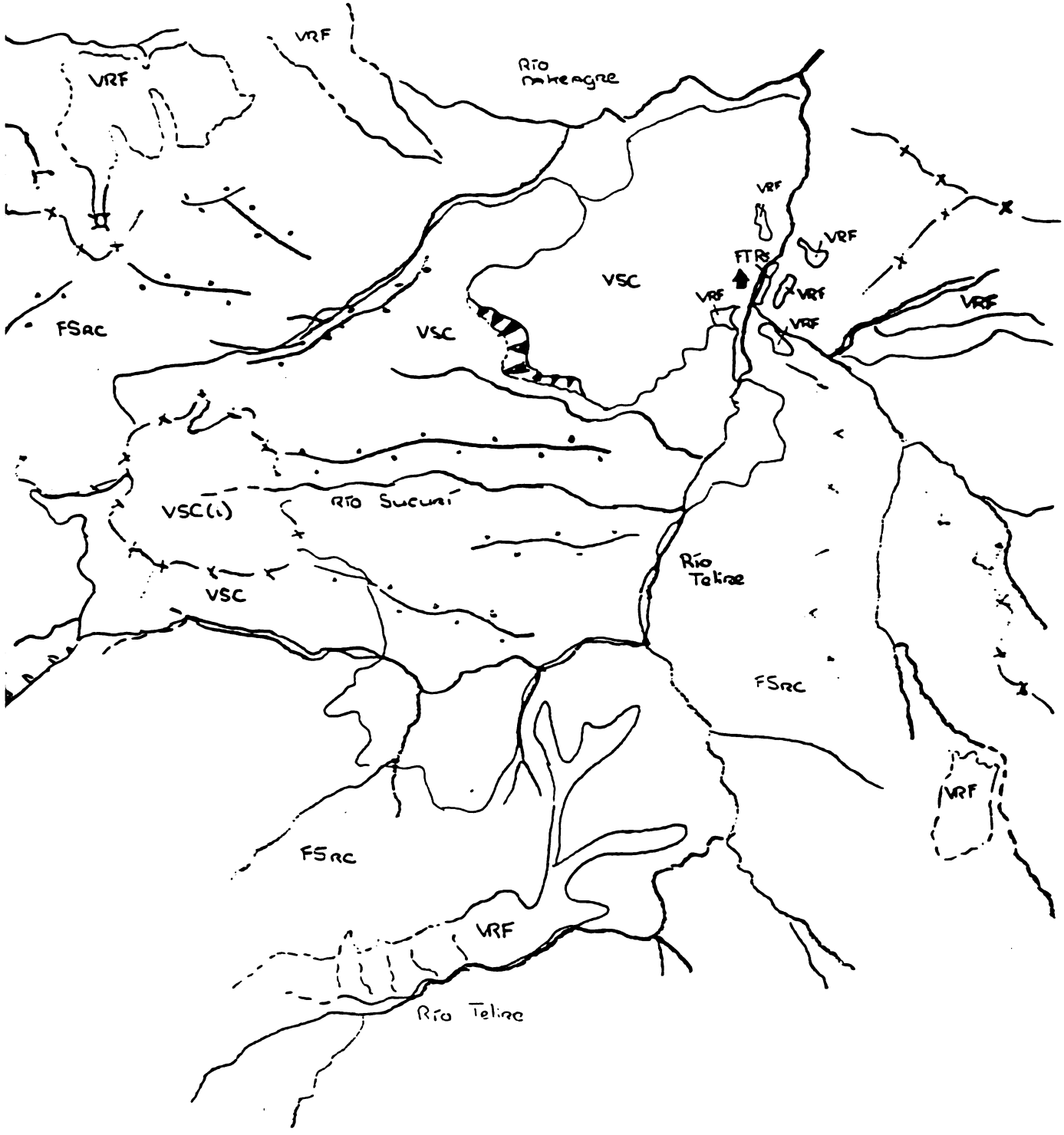
CR2CM8, Talamanca, block 'Cordillera Central' (B55), run 4, photograph 23.



CR2CM8, Talamanca, block 'Cordillera Central' (B55), run 3a, photograph 31.



CR2CM8, Talamanca, block 'Cordillera Central' (B55), run 3a, photograph 32.



Appendix 5 Nomenclature of the soil profiles after Soil Taxonomy and FAO

Prof. No.	SOIL TAXONOMY Soil Survey Staff (1975)	FAO (1988)
1	Lithic Troposaprist	Terric Histosol
2	(Histic) Acric Hapludand	Histi-Haplic Andosol
3	Andic Dystropept	Haplic Andosol
4	Lithic Placaquand	Andi-Umbric Leptosol
5	Typic Hapludand	Haplic Andosol
6	Andic Eutropept	Humi-Andi Eutric Regosol
7	Typic Hapludand	Umbric Andosol
8	Andic Eutropept	Andi-Umbric Regosol
9	(Histic) Alic Hapludand	Humi-Andi Umbric Regosol
10	(Histic) Andic Humitropept	Humi-Andic Umbric Regosol
11	(Histic) Typic Hapludand	Humi-Umbric Andosol
12	(Histic) Typic Hapludand	Humi-Umbric Andosol
13	(Histic) Alic Hapludand	Humi-Haplic Andosol
14	(Histic) Acric Hapludand	Humi-Haplic Andosol
15	(Histic) Andic Humitropept	Humi-Andic Dystric Regosol
16	Lithic Haplumbrept	Umbric Regosol
17	(Histic) Typic Hapludand	Humi-Haplic Andosol
18	(Histic) Acric Hapludand	Humi-Haplic Andosol
19	(Histic) Acric Hapludand	Humi-Haplic Andosol
20	(Histic) Typic Hapludand	Humi-Umbric Andosol
21	(Histic) Andic Humitropept	Humi-Andic Dystric Regosol
22	(Histic) Typic Hapludand	Humi-Haplic Andosol
23	(Histic) Lithic Placudand	Humi-Umbric Andosol
24	Lithic Troposaprist	Terric Histosol
25	(Histic) Lithic Humitropept	Humi-Dystric Regosol
26	Lithic Troposaprist	Terric Histosol
27	Lithic Troposaprist	Terric Histosol
28	Lithic Troposaprist	Terric Histosol
29	(Histic) Typic Placudand	Humi-Mollic Andosol
30	(Histic) Placic Humitropept	Humi-Dystric Regosol
31	(Histic) Andic Humitropept	Humi-Andic Dystric Regosol
32	(Histic) Typic Hapludand	Humi-Haplic Andosol
33	(Histic) Acric Hapludand	Humi-Umbric Andosol
34	(Histic) Typic Hapludand	Humi-Umbric Andosol
35	(Histic) Typic Humitropept	Humi-Mollic Regosol
36	(Histic) Typic Humitropept	Humi-Mollic Regosol

SOIL SURVEY STAFF, 1975. Soil Taxonomy. Soil Conservation Service, Agricultural Handbook no. 436, US Department of Agriculture, Washington DC.

FAO, 1988. Soil map of the world (revised legend). World Soil Resources Report 60. FAO, Rome.

Appendix 6 Method for the field description of the humus profile

Horizons	Non to slightly fragmented litter	Fine organic material	Mineral material
L	*		
F	*	* 10% to 70%	
H		* > 70%	none to some
AL (Al)		*	dominant

The master horizons can be further subdivided according to the system developed by BABEL (1971):

L horizon:
- Ln subhorizon: the litter is fresh, non fragmented and shows no visible signs of alteration or discoloration
- Lv subhorizon: the litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration.

F horizon:
- Fr subhorizon: composed of well identifiable litter fragments with minor amounts of fine organic material
- Fm subhorizon: composed of about equal amounts of more or less fragmented litter and finely diveded organic material.

H horizon:
- Hr subhorizon: dominantly composed of fine organic material, but with some litter fragments
- Hf subhorizon: dominantly composed of fine organic material, free of litter fragments, but mineral grains are present

From MUELLER-DOMBOIS, D., M. A. LITTLE & T. VAN DER HAMMEN (eds), 1988. Manual of Methods for Mountain Transect Studies (first approx.). Comparative Studies of Tropical Mountain Ecosystems. International Union of Biological Sciences-Decade of the Tropics.

BABEL, U., 1971.Gliederung und Beschreibung des Humusprofils in mittel-europaischen Waldern. Geoderma 5: 297-324.

Appendix 7 Soil temperatures measured in the soil profiles at intervals of 10 cm

Profile number	Altitude m	Depth of measurement (cm) 10	20	30	40	50	60	70	80
1	3500	13.0							
2	3470	10.9	9.8	9.8	9.9				
3	3365	11.4	11.1	11.3					
4	3560	11.1	10.0	9.9	9.8	9.8			
5	3390	9.6	9.6	9.4	9.4				
6	3340	10.5	-	-	10.5				
7	3250	10.5	10.6	-	10.5				
8	3160	9.3	10.2	10.4					
9	3100	8.7	8.7	8.9					
10	2910	11.2	10.4	10.2	10.1	10.0	9.9		
11	2680	11.3	11.2	11.1					
12	2470	15.2	15.3	15.2	15.0	14.7			
13	2300	13.7	13.6	13.6	13.5	13.5			
14	2100	18.7	19.0	18.5	18.3	18.0			
15	1900	14.4	14.7	14.6					
16	1700	16.0	15.7						
17	2100	8.8	8.8	8.8	8.8				
18	2300	9.9	10.4	10.4	10.5	10.5	10.5	10.6	10.7
19	2500	10.2	10.4	10.5	10.5	10.6			
20	2700	9.5	9.9	10.1	10.0	10.2			
21	2900	10.4	10.4	10.2	10.1	10.0	10.0	10.0	
22	3000	9.5	9.3	9.2	9.2				
23	3100	9.4	9.1	9.1					
24	3250	10.9	10.3	10.1	10.0				
25	3300	11.0	10.0						
26	3250	8.8	8.6	8.5	8.5	8.6			
27	3100	9.2	9.2	9.1	8.9	8.9			
28	2900	8.9	9.1	9.0	9.0	8.9	8.9		
29	2700	11.1	11.0	11.0	10.4				
30	2500	11.7	11.1	11.0					
31	2300	11.4	11.4	11.4	11.3	11.3	11.3	11.3	
32	2100	14.2	14.3	14.4	14.2	14.1	14.0		
33	1900	16.0	16.0	15.3	15.0	15.7	15.2	15.0	15.0
34	1700	18.0	17.9	17.8	18.0	18.0	18.0	18.0	18.0
35	1500	18.8	18.7	19.2	19.1	18.6			
36	1300	20.3	-	17.4	-	17.4			

Apppendix 8 Soil fauna (% of total weight) collected from most profile dugs

	Transect 1									Transect 2															
Profile number Altitude	5 3390	6 3340	8 3160	9 3100	11 2680	12 2470	13 2300	14 2100	15 1900	20 2700	21 2900	22 3000	24 3250	25 3300	26 3250	27 3100	28 2900	29 2700	30 2500	31 2300	32 2100	33 1900	34 1700	35 1500
INSECTA																									
Larva insecta	9.7				14.1			2.8		10.1	22.6	5.6		1.2	29.6										
Acari																									
Lepidoptera		2.4												22.2											
Larva Lepidoptera	10.6													53.1	20.4										
Hemiptera																									
Neuroptera																				12.5					
Trichoptera																									
Ephemer Optera																									
Odonata																									
Mecoptera																									
Thysanoptera																									
Psocoptera																									
Hymenoptera	2.9	0.6					3.0	1.4	1.9			5.6	11.1					0.9			2.2	0.3			
Dermaptera								2.8		1.7	9.7						0.8	9.8		12.5		2.1			
Orthoptera							2.8		15.7													4.7			0
Coleoptera	0.9			0.6		6.1		13.9	20.1	1.7	4.8	2.8				27.4		9.8	2.3			8.8	18.2		1
Larva Coleoptera	69.3	59.2	76.5	14.5	77.3	14.3	80.6		21.4	68	32.3	11.1	88.9		2	37.9	20.2	15.2			40.7	0.9	63.6		0
Diptera																									
Larva Diptera								8.3																	
Strepsiptera																									
Thysanura																									
Diplura																				6.3					
Collembola																									
Protura																									
total-insecta	93.4	62.2	76.5	15.1	91.4	26.5	86.4	29.2	59.1	81.5	69.4	25.1	100	76.5	52	65.3	21	35.7	2.3	31.3	42.9	16.8	81.8		1
ARACHNIDA		24.9					0.6	11.1		0.4		16.7		1.2			19.8						9.1		0
Chelonethi																									
Opiliones																									
Araneida																									
Acari																									
MALACOSTRACA																									
Isopoda						4.1		6.9	3.1		4.8						5.5				4.4	3.5	9.1		
PAURAPODA																									
SYMPHYLA																									
CHILOPODA	6.3	0.6	2.2	2.4	4.7	30.6	0.4	50.0	1.9	3.4	21	58.3			1	34.7	2.8	17	3.9	50	6.6	0.9			0
DIPLOPODA					3.9	6.1	3.8	2.8		1.7	3.2			3.7	2		2	7.1							
CHAETOPODA				*																					
Oligochaeta		12.4	21.3	82.6		14.3	8.5		16.4	12.9	1.6			18.5	44.9		36	36.6	93.8		46.2	77.1			99
HIRUDINEA																									
NEMATODA																									
NEMATOMORPHA																									
GASTROPODA																	12.3								
Blattaridea	1.1					18.4	0.4		19.5								0.8	3.6		18.8		1.7			
Total weight (gr)	3.49	1.69	1.83	5.45	1.28	0.49	5.16	0.72	1.59	4.66	0.62	0.36	0.09	0.81	0.98	0.95	2.53	1.12	0.31	0.16	0.91	3.4	0.11	10.18	

* As for green worms normally living in the forest canopy.

ATLANTIC ZONE PROGRAMME

SEPARATE APPENDICES

A GEOLOGICAL/GEOMORPHOLOGICAL AND SOIL TRANSECT STUDY OF THE CHIRRIPO MASSIF AND ADJANCENT AREAS, CORDILLERA DE TALAMANCA, COSTA RICA

J.G. van Uffelen

September 1993

CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA - CATIE

AGRICULTURAL UNIVERSITY WAGENINGEN - AUW

MINISTERIO DE AGRICULTURA Y GANADERIA DE COSTA RICA - MAG

CONTENTS

SEPARATE APPENDICES

Appendix 9 Soil profile descriptions

I Information on the site:

a. Profile number: 1.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Lithic Troposaprist.
   FAO: Terric Histosol.
d. Date of examination: 12 September 1988.
e. Author: J.G. van Uffelen.
f. Location: just south from a small lake which is situated in the south-western part of the 'Valle de las Morrenas' within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3500 m.
h. Land form:
   i. physiographic position of the site: small valley bottom (width of some 100 m) in a glacial landscape (groundmoraine).
   ii. topography of surrounding country: hilly.
   iii. microtopography: none.
i. Slope on which profile is sited: flat (0%).
j. Land-use: bamboo-páramo.
k. Climate: see section 2.2 of this report.
   The soil temperature was 13.4 degrees Celcius at a depth of 10 cm. The soil temperature regime is isomesic

II General information on the soil:

a. Parent material: drift mainly derived intrusive rock.
b. Drainage: class 1 - poorly drained.
c. Moisture conditions in the profile: profile wet throughout.
d. Depth of groundwater table: 30 cm.
e1. Presence of surface stones: stony (boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: slight water erosion.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Very shallow very poorly drained black to very dark brown profile, 25 cm thick layer rich in sapric soil material (up to 43 % organic matter in the upper horizon). The profile is wet during the rainy season. Structure is weak subangular blocky in the upper part. Slightly sticky and slightly plastic throughout. There are few micro to fine pores and the biological activity is low. Only in the upper part one finds few fine roots.

IV Profile description:

H1	25-15	Black (10YR 2/1) wet; loamy sand rich in sapric soil materials; weak medium subangular blocky; slightly sticky, slightly plastic; few micro vesicular pores; few fine roots; pH H20 5.2; abrupt smooth boundary to:
H2	15-7	Very dark brown (10YR 2/2) wet; sandy loam rich in

		sapric soil materials (up to 28%); structureless; sticky, plastic; few very fine vesicular pores; pH H2O 5.2 ; abrupt smooth boundary to:
H3	7-0	Black (10YR 2/1) wet; sandy loam rich in sapric soil materials (up to 20%), very bouldery; structureless; slightly sticky, slightly plastic; few very fine vesicular pores; very frequent granite boulders, angular, fresh; few fine roots; pH H2O 5.5; overlying boulders and stones.

I Information on the site:

a. Profile number: 2.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Acric Hapludand.
   FAO: Histi-Haplic Andosol.
d. Date of examination: 14 September 1988.
e. Author: J.G. van Uffelen.
f. Location: within the 'Valle de las Morrenas' 300 meters north-west of the hovel, within the 'Parque Nacional Chirripó'. East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3470 m.
h. Land form:
   i. physiographic position of the site: concave slope with a length of about 100 m just 200 m below the crest in a glacial landscape.
   ii. topography of surrounding country: hilly.
   iii. microtopography: none.
i. Slope on which profile is sited: concave slope (18%).
j. Land-use: bamboo-páramo.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 10.9 degrees Celcius at a depth of 10 cm to 9.9 degrees Celsius at a depth of 40 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: drift mainly derived from intrusive rocks.
b. Drainage: class 2 - imperfectly drained.
c. Moisture conditions in the profile: profile wet throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: stony (boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: slight water erosion.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep imperfectly drained very dark brown to olive profile. An 13 cm thick horizon rich in sapric soil material overlies a loamy sand which contains very weathered gravel causing the presence of nodules and mottles. Structure is moderately subangular blocky in the upper part and weak in the lower part of the profile. Very few pores in the upper 50 cm of the profile and a normal root distribution. Relative high pH values (pH H2O 5.2-6.2).

IV Profile description:

O/Ah 0-13 Very dark brown (10YR 2/2) wet; sandy loam rich in sapric soil materials; moderate fine subangular blocky; sticky, non plastic; common very fine vesicular pores; frequent very fine roots; pH H2O 5.2 ; gradual wavy

		boundary to:
Ah	13-50	Dark yellowish brown (10YR 3/6) wet; sandy loam, gravelly; weak very fine subangular blocky; sticky, non plastic; few very fine vesicular pores; frequent granitic gravel, rounded, weathered; frequent small hard spherical yellow red iron nodules, as a result of the weathering of the gravel which results in common medium distinct clear, dark reddish brown (5YR) mottles; common medium roots; pH H2O 6.1; diffuse irregular boundary to:
Bw	50-75	Olive (5Y 5/4) wet; few fine faint clear yellowish brown (10YR) mottles; sandy loam, gravelly and stony; weak very fine subangular; slightly sticky, non plastic; very frequent gravel (rounded and weathered), stones and boulders, angular, fresh; frequent small soft irregular, yellow iron nodules as a result of the weathering of the gravel; few coarse roots; pH H2O 6.0.

I Information on the site:

a. Profile number: 3.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Andic Dystropept.
   FAO: Haplic Andosol.
d. Date of examination: 15 September 1988.
e. Author: J.G. van Uffelen.
f. Location: western flank of the lower part of the 'Valle de las Morrenas' within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3365 m.
h. Land form:
   i. physiographic position of the site: lateral moraine with a straight slope of 77% (orientation of 76 degrees), in a glacial landscape
   ii. topography of surrounding country: mountainous.
   iii. microtopography: very small terraces with a width of 50 cm and a length of several meters.
i. Slope on which profile is sited: very steep (77%).
j. Land-use: high mountane dwarf forest.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 11.4 degrees Celcius at a depth of 10 cm to 11.3 degrees Celsius at a depth of 30 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: bouldery drift mainly derived from intrusive rock.
b. Drainage: class - well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: very stony (stones, gravel and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: slight water erosion (rill).
g. Presence of salt or alkali: none.
h. Human influence: influenced by the big fire of 1976, which burned almost the trees growing on this lateral moraine.

III Brief description of the Profile:

Moderately deep well drained black to strong brown to pinkish gray profile. At the soil surface one finds a 1 cm thick layer of hemic soil material, in the upper part of the mineral soil material one finds charcoal as a result of the big fire of 1976. Texture varies between sandy loam and loamy sand. Gravel and stones throughout the profile, fresh and weathered (with mottles). Weak very fine subangular blocky in the upper part of the profile. In the upper part common very fine pores and common fine to medium roots, in the lower part few very fine pores and few medium roots. pH is relatively high (pH H20 ranges from 6.2 to 6.5). Root distribution is normal. Very fine roots in the first 20 cm of the profile.

IV Profile description:

O	1-0	Composed of well identifiable litter fragments with minor amounts of fine organic material; abrupt wavy boundary to:
Ah	0-7	Black (10YR 2/1) moist; loamy sand, slightly gravelly; weak very fine subangular blocky; slightly sticky, non plastic, friable moist; common micro vesicular pores; very few gravel, angular, fresh and weathered resulting in residual nodules; common fine roots; pH H2O 6.2 ; clear wavy boundary to:
Bw1	7-28	Strong brown (7.5YR 5/6) moist; sandy loam, slightly gravelly; many fine faint clear reddish yellow (7.5 YR) mottles; weak very fine subangular blocky; sticky, slightly plastic, friable moist; common very fine vesicular pores; very few angular gravel, fresh and weathered resulting in residual nodules with red mottles; common medium roots; pH H2O 6.5 ; gradual wavy boundary to:
Bw2	28-100	Pinkish gray (5YR 6/2) to pink (5YR 7/4) moist; loamy sand, very stony; structureless; slightly sticky, non plastic, friable moist; few very fine vesicular pores; very frequent gravel and stones, angular and rounded, weathered resulting in nodules with red mottles; few medium roots; pH H2O 6.4.

I Information on the site:

a. Profile number: 4.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Lithic Placaquand.
   FAO: Andi-Umbric Leptosol.
d. Date of examination: 24 September 1988.
e. Author: J.G. van Uffelen.
f. Location: in the upper part of the 'Valle de los Conejos' within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3560 m.
h. Land form:
   i. physiographic position of the site: at almost flat valley bottom, in a glacial landscape.
   ii. topography of surrounding country: undulating.
   iii. microtopography: none.
i. Slope on which profile is sited: gently sloping (3%).
j. Land-use: bamboo-páramo.
k. Climate: see section 2.2 of this report.
   The soil temperature was 11.9 degrees Celcius at a depth of 10 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: drift mainly derived from intrusive and sedimentary rock.
b. Drainage: class 0 - very poorly drained.
c. Moisture conditions in the profile: profile wet throughout.
d. Depth of groundwater table: not detected but there will be an artificial water table above the iron pan during excessive rains.
e1. Presence of surface stones: stony (gravel and stones).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: detected near the site, water erosion (sheet erosion) of the soil material above the iron pan.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Very shallow very poorly drained black to dark brown profile. Loamy sand overlying a sandy loam both having a weak subangular blocky structure. Slightly sticky and slightly plastic throughout the profile. Common micro to very fine pores and common (very) fine roots. In the lower part one finds very frequent gravel with many yellowish mottles as a result of chemical weathering of gravel which results in residual nodules and water logging. The profile overlies a iron pan which has formed over an almost impermeable layer, formed by a abraded (rotten) rock surface. Relative high pH values (pH H2O 5.9-6.3).

IV Profile description:

Ah 0-9 Black (10YR 2/1) wet; loamy sand, weak fine subangular

		blocky; slightly sticky, slightly plastic; common very fine vesicular pores; frequent very fine roots; pH H20 5.9; clear smooth boundary to:
Ah/(E)	9-20	Dark yellowish brown (10YR 3/6) wet; sandy loam, very gravelly; weak very fine subangular blocky; slightly sticky, slightly plastic; common micro vesicular pores; very frequent gravel, angular, weathered and very weathered which result in residual nodules with many medium distinct,clear, (5YR) 4/6 mottles; common fine roots; pH H20 6.3; abrupt and smooth boundary to:
Bs	20-21	Thin iron pan no thicker than some 10 mm; continuos and nodular, formed over an abraded rock surface.

I Information on the site:

a. Profile number: 5.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Typic Hapludand.
   FAO: Haplic Andosol.
d. Date of examination: 17 September 1988.
e. Author: J.G. van Uffelen.
f. Location: 300 m north-east (down-valley) of the three hovels situated in the 'Valle de los Conejos', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3390 m.
h. Land form:
   i. physiographic position of the site: on a concave slope some 200 m below the crest in a glacial landscape.
   ii. topography of surrounding country: mountainous.
   iii. microtopography: none.
i. Slope on which profile is situated: very steep (88%).
j. Land-use: bamboo-páramo.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 11.1 degrees Celcius at a depth of 10 cm to 9.8 degrees Celsius at a depth of 50 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: drift mainly derived from intrusive and sedimentary rock.
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: stony (stones and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: slight water erosion.
g. Presence of salt or alkali: none.
h. Human influence: in the upper parts of the profile one finds pieces of charcoal as relicts of the fire of 1976.

III Brief description of the Profile:

Moderately deep well drained profile consisting of dark reddish brown loamy material and yellowish brown loamy sand which contains fresh to very weathered stones and boulders. A 5 cm thick layer of hemic soil material overlies the mineral soil material. Rounded gravel in the upper part. Weak subangular blocky structure, structureless in the lower part. Slightly sticky and slightly plastic. In the upper part many, and in the lower part few pores. Root distribution is normal, pH is relative high (pH H2O 6.4 to 6.2).

IV Profile description:

O 5-0 Composed of about equal amounts of more or less

		fragmented litter and finely divided organic material. Abrupt wavy boundary to:
Ah1	0-3	Black (10YR 2/1) moist; sandy loam, slightly gravelly; weak fine subangular blocky; slightly sticky, slightly plastic, friable moist; many very fine vesicular pores; pH H2O 6.4 ; clear wavy boundary to:
Ah2	3-11	Dark brown (10YR 3/3) moist; loam, slightly gravelly; weak subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine vesicular pores; very few rounded gravel and few residual nodules; pH H2O 6.4 ; clear wavy boundary to:
Bw1	11-35	Reddish brown (5YR 4/3) moist; sandy loam, slightly gravelly; weak medium subangular blocky; slightly sticky, slightly plastic, friable moist; few fine vesicular pores; few rounded gravel and few residual nodules; pH H2O 6.3; gradual wavy boundary to:
Bw2	35-60	Dark yellowish brown (10YR 3/6) moist; loamy sand, stony; weak medium subangular blocky; sticky, slightly plastic, friable moist; few medium vesicular pores; frequent angular stones; pH H2O 6.2; clear wavy boundary to:
C	60-70	Light yellowish brown (10YR 6/4) moist; loamy sand, very stony; structureless; slightly sticky, non plastic, firm moist; very few stones, gravel and boulders, angular.

I Information on the site:

a. Profile number: 6.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Andic Eutropept.
   FAO: Humi-Andi Eutric Regosol.
d. Date of examination: 20 September 1988.
e. Author: J.G. van Uffelen.
f. Location: on the 'Fila Cementerio de la Máquina' just a ten minutes walk before reaching the three hovels situated in the 'Valle de los Conejos', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation:3340 m.
h. Land form:
   i. physiographic position of the site: straight slope formed by a lateral moraine in a glacial landscape.
   ii. topography of surrounding country: mountainous.
   iii. microtopography: none.
i. Slope on which profile is sited: very steep (57%).
j. Land-use: high montane dwarf forest.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 9.6 degrees Celcius at a depth of 10 cm to 9.4 degrees Celsius at a depth of 40 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: drift mainly derived from sedimentary and volcanic rock.
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: exceedingly stony (gravel, stones and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: slight rill erosion.
g. Presence of salt or alkali: none.
h. Human influence: the area is influenced by the big fire of 1976, direct neighbourhood of the location of the soil profile was not influenced.

III Brief description of the Profile:

Moderately deep well draind soils. Black organic horizon rich in sapric soil material overlies a dark reddish brown to dark yellowish brown loamy sand in which one finds angular gravel, stones and boulders, both fresh and weathered. Subangular blocky structure. Non sticky and non plastic in the upper part. Common very fine pores in the upper parts and few very fine pores in the lower parts. Few roots. Relative high pH values (pH H20 6.3 to 6.5). In the lower part slightly tixotropic.

IV Profile description:

O	3-0	Composed of about equal amounts of more or less fragmented litter and finely divided organic material. Abrupt wavy boundary to:
Ah	0-22	Dark reddish brown (5YR 3/4) moist; loamy sand, very stony; moderate medium subangular blocky; non sticky, non plastic, friable moist; common very fine vesicular pores; very frequent gravel and frequent stones, angular, fresh and weathered; common fine roots and few coarse roots; pH H20 6.5; diffuse wavy boundary to:
Bw1	22-57	Strong brown (7.5YR 5/6) moist; loamy sand, gravelly, stony and bouldery; weak medium subangular blocky; slightly tixotropic; non sticky, slightly plastic, friable moist; common very fine vesicular pores; few boulders, frequent stones and gravel angular, fresh and weathered with residual nodules; few fine to coarse roots; pH H20 6.3; clear wavy boundary to:
Bw2	57-67	Dark yellowish brown (10YR 3/4) moist; loamy sand, gravelly and very stony; weak medium subangular blocky; slightly tixotropic; slightly sticky, non plastic, friable moist; few very fine vesicular pores; frequent gravel and very frequent stones, angular, fresh and weathered resulting in residual nodules; very few fine roots.

I Information on the site:

a. Profile number: 7.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Typic Hapludand.
   FAO: Umbric Andosol.
d. Date of examination: 21 September 1988.
e. Author: J.G. van Uffelen.
f. Location: at left side of the 'Fila Cementerio de la Máquina', just a 40 minutes walk before reaching the three hovels situated in the 'Valle de los Conejos', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3250 m.
h. Land form:
   i. physiographic position of the site: straight slope of 66% (orientation of 54 degrees) in a glacial landscape.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: very steep (66%).
j. Land-use: high montane dwarf forest.
k. Climate: see section 2.2 of this report.
   The soil temperature was univorm (10.5 degrees Celcius) throughout the entire soil depth. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: drift mainly derived from sedimentary and volcanic rock.
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile wet throughout (as a result of heavy rain).
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: rubble land (stones and boulders)
e2. Presence of rock outcrops: none.
f. Evidence of erosion: slight rill erosion.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep well drained black to dark yellowish brown profile overlaid by an organic horizon rich in hemic soil material. Uniform in texture (loamy sand) with few to frequent gravel, stones and boulders, fresh and also weathered in the lower parts which results in the presence of residual nodules. Moderate to weak subangular blocky structure, non sticky and non plastic in the upper part of the profile. Fine and very fine pores and a normal root distribution. Relative high pH values (ph H2O 6.3 to 6.4).

IV Profile description:

O 3-0 Composed of well identifiable litter fragments with

		minor amounts of fine organic materials. Abrupt wavy boundary to:
Ah1	0-15	Black (10YR 2/1) wet; loamy sand, slightly gravelly, stony and bouldery; moderate medium subangular blocky; non sticky, non plastic; many very fine and few fine vesicular pores; frequent gravel and few stones, angular, fresh; very frequent fine roots; pH H2O 6.3; clear wavy boundary to:
Ah2	15-40	Dark brown (10YR 3/3) wet; loamy sand, gravelly and very stony; weak medium subangular blocky; slightly tixotropic; non sticky, non plastic; common very fine vesicular pores; frequent gravel and few stones, angular and rounded, fresh and weathered with residual nodules; frequent fine, few medium to coarse roots; pH H2O 6.4; gradual wavy boundary to:
Bw	40-60	Dark yellowish brown (10YR 3/4) wet; loamy sand, gravelly and very stony; weak medium subangular blocky; slightly tixotropic; slightly sticky, slightly plastic; few very fine vesicular pores; frequent stones and boulders, angular and rounded, fresh and weathered resulting in residual nodules; common medium roots.

I Information on the site:

a. Profile number: 8.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Andic Eutropept.
   FAO: Andi-Umbric Regosol.
d. Date of examination: 22 September 1988.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Fila Cementerio de la Máquina', just after passing the 'refugio natural', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3160 m.
h. Land form:
   i. physiographic position of the site: concave slope (44%, orientation of 88 degrees).
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: steep (44%).
j. Land-use: high montane dwarf forest.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 9.3 degrees Celcius at a depth of 10 cm to 10.4 degrees Celsius at a depth of 80 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: drift mainly derived from volcanic rock.
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile wet throughout, as a result of heavy rains.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: exceedingly stony (stones and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: not detected.
g. Presence of salt or alkali: none.
h. Human influence: there is some influence of the fire (1976) which is reflected in the small parts of charcoal found near the soil surface.

III Brief description of the Profile:

Moderately deep well drained black to brownish yellow profile. In the upper parts loamy sand and in the lower parts sandy loam. The mineral soil material is overlaid by a 5 cm thick horizon rich in hemic soil material. Within the profile one finds abundant gravel, stones and boulders. Structure is moderate to weak subangular blocky. Consistence when wet is slightly sticky and slightly plastic. Common micro to very fine vesicular pores throughout the profile, normal root distribution. Relative high pH values (pH H2O 6.2 to 6.5).

IV Profile description:

O1	3-0	Composed of well identifiable litter fragments with minor amounts of fine organic material; abrupt irregular boundary to:
Ah1/O2	0-10	Black (10YR 2/1) wet; loamy sand, gravelly, stony and bouldery; moderate medium subangular blocky; non sticky, slightly plastic; many very fine and few fine vesicular pores vesicular pores; very frequent boulders and frequent gravel and stones; common very fine to coarse roots; pH H2O 6.5; clear irregular boundary to:
Ah2	10-45	Dark brown (10YR 3/3) wet; loamy sand, gravelly and stony; weak medium subangular blocky; slightly sticky, slightly plastic; common very fine and few fine vesicular pores; frequent gravel very weathered (which results in residual nodules), stones, few boulders, angular, fresh and weathered; common very fine to coarse roots; pH H2O 6.3; gradual irregular boundary to:
Bw	45-60	Brownish yellow (10YR 6/8) wet; sandy loam, gravelly; weak fine subangular blocky; slightly sticky, slightly plastic; common micro to very fine vesicular pores; frequent very weathered gravel (residual nodules!), frequent stones angular and rounded, fresh and weathered; few fine to medium roots; pH H2O 6.2.

I Information on the site:

a. Profile number: 9.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Alic Hapludand.
   FAO: Humi-Umbric Regosol.
d. Date of examination: 26 march 1989.
e. Author: J.G. van Uffelen.
f. Location: on left side of the 'Fila Cementerio de la Maquina' in the neighbourhood of the 'Monte Sin Fé', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3100 m.
h. Land form:
   i. physiographic position of the site: on gently convex slope near crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (18%).
j. Land-use: montane pure oakforest of Q. Costaricensis.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 8.7 degrees Celcius at a depth of 10 cm to 8.9 degrees Celsius at a depth of 30 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: volcanic rock.
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 2 - stony (stones and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: not detected.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderate deep wel drained dark brown to yellowish brown profile with a yellowish brown eluvial horizon containing some pure quartz grains. Mineral soil material is overlaid by a 10 cm thick layer of fibric to hemic organic soil materials. Podsolization! Structural development is weak, very fine crumb in the upper and subangular blocky in the upper and lower part, structureless in the eluvial horizon. Few vesicular pores, abundant roots in the organic soil material and very few in the eluvial horizon.

IV Profile description:

3 cm The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Clear and wavy boundary to:

Ol	7-0	Composed of about equal amounts of more or less fragmented litter and finely divided organic material, mineral grains are present. Very dark brown (10YR) moist; abundant very fine to medium roots; clear and wavy boundary to:
E(Ah)	0-2	Yellowish brown (10YR 5/4) moist; sand; structureless; non sticky, non plastic,loose moist; very few medium roots; pH H20 4.2; abrupt smooth boundary to:
Bw1	2-8/14	Dark brown (10YR 4/3) moist; sandy loam, slightly gravelly; weak medium subangular blocky and weak very fine crumb; slightly sticky, slightly plastic, friable moist; common micro to fine vesicular pores; frequent, between angular and rounded, stones, weathered; common very fine to medium roots; pH H20 4.4; clear wavy boundary to:
2Bw1	8/14-38	Dark yellowish brown (10YR 4/4) moist, yellowish brown (10YR 5/4) dry; few, fine, distinct, sharp, reddish yellow (7.5YR) mottles; loamy sand, slightly gravelly; weak very fine subangular blocky; slightly sticky, slightly plastic, friable moist; few micro and very fine vesicular pores; frequent stones, between angular and rounded, weathered; few fine to coarse roots; pH H20 4.8; abrupt irregular boundary to:
2Bw2	38-43	Dark yellowish brown (10YR 4/6) moist; sandy loam, very gravelly and very stony; weak very fine angular blocky; sticky, plastic, firm moist, few macro and very fine vesicular pores; very frequent boulders, between angular and rounded, strongly weathered; very few to coarse roots.

I Information on the site:

a. Profile number: 10.
b. Soil Name:
c. Higher Category Classification;
   USDA: (Histic) Andic Humitropept.
   FAO: Humi-Andic Umbric Regosol.
d. Date of examination: 26 march 1989.
e. Author: J.G. van Uffelen.
f. Location: on right side of the 'Fila Cementerio de la Maquina', a twenty minutes walk before reaching 'Monte Sin Fé', within the 'Parque Nacional Chirripó'.
g. Elevation: 2910 m.
h. Land form:
   i. physiographic position of the site: on steep convex slope near crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (15%).
j. Land-use: montane pure oakforest of Q. Costaricensis.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 11.2 degrees Celcius at a depth of 10 cm to 9.9 degrees Celsius at a depth of 60 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: volcanic rock.
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 4 - exceedingly stony (gravel and stones).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: the physiographic position implies a risk for erosion.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderate deep, well drained (dark) yellowish brown to yellowish brown profile overlaid by a 10 cm thick layer of fibric to sapric organic soil material. Loamy sand with frequent gravel and a few stones, both weathered. Weak subangular blocky structure and also weak crumb structure in the upper part. Slightly sticky and slightly plastic throughout the profile. Micro to very fine pores, abundant roots in the organic soil material.

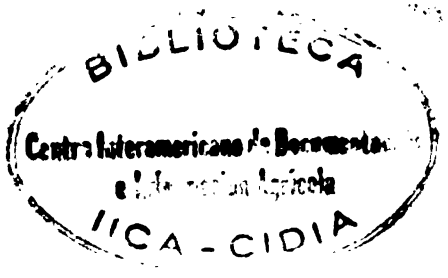
IV Profile description:

	3 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundary to:
O1	7-0	Dominantly composed of fine organic material, but with some litter fragments. Very dark brown (10YR 2/2) moist;

abundant fine to medium roots; abrupt wavy boundary to:

Ah 0-1/28 Dark yellowish brown (10YR 3/4) moist, brown (10YR 5/3) dry; loamy sand, gravelly and slightly stony; weak medium subangular blocky, weak crumb; slightly sticky, slightly plastic, very friable moist; many micro to very fine vesicular pores; frequent gravel, angular, weathered and few stones, angular, weathered; common fine to coarse and few very fine roots; pH H2O 5.0; abrupt wavy boundary to:

Bw 1/28-53 Yellowish brown (10YR 5/6) moist, dark brown (10YR 4/3) dry; loamy sand, gravelly and slightly stony; weak medium subangular blocky; slightly sticky, slightly plastic, very friable; many micro to very fine pores; frequent gravel, angular weathered and few stones, angular, weathered; common fine to coarse roots; pH H2O 5.1.



I Information on the site:

a. Profile number: 11.
b. Soil Name:
c. Higher Category Classification;
   USDA: (Histic) Typic Hapludand.
   FAO: Humi-Umbric Andosol.
d. Date of examination: 26 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Fila Cementerio de la Maquina', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2680 m.
h. Land form:
   i. physiographic position of the site: on convex slope near crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: very steep (88%)
j. Land-use: montane pure oakforest of Q. Costaricensis.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 11.3 degrees Celcius at a depth of 10 cm to 11.1 degrees Celsius at a depth of 30 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: intrusive rock (granodiorite).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 2 - stony (gravel and stones).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: land slides in the direct neighbourhood.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep well drained black to olive yellow profile with a very dark grayish brown eluvial horizon overlaid by a 13 cm thick layer of fibric to sapric organic soil material. Podsolization! Loamy sand with an increase of gravel and stones to the lower part of the profile, weathered or very weathered. Structural development is weak. Sticky and plastic in the horizon underlying the eluvial horizon. Very fine and fine pores, abundant roots in the organic soil material.

IV Profile description:

	3 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundary to:
01	10-5	Composed of about equal amounts of more or less fragmented litter and finely divided organic material. Abundant very fine to coarse roots; clear

		wavy boundary to:
O2	5-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Darkbrown (7.5YR) moist, dark gray (7.5YR 4/1) dry; abundant very fine to coarse roots; clear wavy boundary to:
Ah/(E)	0-2/7	Very dark grayish brown (10YR 3/2) moist, very dark grayish brown (10YR 3/2) dry; loamy sand, slightly gravelly; weak very fine subangular blocky; slightly sticky, slightly plastic, very friable moist; few micro and very fine vesicular pores; few gravel, angular, strongly weathered; common very fine and fine roots; pH H2O 4.3; clear wavy boundary to:
Ah/B	2/7-20	Black (10YR 2/1) moist; few, coarse, prominent, sharp very pale brown (10YR) and strong brown (7.5YR) mottles; loamy sand, slightly gravelly; weak very fine subangular blocky; sticky, plastic, friable moist; few micro and very fine vesicular pores; few gravel, angular, strongly weathered; few very fine and fine roots; pH H2O 4.0; clear irregular boundary to:
Bw1	20-28/38	Dark yellowish brown (10YR 3/4) moist, brown (10YR 5/3) dry; common, coarse, prominent, sharp very pale brown (10YR) and strong brown (7.5YR) mottles; loamy sand, gravelly; weak very fine subangular blocky; slightly sticky, slightly plastic, very friable moist; common micro and very fine, few fine vesicular pores, frequent gravel, angular and rounded, strongly weathered; few very fine to coarse roots; pH H2O 4.8; clear irregular boundary to:
Bw2	28/38-50/57	Strong brown (7.5YR) moist, yellowish brown (10YR 5/6) dry; few, coarse, distinct, clear very pale brown (10YR) and strong brown (7.5YR) mottles; loamy sand, gravelly; weak very fine subangular blocky; slightly sticky, slightly plastic, very friable moist; common micro and very fine vesicular pores; frequent gravel, angular and rounded, strongly weathered; few very fine and fine roots; pH H2O 4.9; clear irregular boundary to:
C	50/57-110	Olive yellow (2.5Y 6/6) moist, very pale brown (10YR 7/3) dry; few coarse distinct, clear very pale brown (10YR) and strong brown (7.5YR) mottles; loamy sand, gravelly, weak very fine subangular blocky; slightly sticky, slightly plastic, friable moist; much micro and very fine and few fine vesicular pores; very frequent gravel, angular and rounded, strongly weathered and few stones, angular and rounded, weathered; few medium coarse roots; pH H2O 5.2.

I Information on the site:

a. Profile number: 12.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Typic Hapludand.
   FAO: Humi-Umbric Andosol.
d. Date of examination: 25 march 1989.
e. Author: J. G. van Uffelen.
f. Location: on the right side of the 'Fila Cementerio de la Maquina', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2470 m.
h. Land form:
   i. physiographic position of the site: on crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: sloping (11%).
j. Land-use: montane pure oakforest of Q. Costaricensis.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 15.2 degrees Celcius at a depth of 10 cm to 14.7 degrees Celsius at a depth of 50 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: volcanic rock (igneous altered lava).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 2 - stony (gravel, stones and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately wel drained (dark) reddish brown profile with a dark gray eluvial horizon overlaid by a 27 thick layer of fibric to sapric organic soil material. Podsolization! Loamy sand overlies a sandy loam containing frequent boulders. Structureless in the eluvial horizon and weak subangular structure in the lower part of the profile. Common very fine and fine pores. Abundant roots in the organic soil material and few in the eluvial horizon.

IV Profile description:

	5 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Clear and wavy boundary to:
01	22-12	Composed of about equal amounts of more or less fragmented litter and finely divided organic material. Dark reddish brown (5YR 3/3) dry; abundant, very fine to

coarse roots, clear wavy boundary to:

O2	12-0	Dominantly composed of fine organic material, but with some litter fragments. Dark reddish brown (5YR 3/2) moist; abundant very fine to coarse roots, pH H20 4.1; abrupt wavy boundary to:
Ah/(E)	0-2	Dark gray (5YR 4/1) moist, very dark brown (10YR 2/2) dry; loamy sand, slightly gravelly and slightly stony; structureless; slightly sticky, slightly plastic, loose moist; few, medium to coarse roots; pH H20 4.2; abrupt wavy boundary to:
Ah/B	2-6/14	Dark reddish brown (5YR 3/3) moist, dark brown (10YR 3/3) dry; sandy loam, slightly gravelly and slightly stony; weak, very fine subangular blocky; sticky, plastic, firm moist; common micro and very fine vesicular pores; frequent gravel, between angular and rounded, weathered; common fine to coarse roots; pH H20 5.1; clear irregular boundary to:
Bw1	6/14-43	Dark yellowish brown (10YR 4/4) moist, dark yellowish brown (10YR 3/4) dry; sandy loam, bouldery; weak very fine subangular blocky; sticky, plastic; common micro and very fine vesicular pores; frequent boulders, angular, weathered; few fine to coarse roots; pH H20 5.4.
Bw2	43-48	Brown (10YR 4/4) moist, few, fine, faint, clear, dark reddish brown (10YR) mottles; sandy loam, bouldery; structureless, frequent boulders, angular weathered; few fine to coarse roots, pH H20 5.4.

I Information on the site:

a. Profile number: 13.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Alic Hapludand.
   FAO: Humi-Haplic Andosol.
d. Date of examination: 27 march 1989.
e. Author: J.G. van Uffelen.
f. Location: at left side of the 'Fila Cementerio de la Maquina', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2300 m.
h. Land form:
   i. physiographic position of the site: on small crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (14%).
j. Land-use: montane mixed oak forest of Q. Copeyensis and Q. Seemanni.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 13.7 degrees Celcius at a depth of 10 cm to 13.7 degrees Celsius at a depth of 60 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: intrusive rock (granodiorite).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 2 - stony (stones and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none detected but the physiographic position implies a risk for landslides.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderate deep well drained dark brown to brownish yellow profile with a dark gray eluvial horizon containing some pure quartz grains. The mineral soil material is overlaid by a 11 cm thick layer of fibric to sapric organic soil material. Podsolization! Structure is weakly developed: subangular blocky. Loamy sand overlying a sandy loam which contains very weathered gravel resulting in the presence of residual nodules. Common micro to very fine pores and few medium pores in the lower part. Abundant roots in the organic soil material and few in the eluvial horizon and the horizon immediately below.

IV Profile description:

	2 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Clear and wavy boundary to:
Oi	9-5	Composed of about equal amounts of more or less

		fragmented litter and finely divided organic material. Common very fine to coarse roots; pH H20 5.2; abrupt and wavy boundary to:
02	5-1	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Dark brown (7.5 YR) moist; abundant very fine to coarse roots; abrupt and smooth boundary to:
O/E	1-0	Dark gray (10YR 4/1) moist; loamy sand; weak very fine subangular blocky; slightly sticky, slightly plastic, very friable moist; many micro, few very fine vesicular pores; few very fine to coarse roots; abrupt smooth boundary to:
Ah/B	0-6	Dark brown (7.5YR 3/2) moist, very dark grayish brown (10YR 3/2) dry; common, medium, faint, clear, dark brown (7.5YR) mottles; loamy sand; weak very fine subangular blocky, slightly sticky, slightly plastic, very friable; common micro pores; few very fine to coarse roots; pH H20 4.3; abrupt smooth boundary to:
Bw1	6-34	Dark yellowish brown (10YR 4/6) moist, yellowish brown (10YR 5/6) dry; common, medium, faint, clear, dark brown (7.5YR) mottles; loamy sand; moderate very fine to medium subangular blocky; slightly sticky, slightly plastic, very friable moist; many micro, common very fine and few fine vesicular pores; very few gravel, angular, weathered and very few gravel (to a section of 2 cm) strongly weathered which results in the presence of residual nodules; common very fine to medium roots; pH H20 4.8; gradual smooth boundary to:
Bw2	34-54	Brownish yellow (10YR 6/8) moist; few, medium, faint, clear, dark yellowish brown (10YR) mottles; sandy loam, slightly gravely; weak very fine subangular blocky; sticky, plastic, firm moist; many micro, common very fine and fine, few medium vesicular pores; frequent gravel, angular, weathered and frequent gravel (to a section of two cm), strongly weathered; few medium roots; pH H20 4.9.

I Information on the site:

a. Profile number: 14.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Acric Hapludand.
   FAO: Humi-Haplic Andosol.
d. Date of examination: 27 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Fila Cementerio de la Maquina', within the 'Parque Nacional Chirripó'.
   East from the town of San Isidro, within the province of Cartago, Costa Rica, Cental America.
g. Elevation: 2100 m.
h. Land form:
   i physiographic position: on small crest.
   ii surrounding land form: steeply dissected.
   iii microtopography: none.
i. Slope on which profile is sited: sloping (12%).
j. Land-use: submontane lauraceous forest with dwarf palms.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 18.7 degrees Celcius at a depth of 10 cm to 18.0 degrees Celsius at a depth of 50 cm. The soil temperature regime is isothermic.

II General information on the soil:

a. Parent material: intrusive rock (granodiorite).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 2 - stony (stones and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none detected but the physiographic position implies a risk for land slides.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep, well drained dark brown profile overlaid by a 13 cm thick layer of fibric to sapric organic soil material. Loamy sand overlies a sandy loam containing stones and boulders weathered. Crumb structure and in the lower part also subangular blocky. Mottles are probably a result of very weathered gravel (section of 2 cm) which have lost their original rock structure. Very fine to medium pores. Abundant roots in the organic soil material.

IV Profile description:

	5 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Clear and wavy boundary to:
O1	8-4	Composed of about equal amounts of more or less fragmented litter and finely divided organic

material. Abundant very fine to fine roots: abrupt and wavy boundery to:

O2	4-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Dark brown (7.5YR) moist; abundant very fine to medium roots; abrupt and wavy boundery to:
Ah1	0-4	Black (10YR 2/1) moist, very dark brown (10YR 2/2) dry; loamy sand; moderate very fine crumb; slightly sticky, slightly plastic, very friable moist; common micro to very fine and few fine vesicular pores; many very fine to medium roots; pH H2O 5.0; clear irregular boundery to:
Ah2	4-17/35	Dark brown (10YR 3/3) moist, dark yellowish brown (10YR 3/4); few fine, distinct, clear dark brown (7.5 Y/R) mottles; loamy sand, slightly gravelly; weak very fine crumb; slightly sticky, slightly plastic, friable moist; many micro, common very fine and few fine medium vesicular pores; few gravel between rounded and angular, weathered; common very fine to coarse roots; pH H2O 4.7; gradual irregular boundary to:
Bw1	17/35-48	Yellowish brown (10YR 5/8) moist, brownish yellow (10YR 6/6) dry; common medium, faint, diffuse, reddish yellow (7.5 YR) mottles; sandy loam, stony; moderate fine and very fine crumb, weak very fine subangular blocky; sticky, plastic, friable moist; many micro and very fine pores, few fine and medium pores; frequent stones and boulders between rounded and angular, weathered; few very fine and fine, common medium to coarse roots; pH H2O 5.0.

I Information on the site:

a. Profile number: 15.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Andic Humitropept.
   FAO: Humi-Andic Dystric Regosol.
d. Date of examination: 29 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Fila cementerio de la Máguina', just outside the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 1900 m.
h. Land form:
   i. physiographic position of the site: on crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: sloping (9%).
j. Land-use: submontane lauraceous forest with dwarf palms.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 14.4 degrees Celcius at a depth of 10 cm to 14.6 degrees Celsius at a depth of 30 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: intrusive rock (granodiorite).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 1 - fairly stony (stones and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: the physiographic position implies a risk for erosion.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep, well drained very dark brown to reddish yellow profile overlaid by a 7 cm thick layer of fibric and sapric organic soil material. Loamy sand overlies a sandy loam which contains weathered to very weathered stones. Mottling is a result of very weathered gravel which already lost its rock structure. Moderate developed crumb in the upper and moderate subangular blocky structure in the lower part of the profile. Few micro to fine (vesicular) pores throughout the profile. Abundant roots in the organic soil material.

IV Profile description:

	3 cm	The litter is non fragmentend, but slightly altered, evidenced by its partial or complete discoloration. Abrupt and wavy boundary to:
01	4-0	Dominantly composed of fine organic material, free of

		litter fragments, but mineral grains are present. Dark brown (10YR) moist; abrupt wavy boundary to:
O/Ah1	0-5	Very dark brown (10YR 2/2) moist; loamy sand; weak to moderate very fine crumb; slightly sticky, slightly plastic, very friable moist; common very fine vesicular pores; abundant very fine to coarse roots; pH H20 4.2; abrupt wavy boundary to:
Ah2	5-11	Dark brown (10YR 4/3) moist and dry; loamy sand; common, fine, prominent, yellow (10YR) to black (10YR) mottles; weak very fine to medium crumb; slightly sticky, slightly plastic, very friable moist; few micro to fine vesicular pores; common fine to coarse roots; pH H20 4.7; abrupt wavy boundary to:
Bw1	11-36	Yellowish brown (10YR 5/8) moist, yellowish brown (10YR 5/6) dry; common, fine, prominent, yellow (10YR) to black (10YR) mottles; sandy loam; moderate very fine subangular blocky; slighty sticky, slightly plastic, very friable moist; few very fine vesicular pores; few fine to coarse roots; pH H20 5.0; gradual wavy boundary to:
Bw2	36-46	Reddish yellow (7.5YR 6/8) moist, reddish yellow (7.5YR 6/8) dry; common, fine, prominent, sharp very pale brown (10YR) to very dark brown (10YR) mottles; sandy loam, slightly stony; weak very fine subangular blocky; sticky, plastic, friable moist; few very fine vesicular pores; frequent stones, between rounded and angular, weathered and strongly weathered; pH H20 5.0.

I Information on the site:

a. Profile number: 16.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Lithic Haplumbrept.
   FAO: Umbric Regosol.
d. Date of examination: 29 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on left side of the 'Fila Cementerio de la Máguina' to the 'Valle de los Crestones', outside the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 1700 m.
h. Land form:
   i. physiographic position of the site: on crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: steep (44%).
j. Land-use: submontane secondary forest.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 16.0 degrees Celcius at a depth of 10 cm to 15.7 degrees Celsius at a depth of 20 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: intrusive rock (granodiorite).
b. Drainage: class 3 - moderately well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 2 - stony (stones and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: the physiographic position implies a risk for erosion.
g. Presence of salt or alkali: none.
h. Human influence: the forest was cleared some five years ago, and this probably resulted in a compaction of the soil. After clearance there was no further human influence.

III Brief description of the Profile:

Shallow moderately well drained dark brown to yellowish brown profile overlaid by a 7 cm thick layer of fibric and humic organic soil material. Sandy loam containing weathered to very weathered gravel and stones. Moderate to weak subangular structure. Slightly sticky and slightly plastic in the upper part. Few to common very fine pores. Only very fine roots in the upper part of the soil profile. The whole profile was compacted (as a result of human activity(?))

IV Profile description:

5 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration.

		Abrupt and wavy boundary to:
Ol	2-0	Composed of about equal amounts of more or less fragmented litter and finely divided organic material, but mineral grains are present. Dark brown (10YR) with parts of charcoal; common very fine and fine roots; abrupt wavy boundary to:
Ah	0-28	Dark brown (10YR 3/3) moist, dark yellowish brown (10YR 4/4) dry; sandy loam, slightly gravelly; moderately very fine subangular blocky; slightly sticky, slightly plastic, friable moist; many micro and few fine vesicular pores; very few gravel, rounded, weathered and very weathered causing very pale brown mottles; very few fine roots; pH H20 4.8; gradual wavy boundary to:
Bw1	28-38	Yellowish brown (10YR 5/8) moist, strong brown (7.5YR 5/6); sandy loam, slightly gravelly and slightly stony; weak very fine subangular blocky; sticky, plastic, firm moist, common very fine vesicular pores; frequent gravel and stones, rounded, weathered and very weathered causing very pale brown mottles; very few fine roots; pH H20 5.1.

I Information on the site:

a. Profile number: 17.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Typic Hapludand.
   FAO: Humi-Haplic Andosol.
d. Date of examination: 1 april 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Fila Palmito Morado' just before the limits of the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2100 m.
h. Land form:
   i. physiographic position of the site: on small crest with a width of about 10 meters.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (22%).
j. Land-use: submontane lauraceous forest with dwarf palms.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 8.8 degrees Celcius at a depth of 10 cm to 7.7 degrees Celsius at a depth of 50 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: intrusive rock (granodiorite).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 1 - fairly stony (gravel and stones)
e2. Presence of rock outcrops: none.
f. Evidence of erosion: land slides near the soil pit.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Shallow well drained dark yellowish brown to brownish yellow profile with a thin pale brown eluvial horizon, overlaid by a 15 cm thick layer of fibric to sapric soil material. Podsolization! Loamy sand containing very weathered gravel, causing mottles in the lower part. Slightly sticky and slightly plastic throughout the profile. Few micro to very few pores to common fine and few medium in the lower part of the profile. Abundant roots in the organic soil material.

IV Profile description:

	3 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundary to:
O1	12-8	Composed of about equal amounts of more or less

		fragmented litter and finely divided organic material. Dark brown (7.5YR) moist; abundant fine to medium roots; abrupt wavy boundary to;
O2	8-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Dark brown (7.5YR) moist; common very fine to coarse roots, abrupt smooth boundary to:
Ah1/(E)	0-2	Pale brown (10YR 6/3) moist; loamy sand; moderate very fine subangular blocky; slightly sticky, slightly plastic, friable moist; few micro and few very fine vesicular pores; few very fine and fine roots; pH H20 4.2; abrupt wavy boundary to:
Ah2	2-20	Dark yellowish brown (10YR 4/4) moist and dry (10YR 4/3); few, fine, faint, clear yellowish red (5YR) mottles; loamy sand, slightly gravelly; weak very fine subangular blocky; slightly sticky, slightly plastic, very friable moist, few micro and very fine vesicular pores; few gravel, angular, strongly weathered; common fine to coarse roots; pH H20 4.8; abrupt wavy boundery to:
Bw	20-33	Brownish yellow (10YR 6/6) moist, very pale brown (10YR 8/4); few, fine, faint, clear, reddish yellow (7.5 YR) mottles; loamy sand, slightly gravelly; weak very fine subangular blocky; slightly sticky, slightly plastic, friable moist; many micro to very fine pores and common fine and few medium vesicular pores; few gravel, angular, strongly weathered; few fine to coarse roots; pH H20 5.1.

I Information on the site:

a. Profile number: 18.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Acric Hapludand.
   FAO: Humi-Haplic Andosol.
d. Date of examination: 31 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Fila Palmito Morado', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2300 m.
h. Land form:
   i. physiographic position of the site: on steep convex slope (88%).
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (22%).
j. Land-use: submontane lauraceous forest with dwarf palms.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 9.9 degrees Celcius at a depth of 10 cm to 10.7 degrees Celsius at a depth of cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: intrusive rock (granodiorite).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: fairly stony (gravel and stones).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: land slides detected near the soil pit.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Well drained, moderately deep dark brown to yellowish brown profile, overlaid by a 20 cm thick layer of fibric to sapric organic soil material. Loamy sand to silt loam containing very weathered gravel causing some mottles in the lower part of the profile. Structural development is weak subangular blocky. Slightly sticky and slightly plastic throughout the profile. Few micro and very fine pores. Abundant very fine to coarse roots in the organic material and few in the Ah horizon, root distribution in the lower part of the profile is normal.

IV Profile description:

	3 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundary to:
O1	18-10	Composed of about equal amounts of more or less

		fragmented litter and finely divided organic material. Very dark grayish brown (10YR) moist, abundant very fine to fine roots; abrupt and wavy boundary to:
O2	10-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are presents. Dark brown (7.5YR) moist very dark grayish brown (10YR 3/2) dry; abundant very fine to coarse roots; abrupt wavy boundary to:
O/Ah1	0-3	Very dark brown (10YR 3/2) moist, dark gray (10YR 4/1) dry; loamy sand; weak very fine subangular blocky; slightly sticky, slightly plastic, firm moist; few micro vesicular pores; very few gravel (section of 3 cm), rounded, very weathered; few very fine to coarse roots; pH H2O 4.2; abrupt wavy boundary to:
Ah2	3-8	Dark yellowish brown (10YR 3/4) moist, dark yellowish brown (10YR 3/4) dry; sandy loam, slightly gravelly (section of 2 cm); weak very fine subangular blocky; slightly sticky, slightly plastic, firm moist; common micro and few very fine vesicular pores; very few gravel, rounded, very weathered, pinkish gray (7.5 YR); common very fine to coarse roots; pH H2O 4.6; clear irregular boundary to:
Bw	8-62	Yellowish brown (10YR 5/6) moist, very pale brown (10YR 3/7) dry; few, fine, faint, clear, strong brown (7.5YR) mottles, silt loam, slightly gravelly to gravelly; weak very fine subangular blocky, slightly sticky, slightly plastic, firm moist; few micro vesicular pores; frequent gravel and stones, angular, weathered, common very fine to coarse roots; pH H2O 5.0.

I Information on the site:

a. Profile number: 19.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Acric Hapludand.
   FAO: Humi-Haplic Andosol.
d. Date of examination: 31 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on left side of the 'Fila Palmito Morado', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2500 m.
h. Land form:
   i. physiographic position of the site: on crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (14%).
j. Land-use: montane lauraraceous forest with dwarf palms.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 10.2 degrees Celcius at a depth of 10 cm to 10.6 degrees Celsius at a depth of cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: volcanic rock (lava)
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 1 - fairly stony (gravel and stones).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep, well drained, very dark brown to pale brown profile overlaid by a 20 cm thick layer fibric to sapric organic soil material. One finds a weak developed eluvial horizon in loamy sand, containing some very weathered gravel, over a sandy loam rich in gravel, stones and boulders, partly very weathered causing some mottling. Structure is weak subangular blocky. Slightly sticky and slightly plastic. Few micro pores except for the eluvial horizon witch has few micro to medium pores. Abundant roots in the lower parts of the organic soil material.

IV Profile description:

5 cm The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundary to:

O1	15-9	Composed of about equal amounts of more or less fragmented litter and finely divided organic material. Dark brown (7.5YR) moist; common very fine to medium roots; clear wavy boundary to:
O2	9-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Dark brown (7.5 YR) moist; abundant fine to coarse roots; abrupt wavy boundary to:
O/Ah1	0-2	Very dark brown (10YR 2/2) moist, dark brown (10YR 4/3) dry; loamy sand; weak subangular blocky; slightly sticky, slightly plastic, very friable moist; many micro to very fine and common fine to medium vesicular pores; few gravel, angular, weathered or very weathered; common fine to medium roots; pH H20 4.4; abrupt wavy boundary to:
Ah2	2-8	Dark brown (10YR 4/3) moist; common, coarse, faint, clear, dark brown (7.5YR) mottles; sandy loam, slightly gravelly; weak subangular blocky; slightly sticky, slightly plastic, very friable moist; few micro vesicular pores; few gravel (0.5-2 cm), angular, weathered or very weathered; few fine to medium and few coarse roots; pH H20 4.5; abrupt wavy boundary to:
Ah3/Bw	8-43	Pale brown (10YR 6/3) moist, yellowish brown (10YR 5/4) dry; few fine to coarse, prominent, sharp brownish yellow mottles (10YR); sandy loam, very gravelly and very stony; weak subangular blocky; slightly sticky, slightly plastic, very friable moist; few micro vesicular pores; frequent gravel (0.5-2 cm), stones and boulders, angular and rounded, weathered; few medium to coarse roots; pH H20 5.2.

I Information on the site:

a. Profile number: 20.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Typic Hapludand.
   FAO: Humi-Umbric Andosol.
d. Date of examination: 31 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on the right side of the 'Fila Palmito Morado' to the 'Fila Urán', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2700 m.
h. Land form:
   i. physiographic position of the site: on relative broad crest (50 meters broad).
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: sloping (7%).
j. Land-use: montane mixed oak forest of Q. Copeyeensis and Q. Seemanni
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 9.5 degrees Celcius at a depth of 10 cm to 10.2 degrees Celsius at a depth of 50 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: colluvial material derived from volcanic rock (lava).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Shallow well drained very dark brown to dark yellowish brown profile with a dark gray eluvial horizon overlaid by a 20 cm thick layer of fibric to sapric organic material. Podsolization! Loamy sand to sandy loam containing weathered boulders. Structural development is moderate to weak subangular blocky. Micro to very fine pores. Abundant roots in the organic soil material, very few in the eluvial horizon.

IV Profile description:

	2 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundery to:
01	18-15	Composed of well identifiable litter fragments with

		minor amounts of fine organic material. Abundant very fine to medium roots abrupt wavy boundery to:
O2	15-10	Composed of about equal amounts of more or less fragmented litter and finely divided organic material. Dark brown (7.5YR) moist; abundant very fine to medium roots; clear wavy boundary to:
O3	10-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Dark brown (7.5YR) moist; frequent very fine to coarse roots; abrupt smooth boundary to:
Ah1/(E)	0-6	Dark gray (10YR 4/1) moist; loamy sand; moderate very fine subangular blocky; slightly sticky, slightly plastic, firm moist; few micro vesicular pores; very few very fine to coarse roots; pH H2O 4.1; abrupt smooth boundery to:
Ah2	6-12	Very dark brown (10YR 2/2) moist, dark gray (10YR 4/1) dry; sandy loam; weak very fine subangular blocky; sticky, plastic, firm moist; common micro and few very fine vesicular pores; common very fine to coarse roots; pH H2O 4.5; clear wavy boundary to:
Ah3	12-32	Dark yellowish brown (10YR 3/4) moist and dry, very dark grayish brown (10YR 3/2) dry; sandy loam, stony and boulderly; weak very fine subangular blocky; sticky, plastic, firm moist; common micro and few very fine vesicular pores; very frequent boulders, rounded, weathered; few very fine to coarse roots; pH H2O 5.0.

I Information on the site:

a. Profile number: 21.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Andic Humitropept.
   FAO: Humi-Andi Dystric Regosol.
d. Date of examination: 1 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on the 'Fila Palmito Morado', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2900 m.
h. Land form:
   i. physiographic position of the site: on gently convex slope.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: sloping (12%).
j. Land-use: montane pure oakforest of Q. Costaricensis.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 10.4 degrees Celcius at a depth of 10 cm to 10.0 degrees Celsius at a depth of 70 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: colluviul material derived from volcanic rock (lava).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 1 - fairly stony (stones).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep well drained very dark brown to brownish yellow profile with a substratum of rotten volcanic rock and overlies a 5 cm thick layer of sapric organic soil material. Very fine subangular blocky. Sandy loam over a loamy sand with weathered stones and rotten rock with common red and gray mottles. Slightly sticky and slightly plastic except for the substratum. Micro and very fine pores. Root distribution normal with abundant roots in the organic soil material.

IV Profile description:

O	5-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains present; very dark brown (10YR 2/2) moist; abundant very fine to coarse roots; gradual wavy boundary to:
Ah	0-18	Very dark brown (10YR 2/2) moist, very dark grayish

		brown 10YR 3/2) dry; sandy loam, slightly gravelly; moderate very fine subangular blocky; slightly sticky, slightly plastic, friable moist; very few rounded stones, weathered; common micro vesicular pores; abundant very fine to coarse roots; pH H2O 5.0; gradual wavy boundary to:
Ah/Bw1	18-45	Dark yellowish brown (10YR 4/6) moist, brownish yellow (10YR 6/6) dry; loamy sand, slightly gravelly; moderate subangular blocky; slightly sticky, slightly plastic, friable moist; very few rounded stones, weathered; common very fine vesicular pores; few fine to medium roots; pH H2O 4.7; clear wavy boundary to:
Bw2	45-60	Brownish yellow (10YR 6/6) moist, very pale brown (10YR 8/3) dry; loamy sand, slightly stony; weak subangular blocky; slightly sticky, slightly plastic, friable moist; very few rounded stones, weathered; few micro vesicular pores; few medium roots; pH H2O 4.9; clear wavy boundary to:
Bw3	60-75	Pale yellow (5Y 7/4) moist, white (2.5Y 8/2)dry; structureless; nonsticky, non plastic, friable moist; few micro vesicular pores; few medium roots; pH H2O 4.9.

I Information on the site:

a. Profile number: 22.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Typic Hapludand.
   FAO: Humi-Haplic Andosol.
d. Date of examination: 1 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Fila Palmito Morado', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3000 m.
h. Land form:
   i. physiographic position of the site: on steep concave slope.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: steep (44%).
j. Land-use: montane pure oak forest of Q. Costarisencis.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 9.5 degrees Celcius at a depth of 10 cm to 9.2 degrees Celsius at a depth of 40 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: volcanic rock (lava).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: class 2 - stony (gravel, stones and boulder).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: non detected, but physiographic position implies risk for erosion (land slides).
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep, well drained, dark brown to dark yellowish brown profile, 10 cm thick layer of sapric organic soil material. Loamy sand overlies a sandy loam containing very frequent fresh gravel and stones. Medium granular and subangular blocky structure, structureless in the Bw2 horizon. Slightly sticky, slightly plastic to sticky and plastic. Common to few micro (vesicular) pores. Abundant roots in the organic soil material.

IV Profile description:

O	10-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Very dark brown (10YR2/2) moist, dark gray (10YR 4/2) dry, abundant very fine to medium roots; pH H2O 4.8; gradual

wavy boundary to:

Ah	0-5	Dark brown (10YR 3/3) moist, brown (10YR 5/3) dry; loamy sand, slightly gravelly; moderate medium granular; slightly sticky, slightly plastic, firm when moist; common, micro vesicular pores; few gravel, angular, weathered; abundant fine to coarse roots; pH H2O 4.8; abrupt wavy boundary to:
Ah/Bw1	5-40	Dark yellowish brown (10YR 4/4) moist, yellowish brown (10YR 5/6) dry; loamy sand, slightly gravelly; weak subangular blocky; slightly sticky, slightly plastic, friable; common micro vesicular pores; few gravel, angular, weathered; common fine to coarse roots; pH H2O 5.0; gradual wavy boundary to:
Bw2	40-55	Dark yellowish brown (10YR 4/6) moist, brownish yellow (10YR 6/6) dry; sandy loam, very gravelly, very stony; structureless; sticky, plastic, firm moist; few micro vesicular pores; very frequent gravel and stones, angular, fresh; very few medium to coarse roots; pH H2O 4.9.

I Information on the site:

a. Profile number: 23.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Lithic Placudand.
   FAO: Humi-Umbric Andosol.
d. Date of examination: 1 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Fila Palmito Morado' near the 'Paso de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3100 m.
h. Land form:
   i. physiographic position of the site: on a very small plateau near the 'Fila Urán', at the border of the glacial landscape.
   ii. topography of surrounding country: hilly.
   iii. microtopography: none.
i. Slope on which profile is sited: sloping (11%).
j. Land-use: high montane dwarf forest.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 9.4 degrees Celcius at a depth of 10 cm to 9.1 degrees Celsius at a depth of 50 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: volcanic rock (lava).
b. Drainage: class 2 - imperfectly drained.
c. Moisture conditions in the profile: soil moist throughout.
d. Depth of groundwater table: not detected, but after periods of excessive rain there will be a superficial water layer over the thin iron pan.
e1. Presence of surface stones: very stony (gravel).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Shallow, imperfectly drained very dark grayish to very dark brown profile, with an dark gray eluvial horizon formed beneath a 15 cm thick layer of sapric organic soil material. Podsolization! In the lower part of the profile a thin iron pan has been formed over a yellow C horizon. Loamy sand overlies a sandy loam both containing some strongly weathered gravel causing clear mottling above the iron pan. Moderate subangular blocky, structureless in the C horizon. Roots are concentrated in the organic soil material and in the upper part of the eluvial horizon.

IV Profile description:

O 15-0 Dominantly composed of organic material (mainly

consisting of spaghnum fibers), but with some litter fragments. Abundant very fine to medium roots. Abrupt and wavy boundary to:

Ah1/(E1) 0-8 Dark gray (5YR 4/1) moist, dark gray (10YR 4/1) dry; loamy sand, slightly gravelly; moderate medium to coarse subangular blocky; slightly sticky, slightly plastic, firm moist; few very fine vesicular pores; very few gravel (0.2-2 cm), angular strongly weathered with few, medium, distinct, clear orange mottles; common very fine to coarse roots; pH H20 4.1; clear wavy boundary to:

Ah2/(E2) 8-28 Very dark grayish brown (10YR 3/2) moist, dark brown (10YR 3/3)dry; sandy loam, gravelly; structureless; sticky, plastic, very firm moist, common very fine vesicular pores; few gravel (0.2-2 cm), between angular and rounded, strongly weathered with many fine distinct clear orange and brown mottles; few medium pores; pH H20 4.7; clear irregular boundary to:

Ah3 28-34 Very dark brown (10YR 2/2) moist, dark brown (10YR 3/3) dry; sandy loam, gravelly; weak medium subangular blocky; sticky, plastic, firm moist; common very fine vesicular pores; few gravel, between angular and rounded, strongly weathered with common fine distinct clear orange and brown mottles; few medium pores; pH H20 4.8; abrupt smooth boundary to:

Bs 34-35 Thin iron pan; hardened with iron; possible to break it by hand; continuous; material has sponge like structure; abrupt and smooth boundary to:

C 35-50 Yellow (10YR 7/8) moist, very pale brown (10YR 8/4) dry; sandy loam, gravelly; structureless; sticky, plastic, very firm moist; few gravel, between angular and rounded, strongly weathered; pH H20 5.2.

I Information on the site:

a. Profile number: 24.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Lithic Troposaprist.
   FAO: Terric Histosol.
d. Date of examination: 28 Februari 1989.
e. Author: J.G. van Uffelen.
f. Location: just on left side of the 'Paso de los Indios' near the 'Cerro Urán', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3250 m.
h. Land form:
   i. physiographic position of the site: on a small convex slope in a glacial landscape.
   ii. topography of surrounding country: hilly.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (20%).
j. Land-use: bamboo-páramo.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 10.9 degrees Celcius at a depth of 10 cm to 10.0 degrees Celsius at a depth of 40 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: drift derived from volcanic rock and volcanic rock in situ (lava).
b. Drainage: class 2 - imperfectly drained.
c. Moisture conditions in the profile: wet throughout, especially at the lower parts.
d. Depth of groundwater table: not detected, but after periods of excessive rain there will be a water layer over the rotten volcanic rock.
e1. Presence of surface stones: exceedingly stony (boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: slight water erosion.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Shallow imperfectly drained black to brown profile resting on rotten volcanic rock. A 38 centimeter thick layer rich in sapric organic soil material overlies the mineral soil material. Loamy sand over a sandy loam containing some very weathered gravel causing mottling. Structural development is weak subangular blocky. Slightly sticky and slightly plastic throughout the profile. Many micro pores in the sapric material and less below this soil material. Common very fine and fine roots in the upper 40 cm of the profile.

IV Profile description:

O	38-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Black (10YR2/1) wet, very dark gray (10YR 3/1)dry; loamy sand; structureless; slightly plastic and slightly sticky; many micro (vesicular) pores; common very fine and fine roots; abrupt irregular boundary to:
Ah1	0-3	Black (10YR 2/1) wet, dark brown (10YR 3/3) dry; loamy sand, weakfine subangular blocky; slightly plastic and slightly sticky; few micro and very fine pores; common very fine and fine roots; pH H20 4.5; clear wavy boundary to:
Ah2	3-14	Brown (10YR 4/4) wet and (10YR 5/3) dry; sandy loam, slightly gravelly, stony; weak very fine subangular blocky; few micro and very fine pores; frequent gravel (0-2 cm) rounded and very weathered causing some mottling; few very fine and fine roots; pH H20 4.7; resting on rotten volcanic rock.

I Information on the site:

a. Profile number: 25.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Lithic Humitropept.
   FAO: Humi-Dystric Regosol.
d. Date of examination: 2 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on left side of the 'Paso de los Indios' near the 'Cerro Urán', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3300 m.
h. Land form:
   i. physiographic position of the site: on a concave slope near a small hill top in a glacial landscape.
   ii. topography of surrounding country: hilly.
   iii. microtopography: none.
i. Slope on which profile is sited: steep (40%).
j. Land-use: bamboo-páramo.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 11.0 degrees Celcius at a depth of 10 cm to 10.0 degrees Celsius at a depth of 20 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: colluvial material derived from volcanic rock (lava).
b. Drainage: class 2 - imperfectly drained.
c. Moisture conditions in the profile: moist above the iron pan, dry below.
d. Depth of groundwater table: not detected, but after periods of excessive rain there will be influence of groundwater on the profile.
e1. Presence of surface stones: exceedingly stony (boulders to a cross-section of 3 m).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Shallow imperfectly drained black to very pale brown profile overlaid by a 22 cm thick black horizon rich in sapric soil material. The BC horizon consits of rotten volcanic rock. Developed in a loamy sand containing frequent gravel which is partly very weathered causing mottles. Slightly sticky, slightly plastic to non sticky and non plastic. Structural development is very weak subangular blocky to structureless. Micro pores in the upper part and common roots in the organic soil material.

IV Profile description:

O/Ah	0-22	Black (10YR 2/1) wet, very dark gray (10YR 3/1) dry; loamy sand rich in sapric soil material; weak subangular blocky to structureless; slightly sticky, slightly plastic; few micro vesicular pores; common very fine to fine, few medium roots; pH H2O 4.6; gradual wavy boundary to:
Ah/(E)	22-34	Dark brown (10YR 3/3) moist, gray (10YR 5/1) dry; common fine distinct clear very pale brown (10YR) to brownish yellow (10YR) mottles; loamy sand, gravelly; weak subangular blocky; slightly sticky, slightly plastic; few micro vesicular pores; frequent gravel, angular, weathered and strongly weathered; few very fine to fine roots; pH H2O 5.1; abrupt irregular boundary to:
Bs	34-35	Thin iron pan formed over a substratum of rotten rock; possible to break it by hand; continuous; material has sponge like structure and vesicular pores; clear wavy boundary or gradual wavy boundary to:
BC	35-45	Very pale brown (10YR 8/4) to brownish yellow (10YR 6/8) moist, pale yellow (2.5Y 8/4) dry; many medium distinct, diffuse clear very pale brown (10YR) to brownish yellow (10YR) mottles; loamy sand, structureless; non sticky, non plastic; stony and bouldery, very strongly weathered rotten rock; pH H2O 5.5.

I Information on the site:

a. Profile number: 26.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Lithic Troposaprist.
   FAO: Terric Histosol.
d. Date of examination: 3 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Paso de los Indios' near the 'Cerro Urán', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3250 m.
h. Land form:
   i. physiographic position of the site: relative broad crest in glacial landscape.
   ii. topography of surrounding country: mountainous.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (18%).
j. Land-use: bamboo-páramo.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 8.8 degrees Celcius at a depth of 10 cm to 8.6 degrees Celsius at a depth of 50 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: colluvial material derived from volcanic rock (lava).
b. Drainage: class 2 - imperfectly drained.
c. Moisture conditions in the profile: profile wet throughout.
d. Depth of groundwater table: at 25 cm.
e1. Presence of surface stones: stony - boulders.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep imperfectly drained black to light yellowish brown profile with a 59 cm thick layer rich in sapric organic soil material overlying the horizons rich in mineral material. Moderate subangular blocky in the B horizons. Structureless in the lower part of the profile. Slightly sticky, slightly plastic throughout. Very common to common fine and very fine pores in the mineral part except for the lower part. Common very fine to medium roots in the upper 65 cm of the profile.

IV Profile description:

01	55-40	Dark brown (10YR 3/3) wet; loamy sand rich in sapric soil material; structureless; slightly sticky, slightly plastic; abundant, very fine to

		medium roots; clear wavy boundary to:
02	40-25	Very dark brown (10YR 2/2) wet and dry; loamy sand rich in sapric soil material; weak very fine subangular blocky; slightly sticky, slightly plastic; many very fine vesicular pores; common very fine to medium roots; clear wavy boundary to:
03	25-0	Black (10YR 2/1) wet and dry; loamy sand, slightly gravelly rich in sapric soil material; weak very fine subangular blocky, slightly sticky, slightly plastic; very common very fine vesicular pores; few gravel (5-7.5 cm) rounded, weathered; common very fine to medium roots; pH H2O 4.5; clear wavy boundary to:
Ah	0-10/20	Dark brown (10YR 3/3) wet, very dark grayish brown (10YR 3/2); loamy sand, slightly gravelly; moderate very fine subangular blocky; slightly sticky, slightly plastic; common fine vesicular pores; few gravel (5-7.5 cm) rounded, weathered; common very fine to medium roots; pH H2O 4.6; clear irregular boundary to:
Bw	10/20-30	Light yellowish brown (10YR 6/4) wet; common to coarse, distinct, diffuse, yellowish brown (10YR) mottles; sandy loam, stony and bouldery; structureless; slightly sticky, slightly plastic; frequent boulders, rounded, strongly weathered.

I Information on the site:

a. Profile number: 27.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Lithic Troposaprist.
   FAO: Terric Histosol.
d. Date of examination: 3 March 1989.
e. Author: J.G. van Uffelen.
f. Location: just on left side of the 'Paso de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 3100 m.
h. Land form:
   i. physiographic position of the site: on crest in glacial landscape.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: sloping (11%).
j. Land-use: high montane dwarf forest.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 9.2 degrees Celcius at a depth of 10 cm to 9.0 degrees Celsius at a depth of 70 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: drift derived from volcanic rock and volcanic rock in situ (lava).
b. Drainage: class 3 - moderately well drained.
c. Moisture conditions in the profile: wet throughout
d. Depth of groundwater table: not detected, but the profile will be influenced by groundwater after periods of excessive rain.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep and moderately well drained black to yellowish brown profile overlaid by a 23 cm thick layer of fibric to sapric organic soil material. Some small parts of charcoal (0.5-2.0 cm) were found in the upper part of the organic soil material. Sandy loam, containing some weathered gravel, overlies rotten volcanic rock. Slightly sticky and slightly plastic throughout the profile. Common micro (vesicular) pores to a depth of some 70 cm. Common very fine to medium roots in the organic soil material, fewer roots in the mineral part of the profile.

IV Profile description:

O1	61-58	Composed of well identifiable litter fragments with minor amounts of fine organic material. Abrupt wavy

		boundary to:
02	58-45	Dominantly composed of fine organic material, but with some litter fragments. Dark reddish brown (5YR) wet; slightly sticky, slightly plastic; many micro to very fine vesicular pores; abundant very fine to medium roots; clear wavy boundary to:
03	45-38	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Black (10YR 2/1) wet; slightly sticky, slightly wet; common micro vesicular pores; common very fine to fine and few medium roots; clear wavy boundary to;
04	38-20	Black (10YR 2/1) wet; sandy loam; weak subangular blocky; slightly sticky, slightly plastic; common micro vesicular pores; common very fine to fine and few coarse roots; pH H20 4.2; clear wavy boundary to:
05	20-0	Very dark brown (10YR 2/2) wet; sandy loam, slightly gravelly; weak subangular blocky; slightly sticky, slightly plastic; common, micro vesicular pores; very few rounded weathered granite; common very fine to fine and few coarse roots; pH H20 4.5; clear wavy boundary to:
Ah/Bw	0-12/26	Brown (10YR 5/3) wet and dry (7.5YR 5/2); common, medium, distinct, clear brown (10YR) to very dark brown (10YR) mottles; sandy loam, slightly gravelly; weak very fine angular blocky; slightly sticky, slightly plastic; common micro vesicular pores; very frequent gravel (0.5-2.0 cm), angular, strongly weathered volcanic rock; few very fine to fine roots; pH H20 4.6; clear irregular boundary to:
BwC	12/26-32	Light yellowish brown (10YR 6/4) moist, very pale brown (10YR 7/4) dry; many medium to coarse prominent sharp brownish yellow (10YR) to strong brown (7.5YR) mottles; rotten rock with patches of sandy loam; structureless; pH H20 4.7.

I Information on the site:

a. Profile number: 28.
b. Soil Name: -
c. Higher Category Classification;
   USDA: Lithic Troposaprist.
   FAO: Terric Histosol.
d. Date of examination: 6 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Camino de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2900 m.
h. Land form:
   i. physiographic position of the site: on small crest with a width of several meters at the border of the glacial landscape.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (16%).
j. Land-use: montane pure oakforest of Q. Costaricensis.
k. Climate: see section 2.2 of this report.
   The soil temperature was almost univorm (8.9 degrees Celsius) throughout the entire soil depth. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: colluvial material derived from volcanic rock (lava).
b. Drainage: class 2 - imperfectly drained.
c. Moisture conditions in the profile: profile wet above the iron pan, moist below.
d. Depth of groundwater table: not detected, but after periods of excessive rain a water layer above the iron pan will influence the profile.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderate deep, imperfectly drained dark brown to brownish yellow profile with an iron pan formed over rotten volcanic rock. A 43 cm thick layer of fibric to sapric organic soil material overlies the mineral soil material. Sandy clay loam over a sandy loam resting on the rotten rock. Weakly developed eluvial horizon above the iron pan which is continuos and can be broken by hand. Many micro to fine pores in the sapric soil material and common micro above the iron pan. Abundant roots in the sapric soil material.

IV Profile description:

O1	43-38	Composed of well identifiable litter fragments with minor amounts of fine organic material. Abrupt wavy boundary to:
O2	38-20	Dominantly composed of fine organic material, but with some litter fragments, but mineral grains present; very dark grayish brown (10YR) wet, very dark brown (10YR 2/2) dry; non sticky, slightly plastic; many micro to fine vesicular pores; abundant fine roots; pH H2O 4.4; gradual wavy boundary to:
O3	20-0	Dominantly composed of fine organic material, free of litter fragment, mineral grains present; very dark brown (10YR) wet; slightly sticky, slightly plastic; many micro to very fine vesicular pores; abundant fine to coarse roots; pH(H2O) 3.9; clear wavy boundary to:
Ah1/(E1)	0-15	Dark brown (10YR 4/3) wet, gray (10YR 6/1) dry; sandy clay loam; moderate very fine subangular blocky; slightly sticky, slihtly plastic; common micro vesicular pores; few very fine and common coarse roots; pH H2O 4.0; clear wavy boundary to:
Ah2(E2)	15-22	Brown (10YR 4/3) wet, brownish yellow (10YR 6/8) dry; 30% of this horizon is black mottled as a result of organic matter; sandy clay loam; weak very fine subangular blocky; slightly sticky, slightly plastic; common micro vesicular pores; common very fine to fine and few coarse roots; pH H2O 4.3; abrupt wavy boundary to:
Bs	22-22.3	Yellowish red (10YR 5/6); hardened with iron; possible to break it by hand; continuous; material has sponge like structure; abrupt and smooth boundary to:
Bw	22.3-45	Brownish yellow (10YR 6/8) moist; sandy loam, bouldery; structureless; non sticky, non plastic; very frequent boulders, rounded, very strongly weathered; pH H2O 5.1.

I Information on the site:

a. Profile number: 29.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Typic Placudand.
   FAO: Humi-Mollic Andosol.
d. Date of examination: 9 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Camino de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2700 m.
h. Land form:
   i. physiographic position of the site: on crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (17%).
j. Land-use: montane pure oakforest of Q. Costaricensis.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 11.1 degrees Celcius at a depth of 10 cm to 10.9 degrees Celsius at a depth of 40 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: volcanic rock.
b. Drainage: class 2 - imperfectly drained.
c. Moisture conditions in the profile: profile wet above the iron pan, below the pan moist.
d. Depth of groundwater table: not detected, but after periods of excessive rain there will be a water layer over the iron pan.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: none.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Shallow, imperfectly drained very dark grayish brown to yellowish brown profile with a dark gray, weakly developed, eluvial (?) horizon overlaid by a 30 cm thick layer of fibric to sapric soil material. Podsolization! Sandy loam with few gravel to loam containing frequent gravel. The gravel is partly very weathered causing mottling. Slightly plastic and slightly sticky. Micro to fine pores in all the horizons. Abundant roots in the organic soil material.

IV Profile description:

	3 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundary to:
O1	27-17	Composed of wel identifiable litter fragments with

		minor amounts of fine organic material. Clear wavy boundary to:
O2	17-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Very dark grayish brown (10YR) wet; slightly sticky, slightly plastic; abundant very fine to coarse roots; pH H2O 4.9; clear wavy boundary to:
Ah1/(E1)	0-2	Dark gray (10YR 4/1) wet, gray (10YR 5/1) dry; sandy loam; weak medium subangular blocky; slightly sticky, slightly plastic; common very fine to fine vesicular pores; few gravel (0.2-2 cm), rounded, weathered; common very fine to fine and few medium to coarse roots; pH H2O 4.6; clear wavy boundary to:
Ah2	2-14	Very dark grayish brown (10YR 3/2) wet, light yellowish brown (10YR 6/4) dry; sandy loam, gravelly; moderate subangular blocky; slightly sticky, slightly plastic; few micro to fine vesicular pores; few gravel (0.2-5 cm), rounded, weathered and very weathered with common coarse prominent sharp brown (7.5YR) mottles; common very fine to fine and few medium to coarse roots; pH H2O 5.9; abrupt wavy boundary to:
Bs	14-14.2	Yellowish red (5YR 5/6) moist; hardened with iron, possible to break it by hand; continuos; material has no recognizable structure; abrupt and wavy boundary to:
Bw	14.2-53	Yellowish brown (10YR 5/4) moist; loam, in the upper part very gravelly in the lower part stony; weak subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine and few fine vesicular pores; frequent gravel (0.2-4 cm), rounded, weathered with common coarse distinct clear strong brown (7.5 YR) mottles and few stones, angular, fresh; common medium to coarse roots.

I Information on the site:

a. Profile number: 30.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Placic Humitropept.
   FAO: Humi-Dystric Regosol.
d. Date of examination: 7 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on left side of the 'Camino de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2500 m.
h. Land form:
   i. physiographic position of the site: on crest (slope between 22% and 44%).
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: sloping (11%).
j. Land-use: montane mixed oakforest of Q. Copeyensis and Q. Seemanni.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 11.7 degrees Celcius at a depth of 10 cm to 11.0 degrees Celsius at a depth of 30 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: volcanic rock.
b. Drainage: class 2 - imperfectly drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected, but after periods of excessive rains there will be some influence on the profile.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: not detected.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Shallow imperfectly drained black to yellowish brown profile with a very weak developed iron pan. A layer of 25 cm fibric to sapric organic soil material overlies the eluvial horizon. Podsolization! Sandy clay loam and loam over a sand loam all containing weathered to very weathered gravel and stones causing mottles. Common micro and very fine pores. Abundant roots in the sapric organic matter, few very fine to fine in the eluvial horizon.

IV Profile description:

	4 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundary to:
01	21-2	Dominantly composed of fine organic material, but

		with some litter fragments. Black (10YR) to dark reddish brown (5YR) moist; abundant very fine to coarse roots; pH H20 4.9; abrupt wavy boundary to:
O2	2-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Black (10YR 2/1) moist, dark grey (5YR 4/1) dry; sandy clay loam; moderate subangular blocky; slightly sticky, slightly plastic, friable moist; common micro to very fine vesicular pores; few very fine to fine roots; pH H20 4.1; abrupt wavy boundary to:
Ah1/(E1)	0-3	Yellowish brown (10YR 5/4) moist, light brownish gray (10YR 6/2) dry; few medium distinct clear strong brown (7.5YR) and very pale brown (10YR) mottles; clay loam; weak subangular blocky; common micro to very fine pores; slightly sticky, slightly plastic; friable moist; few very fine to fine roots; pH H20 4.1; abrupt wavy boundary to:
Ah2	3-10	Brown (10YR 4/3) moist, yellowish brown (10YR 5/4) dry; common coarse distinct clear strong brown (7.5YR) mottles; loam, slightly gravelly; weak medium subangular blocky; common micro to very fine pores; slightly sticky, sligtly plastic, firm moist; few gravel (0.2-1 cm), rounded, weathered and strongly weathered; common medium to coarse roots; pH H20 4.3; clear wavy boundery to:
Bs	10-10.2	Yellowish red (5YR 5/6); hardened with iron; possible to break it by hand; not continuous because this pan has been developed only in places; abrupt and wavy boundary to:
Bw	10.2-44	Yellowish brown (10YR 5/8) moist and dry (10YR 5/6); common fine to coarse faint diffuse yellowish brown (10YR) mottles; sandy loam, stony; weak subangular blocky; slightly sticky, slightly plastic, friable moist; few very fine vesicular pores; frequent gravel and stones rounded and angular, weathered and strongly weathered; few medium to coarse roots; pH H20 4.8.

I Information on the site:

a. Profile number: 31.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Andic Humitropept.
   FAO: Humi-Andi Dystric Regosol.
d. Date of examination: 7 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on left side of the 'Camino de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2300 m.
h. Land form:
   i. physiographic position of the site: straight slope of 66%.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: steep (28%).
j. Land-use: submontane lauraceous forest with dwarf palms.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 11.4 degrees Celcius at a depth of 10 cm to 11.3 degrees Celsius at a depth of 70 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: volcanic rock (lava).
b. Drainage: class 3 - moderately well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected, but after periods of excessive rain groundwater influences the profile.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: not detected.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep, moderately well drained dark brown to yellowish brown profile with a 29 cm thick layer of fibric to sapric organic soil material. Sandy loam over loam containing some weathered gravel. Slightly sticky and slightly plastic throughout. Structure is moderate subangular blocky. Few medium pores in the upper part of the mineral soil material. Abundant roots in the organic soil material.

IV Profile description:

	3 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundary to:
01	25-4	Composed of about equal amounts of more or less fragmented litter and finely divided organic material. Dark brown (7.5 YR) moist; abrupt wavy boundary to:

O2	4-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Dark brown (7.5 YR) moist and dry (10YR 3/3); abundant very fine to medium and common coarse roots; abrupt wavy boundary to:
Ah	0-15	Dark brown (10YR 3/3) moist, dark brown (7.5YR 4/2) dry; sandy loam, slightly gravelly; moderate very fine to fine subangular blocky; slightly sticky, slightly plastic, friable moist; many micro to very fine and few medium vesicular pores; common very fine to medium and few coarse roots; pH H20 4.3; clear irregular boundary to:
Bw1	15-58	Yellowish brown (10YR 5/8) moist, light yellowish brown (2.5Y 6/4) dry; loam, slightly gravelly in the upper part and gravelly in the lower part; moderate very fine subangular blocky; slightly sticky, slightly plastic, friable moist; common micro and few fine vesicular pores; very few gravel in the upper part and few gravel in the lower part of the profile, rounded, weathered; common very fine to fine, few medium to coarse roots; pH H20 4.7.

I Information on the site:

a. Profile number: 32.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Typic Hapludand.
   FAO: Humi-Haplic Andosol.
d. Date of examination: 11 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Camino de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 2100 m.
h. Land form:
   i. physiographic position of the site: on straight slope near the crest.
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: steep (55%).
j. Land-use: submontane lauraceous forest with dwarf palms.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 14.2 degrees Celcius at a depth of 10 cm to 14.0 degrees Celsius at a depth of 60 cm. The soil temperature regime is isomesic.

II General information on the soil:

a. Parent material: colluvial/residual material derived from volcanic rock.
b. Drainage: class 3 - moderately well drained.
c. Moisture conditions in the profile: profile wet throughout.
d. Depth of groundwater table: not detected, but after periods of excessive rain there will be influence of groundwater on the profile.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: not detected.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep and moderately well drained black to brownish yellow profile overlaid by a 20 cm thick layer of fibric to sapric organic soil material. Clay loam over clay containing some very weathered gravel in the lower part causing mottles. Mottles in the higher part are a result of accumulated organic matter (filled up root spaces). Slightly sticky and slightly plastic throughout. Structure is moderate to weak subangular blocky. Common micro and very fine pores. Abundant roots in the organic soil material and common very fine to fine roots in the first two mineral horizons.

IV Profile description:

	10 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt irregular boundary to:
O1	12-2	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Dark brown (7.5YR 3/2) wet; slightly sticky, slightly plastic; abundant very fine to coarse roots; pH H2O 4.5; abrupt irregular boundary to:
O2	2-0	Black (10YR 2/1) wet; clay loam; slightly sticky, slightly plastic; common micro to very fine vesicular pores; common very fine to fine roots; pH H2O 4.1; abrupt irregular boundary to:
Ah1	0-1	Dark brown (10YR 4/3) wet, yellowish brown (10YR 5/6) dry; clay; slightly sticky, slightly plastic; moderate subangular blocky; common micro to very fine vesicular pores; common very fine to fine roots; pH H2O 4.3; abrupt irregular boundary to:
Ah2	1-23	Yellowish brown (10YR 5/8) wet; few, fine, faint, clear, brownish yellow (10YR) mottles and common coarse, prominent sharp black to dark brown mottles; clay; slightly sticky, slightly plastic; moderate subangular blocky; common micro to very fine vesicular pores; few fine to coarse roots; pH H2O 4.6; gradual wavy boundary to:
Bw	23-55	Brownish yellow (10YR 6/6) wet, very pale brown (10YR 8/4) dry; common fine, faint, clear brownish yellow (10YR) mottles; clay, slightly gravelly; slightly sticky, slightly plastic; weak subangular blocky; common micro to very fine vesicular pores; few gravel, rounded, weathered and strongly weathered; few fine to coarse roots; pH H2O 5.0.

I Information on the site:

a. Profile number: 33.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Acric Hapludand.
   FAO: Humi-Umbric Andosol.
d. Date of examination: 12 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Camino de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 1900 m.
h. Land form:
   i. physiographic position of the site: on small crest (slope of 77%).
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: steep (44%).
j. Land-use: submontane lauraceous forest with dwarf palms.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 16 degrees Celcius at a depth of 10 cm to 15 degrees Celsius at a depth of 80 cm. The soil temperature regime is isothermic.

II General information on the soil:

a. Parent material: volcanic rock (lava).
b. Drainage: class 2 - imperfectly drained.
c. Moisture conditions in the profile: profile wet throughout (after four days of heavy rain).
d. Depth of groundwater table: water stands at a depth of some 50 cm in the soil pit.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: not detected.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep imperfectly drained very dark grayish brown (eluvial horizon(?)) to yellowish brown profile, overlaid by a 32 cm thick layer of fibric to sapric organic soil material. Structural development is moderate crumb to weak crumb. Micro and very fine pores throughout and root distribution is normal except for the fact that one finds abundant roots in the organic soil material.

IV Profile description:

	15 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration.
O1	20-2	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are present. Dark

		brown (7.5YR) wet, very dark grayish brown (10YR 3/2) dry; abundant very fine to coarse roots; pH H2O 4.0); abrupt wavy boundary to:
O2	2-0	Very dark grayish brown (10YR 3/2) wet, very dark brown (10YR 2/2) dry; sandy loam; moderate fine crumb; slightly sticky, slightly plastic; many very fine and common fine vesicular pores; common fine to coarse roots; pH H2O 3.9; clear wavy boundary to:
Ah	0-22	Dark brown (10YR 4/3) wet, dark yellowish brown (10YR 4/4) dry; sandy clay loam, slightly gravelly; moderate fine crumb; many very fine, common fine vesicular pores; very few gravel (0.2-4 cm), rounded, weathered and very weathered; common fine to coarse roots; pH H2O 4.5; gradual wavy boundary to:
Bw	22-60	Yellowish brown (10YR 5/6) wet, yellowish brown (10YR 5/6) dry; few fine, faint, clear, strong brown (7.5YR) mottles; sandy clay loam, slightly gravelly; moderate fine crumb; slightly sticky, slightly plastic; many very fine and common fine vesicular pores; very few gravel (0.2-4 cm), rounded, weathered and very weathered; few fine to medium roots; pH H2O 5.1.

I Information on the site:

a. Profile number: 34.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Typic Hapludand.
   FAO: Humi-Umbric Andosol.
d. Date of examination: 13 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Camino de los Indios', within the 'Parque Nacional Chirripó'.
East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 1700 m.
h. Land form:
   i. physiographic position of the site: on crest (slope 47%).
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: moderately steep (22%).
j. Land-use: submontane lauraceous forest with dwarf palms.
k. Climate: see section 2.2 of this report.
   The soil temperature was almost univorm (18 degrees Celcius) throughout the entire soil depth. The soil temperature regime is isothermic.

II General information on the soil:

a. Parent material: colluvial material derived from volcanic rock (lava).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: not detected.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately well drained very dark grayish brown to brownish yellow profile with a layer of 8 cm fibric and sapric organic soil material. Structural development is moderate crumb and also subangular blocky in the Ah horizon. Sandy loam over a sandy clay loam containing some strongly weathered gravel causing mottling. Common micro and very fine pores. Root distribution is normal but one finds abundant roots in the lower part of the organic soil material.

IV Profile description:

	5 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt wavy boundary to:
01	3-0	Dominantly composed of fine organic material, free of litter fragments, but mineral grains are

		present. Dark brown (7.5YR) moist; slightly sticky, slightly plastic; abundant very fine to coarse roots; pH H20 4.8; gradual wavy boundary to:
Ah1	0-20	Very dark grayish brown (10YR 3/2) moist and dry (10YR 4/2); sandy loam; moderate fine crumb and very fine subangular blocky; slightly sticky, slightly plastic, friable moist; many micro to very fine and commom fine vesicular pores; very few gravel (0.2-3 cm), rounded, strongly weathered with few, medium, distinct, sharp, strong brown (7.5YR) mottles; common very fine to coarse roots; pH H20 4.5; gradual wavy boundary to:
Ah2/Bw1	20-27	Dark yellowish brown (10YR 4/4) moist, yellowish brown (10YR 5/4); sandy loam, slightly gravelly; moderate very fine and very fine crumb; slightly sticky, slightly plastic, friable moist; common micro to very fine vesicular pores; few gravel, angular and rounded, weathered and strongly weathered with few medium, faint, sharp, strong brown (7.5YR) mottles; few very fine to fine and common medium to coarse roots; pH H20 4.9; clear wavy boundary to:
Bw	27-77	Brownish yellow (10YR 6/6) moist, pale yellow (2.5Y 7/4) dry; sandy clay loam, slightly gravelly; moderate fine crumb; sticky, plastic, friable moist; common micro to very fine vesicular pores; very few gravel, angular and rounded, weathered and strongly weathered with common medium to coarse, faint diffuse brownish yellow (10YR) mottles; few very fine to coarse roots, pH H20 5.0.

I Information on the site:

a. Profile number: 35.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Typic Humitropept.
   FAO: Humi-Mollic Regosol.
d. Date of examination: 13 march 1989.
e. Author: J.G. van Uffelen.
f. Location: just on left side of the 'Camino de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 1500 m.
h. Land form:
   i. physiographic position of the site: on small crest (slope of 66%).
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: steep (33%).
j. Land-use: submontane lauraceous forest.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 18.7 degrees Celcius at a depth of 10 cm to 18.9 degrees Celsius at a depth of 50 cm. The soil temperature regime is isothermic

II General information on the soil:

a. Parent material: volcanic rock (lava).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: none.
e2. Presence of rock outcrops: none.
f. Evidence of erosion: not detected.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep well drained dark yellowish brown to brownish yellow profile with a 12 cm thick layer of fibric to sapric organic soil material. Loamy sand containing some very weathered gravel causing mottles. Frequent gravel and stones in the lower part of the horizon. Moderate crumb structure. Slightly sticky and slightly plastic throughout. Micro to medium pores in the mineral part of the horizon. Root development is normal.

IV Profile description:

	5 cm	The litter is non fragmented, but slightly altered,- evidenced by its partial or complete discolorisation. Abrupt wavy boundary to:
01	7-0	Dominantly composed of fine organic material, almost free of litter fragments, but mineral grains are

present. Dark brown (7.5YR) moist; many micro to medium vesicular pores; abundunt very fine to coarse roots; pH H2O 4.9; abrupt wavy boundary to:

Ah	0-23	Dark yellowish brown (10YR 3/4) moist, very pale brown (10YR 7/4) dry; loamy sand, slightly gravelly; moderately very fine crumb; slightly sticky, slightly plastic, very friable moist; many micro to very fine and few medium vesicular pores; very few gravel (0.2-2 cm), rounded, strongly weathered; many very fine to coarse roots; pH H2O 4.8; clear irregular boundary to:
Bw1	23-43	Yellowish brown (10YR 5/6) moist, very pale brown (10YR 8/4) dry; loamy sand, slightly gravelly; moderate very fine crumb; slightly sticky, slightly plastic, friable moist; many micro to very fine and common fine to medium vesicular pores; few gravel, rounded, strongly weathered with few medium to coarse, distinct, sharp very pale brown (10YR) mottles; common fine to coarse roots; pH H2O 4.9; clear irregular boundary to:
Bw2	43-63	Brownish yellow (10YR 5/8) moist, yellow (10YR 7/6) dry; loamy sand, gravelly and slightly stony; moderate very fine crumb and very fine subangular blocky; slightly sticky, slightly plastic, friable moist; many micro to fine and common medium vesicular pores; frequent gravel and stones, angular and rounded, weathered and strongly weathered with few medium to coarse, distinct, sharp very pale brown (10YR) mottles; few medium to coarse roots; pH H2O 5.2.

I Information on the site:

a. Profile number: 36.
b. Soil Name: -
c. Higher Category Classification;
   USDA: (Histic) Typic Humitropept.
   FAO: Humi-Mollic Regosol.
d. Date of examination: 14 March 1989.
e. Author: J.G. van Uffelen.
f. Location: just on right side of the 'Camino de los Indios', within the 'Parque Nacional Chirripó'.
   East of the town of San Isidro, within the province of Cartago, Costa Rica, Central America.
g. Elevation: 1300 m.
h. Land form:
   i. physiographic position of the site: straight slope (88%).
   ii. topography of surrounding country: steeply dissected.
   iii. microtopography: none.
i. Slope on which profile is sited: very steep (88%).
j. Land-use: submontane lauraceous forest.
k. Climate: see section 2.2 of this report.
   The soil temperature ranged from 20.3 degrees Celcius at a depth of 10 cm to 17.4 degrees Celsius at a depth of 30 cm. The soil temperature regime is isothermic.

II General information on the soil:

a. Parent material: colluvial material derived from volcanic rock which overlies sedimentary rock (very fine siltstone with calcareous cement).
b. Drainage: class 4 - well drained.
c. Moisture conditions in the profile: profile moist throughout.
d. Depth of groundwater table: not detected.
e1. Presence of surface stones: exceedingly stony (gravel, rocks and boulders).
e2. Presence of rock outcrops: none.
f. Evidence of erosion: risk of land slides.
g. Presence of salt or alkali: none.
h. Human influence: none.

III Brief description of the Profile:

Moderately deep well drained profile with a 22 cm thick layer of fibric and sapric organic soil material. Loamy sand to sandy loam containing gravel, stones and boulders. Structural development is weak. Micro to fine pores and normal root distribution. Abundant roots in the organic soil material and common roots in the mineral soil material.

IV Profile description:

	5 cm	The litter is non fragmented, but slightly altered, evidenced by its partial or complete discoloration. Abrupt irregular boundary to:
O2	17-0	Dominantly composed of fine organic material, almost free of litter fragments, but mineral grains are

present. Dark brown (7.5YR) moist, dark grayish brown (10YR 4/2) dry; abundant very fine to medium roots; pH H2O 5.2; clear irregular boundary to:

Ah/Bw 0-63 Dark brown (10YR 3/3) moist; spots of loamy sand and sandy loam, gravelly, stony and boulderly; weak very fine crumb to structureless; slightly sticky, slightly plastic, friable moist; few fine, many micro to very fine vesicular pores; few gravel, stones and boulders, angular and rounded, weathered and strongly weathered with common coarse distinct clear brownish yellow (10YR) mottles; common very fine to coarse roots; pH H2O 5.7.

Appendix 10 Chemical and physical analyses of the soil profiles

--- Chemical and physical analyses - profile 1 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
25-15	H1	75	13	12	42.9
15-7	H2	78	12	10	27.9
7-0	H3	69	19	12	19.8

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
5.2	4.1	8.5	57
5.3	4.0	8.5	78
5.5	4.1	9.5	86

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
59.4	1.2	0.8	0.8	0.17	5	1.5
63.2	0.6	0.5	0.6	0.15	3	3.7
55.0	0.5	0.3	0.3	0.12	2	5.9

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
1.50	1.5	0.5	0.3	12	3.8	1	1	+100
4.00	1.5	0.6	0.2	21	3.2	1	1	76
3.40	1.5	0.3	0.1	16	3.0	1	1	30

Depth (cm)	Dry bulk dens. (g/cm3)
25-15	0.29
15-7	0.29

--- Chemical and physical analyses - profile 2 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
0-13	O/Ah	73	15	12	28.9
13-50	Ah	73	21	6	2.1
50-75	Bw	59	27	14	1.6

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
5.2	4.3	10.0	90
6.1	4.7	10.2	92
6.0	4.3	9.7	68

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
55.5	0.5	0.3	0.4	0.11	2	3.8
19.3	0.8	0.2	0.2	0.09	6	0.5
14.3	0.7	0.2	0.3	0.12	9	0.8

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
2.00	1.5	0.4	0.2	13	3.8	2	1	+100
0.10	1.5	0.3	0.1	8	2.6	1	1	27
0.90	1.5	0.3	0.1	12	3.6	2	4	18

Depth (cm)	Dry bulk dens. (g/cm3)
0-13	0.45

--- Chemical and physical analyses - profile 3 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
1-0	Ol	-	-	-	-
0-7	Ah	55	35	10	16.6
7-28	Bw1	73	21	6	3.5
28-100	Bw2	69	23	8	1.6

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
6.2	4.5	9.8	89
6.5	5.4	10.2	100
6.4	5.0	9.7	52

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
44.5	4.7	0.4	0.3	0.12	12	1.0
20.4	0.8	0.2	0.2	0.12	7	0.1
16.5	0.6	0.2	0.2	0.11	7	0.2

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	-	-	-	-	-	-	-	-
0.30	2.5	0.4	0.1	9	3.0	1	1	+100
0.10	1.5	0.3	0.1	6	3.4	1	1	50
0.10	1.5	0.6	0.1	8	2.2	1	1	8

Depth (cm)	Dry bulk dens. (g/cm3)
0-7	0.54
7-28	0.77

--- Chemical and physical analyses - profile 4 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
0-9	Ah	57	27	15	17.9
9-20	Ah/(E)	71	21	8	11.0
20-21	Bs	-	-	-	-

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
5.9	4.2	10.0	89
6.3	4.5	11.5	98
-	-	-	-

CEC	Ca	Mg	K	Na	BS	Extract. Acid.	
--- cmol(+).kg-1 ----------							
-	-	-	-	-	-	-	-
29.1	1.2	0.3	0.3	0.10	7	7	4.0
28.1	0.6	0.2	0.3	0.10	4	4	1.3

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---------				--- ug/ml ----------				
-	-	-	-	-	-	-	-	-
2.30	1.5	0.8	0.2	20	1.0	1	1	+100
0.70	1.5	0.6	0.1	10	1.4	1	2	70

--- Chemical and physical analyses - profile 5 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
5-0	O1	-	-	-	-
0-3	Ah1	55	35	10	17.1
3-11	Ah2	47	37	16	7.8
11-35	Bw1	55	29	16	7.5
35-60	Bw2	45	41	14	5.9
60-70	C	-	-	-	-

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
6.4	5.2	9.4	65
6.4	4.5	9.7	82
6.3	4.5	10.0	94
6.2	4.4	10.2	93
-	-	-	-

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
---	cmol(+).kg-1					
-	-	-	-	-	-	-
48.4	26.2	4.2	0.9	0.16	65	0.2
31.9	10.0	2.0	0.3	0.15	39	0.6
28.1	3.1	0.6	0.2	0.10	15	1.1
34.6	2.1	0.4	0.2	0.09	8	1.5
-	-	-	-	-	-	-

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
---	cmol(+).dm3			---	ug/ml			
-	-	-	-	-	-	-	-	-
0.10	16.5	3.0	0.3	10	4.6	44	1	58
1.00	7.0	2.0	0.2	12	3.4	21	2	73
0.80	4.0	1.1	0.1	7	2.6	6	1	40
1.50	2.5	0.9	0.1	6	3.8	5	1	+100
-	-	-	-	-	-	-	-	-

Depth (cm)	Dry bulk dens. (g/cm3)
3-11	0.77
11-35	0.88
35-60	0.92

--- Chemical and physical analyses - profile 6 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
3-0	O	59	29	12	48.2
0-22	Ah	57	31	12	6.7
22-57	Bw1	59	29	12	8.0
57-67	Bw2	-	-	-	-

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
6.3	5.0	9.0	44
6.5	4.7	9.9	96
6.3	5.0	8.8	26
-	-	-	-

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
72.0	48.8	5.0	1.6	0.09	77	0.1
41.2	15.0	1.6	0.9	0.10	43	0.3
83.0	50.0	4.8	1.8	0.10	68	0.5
-	-	-	-	-	-	-

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
0.10	19.0	2.2	0.4	15	7.4	60	1	30
0.15	11.5	1.9	0.4	20	4.0	16	2	35
0.10	13.0	1.6	0.4	21	5.8	84	1	12
-	-	-	-	-	-	-	-	-

--- Chemical and physical analyses - profile 7 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
3-0	O	-	-	-	-
0-15	Ah1	59	33	8	11.5
15-40	Ah2	61	31	8	4.3
40-60	Bw	-	-	-	-

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
6.3	4.8	10.9	99
6.4	5.1	10.2	100
-	-	-	-

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
42.9	3.4	0.5	0.4	0.08	10	0.5
28.1	1.5	0.4	0.3	0.08	8	0.2
-	-	-	-	-	-	-

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	-	-	-	-	-	-	-	-
0.15	3.0	1.0	0.2	21	3.4	10	2	85
0.10	2.0	1.0	0.3	12	3.4	14	1	55
-	-	-	-	-	-	-	-	-

--- Chemical and physical analyses - profile 8 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
3-0	O1	-	-	-	-
0-10	Ah1/O2	61	29	10	24.9
10-45	Ah2	67	23	10	8.0
45-60	Bw	65	23	12	1.6

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
6.5	5.3	9.2	36
6.3	4.4	9.7	84
6.2	3.9	9.4	54

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
57.8	42.5	3.5	1.7	0.09	83	0.2
27.5	15.6	1.2	0.7	0.11	64	1.8
30.2	20.0	2.9	0.3	0.14	77	4.8

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	-	-	-	-	-	-	-	-
0.10	14.0	1.7	0.5	20	4.2	260	1	20
1.00	9.0	1.6	0.3	24	1.4	73	2	80
5.00	14.5	3.5	0.2	17	1.0	43	2	63

--- Chemical and physical analyses - profile 9 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
7-0	O2	-	-	-	61.1
0-2	E(Ah)	49	31	20	18.0
2-8/14	Bw	47	31	22	17.2
8/14-38	2Bw1	73	17	10	11.8
38-43	2Bw2	-	-	-	-

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	4.2	7.9	-
4.2	3.7	7.8	38
4.4	4.0	8.2	79
4.8	4.6	10.8	98
-	-	-	-

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
57.75	3.25	1.88	-	-	-	-
49.50	1.25	0.94	0.96	0.12	7	3.9
52.25	1.13	0.73	0.64	0.14	5	10.3
48.25	0.63	0.29	0.32	0.08	3	2.1
-	-	-	-	-	-	-

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---				--- ug/ml ---				
-	3.5	1.3	0.89	29	5.4	44	1	+100
6.00	1.0	0.9	0.41	22	2.4	16	1	+100
11.00	1.5	1.1	0.29	24	3.0	13	2	+100
2.60	1.5	0.8	0.16	5	2.0	3	2	+100
-	-	-	-	-	-	-	-	-

Depth (cm)	Min. (%)	Org. (%)
7-0	12.9	87.1
0-2	64.6	35.4
2-8/14	71.4	28.6

--- Chemical and physical analyses - profile 10 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
7-0	O2	-	-	-	40.7
0-1/28	Ah	55	35	10	7.0
1/28-53	Bw	49	37	14	5.4

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	4.8	8.3	-
5.0	4.8	10.7	98
5.1	4.5	9.6	90

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
35.20	1.38	0.66	0.19	0.10	7	0.4
35.70	1.38	0.70	0.22	0.09	7	0.6

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---				--- ug/ml ---				
-	7.5	2.6	0.62	39	5.4	400	2	+100
0.40	3.0	0.9	0.12	10	1.4	12	4	67
0.70	3.0	1.0	0.12	6	1.6	17	4	63

Depth (cm)	Min. (%)	Org. (%)
7-0	15.9	84.1

--- Chemical and physical analyses - profile 11 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
10-5	O2	-	-	-	-
5-0	O3	-	-	-	44.0
0-2/7	Ah/(E)	53	29	18	12.1
2/7-20	Ah/B	55	27	18	13.4
20-28/38	Bw1	55	23	12	7.2
28/38-50/57	Bw2	65	27	8	7.8
50/57-110	C	65	27	8	1.9

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
-	-	-	-
4.3	5.2	9.2	70
4.0	4.4	8.4	41
4.8	4.0	11.0	90
4.9	4.6	11.3	97
5.2	4.7	10.5	61

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
55.55	3.31	1.63	0.87	-	-	-
31.90	0.69	0.23	0.19	0.10	4	2.0
36.30	0.63	0.39	0.32	0.09	4	3.4
20.35	0.56	0.23	0.16	0.12	5	1.0
33.55	0.69	0.24	0.16	0.12	4	0.7
13.75	1.30	0.41	0.29	0.11	15	0.4

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	-	-	-	-	-	-	-	-
-	5.0	3.1	0.49	26	13.0	20	3	+100
4.40	1.5	0.7	0.19	22	3.0	1	3	+100
5.00	1.5	0.7	0.21	25	3.4	1	3	+100
2.50	1.5	0.6	0.15	10	1.6	1	1	+100
1.50	1.5	0.6	0.15	5	1.8	3	2	47
0.80	1.5	0.5	0.24	3	1.8	1	1	52

Depth (cm)	Min. (%)	Org. (%)
10-5	20.4	79.6
5-0	13.5	86.5

--- Chemical and physical analyses - profile 12 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
22-12	O2	-	-	-	65.4
12-0	O3	-	-	-	-
0-2	Ah/(E)	79	7	14	15.4
2-6/14	Ah/B	75	18	12	19.3
6/14-43	Bw1	83	9	8	14.5
43-48	Bw2	73	17	10	4.0

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
-	-	-	-
4.1	3.9	8.1	27
4.2	4.3	9.2	91
5.1	4.8	11.2	98
5.4	5.2	11.1	98

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
82.50	2.63	1.00	-	-	-	-
115.50	1.44	1.13	-	-	-	-
32.45	0.75	0.31	0.32	0.22	5	2.5
66.00	0.63	0.34	0.42	0.14	2	2.0
60.50	0.63	0.29	0.19	0.16	2	0.4
22.00	0.63	0.19	0.13	0.13	5	0.2

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	3.0	1.1	0.58	43	7.4	14	4	85
-	3.0	0.8	0.44	46	7.0	4	1	+100
2.50	2.5	0.5	0.23	36	4.2	1	1	+100
4.40	2.0	0.6	0.19	10	3.6	1	1	+100
0.50	2.5	0.6	0.15	3	2.6	1	1	+100
0.10	2.5	0.6	0.15	3	2.0	1	2	+100

Depth (cm)	Min. (%)	Org. (%)
22-12	2.7	97.3
12-0	4.9	95.1
0-2	69.7	30.3
2-6/14	60.5	39.5

--- Chemical and physical analyses - profile 13 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
9-5	O1	-	-	-	-
5-1	O2	-	-	-	56.9
1-0	O/E	-	-	-	59.0
0-6	Ah/B	45	37	18	14.7
6-34	Bw1	63	19	18	8.6
34-54	Bw2	63	19	18	1.3

pH(H2O)	pH(KCl)	pH(NaF)	Phos. ret. (%)
5.2	4.8	8.2	-
-	-	-	-
-	-	-	-
4.3	4.4	8.6	73
4.8	4.8	10.7	94
4.9	4.7	10.2	87

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
41.25	0.50	0.33	0.29	0.15	3	3.0
41.80	0.38	0.28	0.16	0.12	2	1.5
16.50	0.81	0.25	0.19	0.10	8	4.2

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---				--- ug/ml ---				
0.50	7.5	2.3	0.66	20	10.0	98	1	+100
-	4.0	2.6	1.31	25	10.6	30	1	+100
-	-	-	-	-	-	-	-	-
4.00	2.0	0.8	0.21	25	5.6	1	1	+100
2.00	1.5	0.4	0.12	8	3.2	1	2	+100
3.80	1.5	1.2	0.10	10	4.0	2	3	+100

Depth (cm)	Min. (%)	Org. (%)
9-5	33.0	67.0
5-1	13.3	86.7
0-6	72.1	27.9

--- Chemical and physical analyses - profile 14 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
8-4	O1	-	-	-	-
4-0	O2	-	-	-	-
0-4	Ah1	61	23	16	20.4
4-17/35	Ah2	83	19	8	16.3
17/35-48	Bw1	51	31	18	4.6

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
-	4.3	-	-
4.2	4.1	8.4	59
4.7	4.7	11.0	95
5.0	5.0	10.8	97

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
-	-	-	-	-	-	-
34.10	0.94	0.75	0.51	0.17	7	2.3
51.70	0.50	0.28	0.32	0.12	2	1.6
19.25	0.44	0.21	0.22	0.10	5	0.5

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	-	-	-	-	-	-	-	-
-	6.5	2.8	0.62	39	6.6	51	1	40
4.00	3.0	1.5	0.31	33	3.0	2	1	+100
2.00	2.0	1.2	0.18	3	1.4	1	2	+100
0.50	2.0	1.0	0.13	3	2.0	1	2	+100

Depth (cm)	Min. (%)	Org. (%)
4-0	7.0	93.0
0-4	60.0	40.0

--- Chemical and physical analyses - profile 15 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
4-0	O1	-	-	-	-
0-5	O/Ah1	55	29	16	20.6
5-11	Ah2	55	29	16	12.3
11-36	Bw1	33	31	36	7.2
36-46	Bw2	57	21	22	1.1

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
4.0	4.4	8.1	69
4.3	4.5	8.6	82
4.8	4.7	8.7	62
4.5	4.8	9.8	88

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
---	cmol(+).kg-1					
-	-	-	-	-	-	-
49.50	1.06	0.80	0.74	0.15	6	2.6
17.50	0.94	0.50	0.45	0.16	12	3.0
39.60	0.69	0.25	0.29	0.12	3	1.3
27.50	0.63	0.29	0.42	0.11	5	1.3

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
---	cmol(+).dm3			---	ug/ml			
-	-	-	-	-	-	-	-	-
4.50	2.0	1.3	0.34	16	4.2	7	2	+100
5.00	2.0	1.3	0.24	12	4.0	2	2	+100
3.00	2.0	0.9	0.19	7	2.2	1	6	+100
2.50	2.0	1.0	0.26	6	2.0	2	2	+100

Depth (cm)	Min. (%)	Org. (%)
4-0	48.1	51.9

--- Chemical and physical analyses - profile 16 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
2-0	O1	-	-	-	-
0-28	Ah	41	33	26	7.0
28-38	Bw1	29	27	44	2.4

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
4.8	5.1	9.4	83
5.1	5.5	8.8	79

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
40.70	1.40	0.50	0.39	0.10	6	0.8
15.70	1.20	0.21	0.20	0.09	11	1.0

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	-	-	-	-	-	-	-	-
2.00	3.0	1.0	0.31	9	2.0	13	3	+100
1.00	2.0	1.0	0.19	6	1.6	2	3	+100

--- Chemical and physical analyses - profile 17 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
12-8	O1	-	-	-	-
8-0	O2	-	-	-	-
0-2	Ah1/(E)	45	47	8	18.8
2-20	Ah2	57	31	12	11.8
20-33	Bw	49	41	10	3.0

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
-	-	-	-
4.2	3.9	8.0	40
4.8	4.5	10.9	97
5.1	4.7	10.6	93

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
-	-	-	-	-	-	-
40.15	0.81	0.58	0.61	0.12	5	3.8
25.85	0.69	0.26	0.29	0.24	6	1.2
48.40	0.63	0.45	0.22	0.19	3	0.6

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---				--- ug/ml ---				
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
4.00	1.0	0.7	0.27	22	3.2	2	1	+100
5.00	1.5	1.0	0.15	6	1.6	1	1	+100
2.00	1.5	0.6	0.13	5	3.4	1	1	41

Depth (cm)	Min. (%)	Org. (%)
12-8	3.9	96.1
8-0	4.0	96.0

--- Chemical and physical analyses - profile 18 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
18-10	O1	-	-	-	-
10-08	O2	-	-	-	-
0-3	O/Ah1	59	29	12	22.5
3-8	Ah2	35	51	14	11.5
8-62	Bw	39	45	16	3.0

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
-	-	-	-
4.2	3.8	7.8	40
4.6	4.3	9.4	85
5.0	4.6	10.5	83

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
-	-	-	-	-	-	-
20.90	0.81	0.45	0.67	0.14	10	2.6
18.70	1.25	0.51	0.26	0.12	11	2.3
61.60	0.63	0.23	0.26	0.19	2	0.6

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---				--- ug/ml ---				
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
6.00	1.0	0.7	0.25	25	4.8	2	1	+100
5.00	1.5	0.7	0.16	17	2.8	1	1	+100
2.00	1.5	0.9	0.12	6	2.0	2	1	37

Depth (cm)	Min. (%)	Org. (%)
18-10	4.1	95.9
10-0	-	-
0-3	61.2	38.8

--- Chemical and physical analyses - profile 19 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
15-9	O1	-	-	-	-
9-0	O2	-	-	-	-
0-2	O/Ah1	57	25	18	-
2-8	Ah2	51	31	18	18.0
8-43	Ah3/Bw	71	21	8	10.2

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
-	-	-	-
4.4	3.8	-	-
4.5	4.2	9.8	94
5.0	4.7	10.9	99

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
-	-	-	-	-	-	-
62.70	0.50	0.45	0.77	-	-	-
51.70	0.56	0.35	0.39	0.11	3	2.6
33.55	0.56	0.23	0.19	0.10	3	0.5

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---				--- ug/ml ---				
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
4.00	1.5	1.0	0.29	29	4.0	3	1	+100
4.80	1.0	0.9	0.24	11	3.4	2	1	+100
0.70	1.0	0.7	0.09	10	0.6	1	1	73

Depth (cm)	Min. (%)	Org. (%)
15-9	3.5	96.5
9-0	-	-
0-2	52.5	47.5
2-8	67.6	32.4

--- Chemical and physical analyses - profile 20 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
18-15	O1	-	-	-	-
15-10	O2	-	-	-	-
10-0	O3	-	-	-	-
0-6	Ah1/(E)	43	39	18	15.8
6-12	Ah2	49	37	14	15.3
12-32	Ah3	73	17	10	11.0

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
-	-	-	-
-	3.9	7.9	-
4.1	3.5	7.7	32
4.5	4.1	9.3	92
5.0	4.5	10.7	98

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
-	-	-	-	-	-	-
64.35	3.13	1.88	-	-	-	-
41.80	0.63	0.35	0.32	0.15	3	1.9
50.05	0.88	0.34	0.29	0.21	3	2.4
41.25	0.81	0.31	0.22	0.12	4	1.1

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	2.0	1.4	0.70	22	5.4	46	1	+100
3.50	1.0	0.8	0.16	25	3.0	1	4	+100
5.50	1.0	0.7	0.13	11	2.0	2	2	+100
1.80	1.5	0.6	0.07	7	1.2	1	2	+100

Depth (cm)	Min. (%)	Org. (%)	Dry bulk dens. (g/cm3)
18-15	5.0	95.0	
15-10	-	-	
10-0	13.1	86.9	0.37
0-6	75.8	24.2	
6-12	70.0	30.0	

--- Chemical and physical analyses - profile 21 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
5-0	O	-	-	-	-
0-18	Ah	64	18	18	16.3
18-45	Ah/Bw1	42	48	10	4.8
45-60	Bw2	44	40	16	1.4
60-75	Bw3	66	22	12	1.1

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
5.0	4.2	9.2	89
4.7	4.5	10.3	95
4.9	4.4	9.6	76
4.9	4.4	9.8	82

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
45.65	1.94	0.68	0.61	0.10	7	1.7
28.85	1.13	0.40	0.26	0.08	6	2.0
11.00	1.00	0.44	0.19	0.12	16	2.0
20.35	1.06	0.41	0.22	0.11	9	1.0

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	-	-	-	-	-	-	-	-
4.50	1.0	1.0	0.32	16	4.6	5	1	+100
1.50	1.0	0.8	0.09	7	1.2	2	1	+100
3.60	1.0	0.8	0.09	15	2.0	2	1	+100
6.30	1.0	0.8	0.13	15	1.6	3	1	35

Depth (cm)	Min. (%)	Org. (%)
5-0	47.1	52.9

--- Chemical and physical analyses - profile 22 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
10-0	O	-	-	-	42.9
0-5	Ah	56	34	10	15.5
5-40	Ah/Bw1	36	54	10	8.6
40-55	Bw2	36	36	28	3.2

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
4.8	4.2	7.9	-
4.8	4.3	9.4	91
5.0	4.7	10.3	98
4.9	4.4	9.4	91

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
---	cmol(+).kg-1					
-	-	-	-	-	-	-
40.70	1.00	0.43	0.55	0.12	5	1.9
32.45	1.25	0.45	0.30	0.11	6	1.3
17.05	1.13	0.45	0.29	0.34	13	1.6

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
---	cmol(+).dm3			---	ug/ml			
0.70	2.5	1.4	0.95	33	2.4	13	1	+100
3.00	1.0	0.8	0.29	11	1.2	9	1	+100
0.60	0.0	0.6	0.15	3	1.0	2	1	+100
0.80	0.0	0.6	0.15	6	0.6	2	1	+100

Depth (cm)	Min. (%)	Org. (%)
10-0	24.1	75.9

--- Chemical and physical analyses - profile 23 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
15-0	O	-	-	-	-
0-8	Ah1/(E)	52	30	18	15.8
8-28	Ah2/(E2)	58	30	18	15.8
28-34	Ah3	52	34	14	11.5
34-35	Bs	-	-	-	-
35-50	C	52	38	10	2.1

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
4.1	3.7	7.8	41
4.7	4.2	10.5	96
4.8	4.4	10.7	96
-	-	-	-
5.2	4.6	10.6	90

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
37.95	1.06	0.46	0.48	0.34	6	3.5
51.15	1.00	0.41	0.26	0.10	3	3.0
31.90	1.00	0.41	0.22	0.12	5	1.8
-	-	-	-	-	-	-
22.00	0.75	0.36	0.16	0.13	6	1.2

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3---------				--- ug/ml ----------				
-	0.0	0.8	0.23	35	1.6	8	1	+100
6.70	0.0	0.8	0.23	35	1.6	8	1	+100
4.60	0.0	0.7	0.10	12	1.0	2	1	+100
3.40	0.0	0.7	0.10	8	0.6	1	1	+100
-	-	-	-	-	-	-	-	-
0.80	0.0	0.6	0.06	7	0.8	1	1	+100

Depth (cm)	Min. (%)	Org. (%)
0-8	74.4	25.6

--- Chemical and physical analyses - profile 24 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
38-0	O	-	-	-	60.0
0-3	Ah1	59	23	18	19.8
3-14	Ah2	53	25	22	9.4

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	4.6	8.0	-
4.5	3.8	9.6	83
4.7	4.0	8.7	83

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
94.60	0.88	0.80	1.22	-	-	-
57.75	0.88	0.29	0.26	-	-	2.5
37.40	0.75	0.23	0.16	-	-	-

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	0.0	1.0	0.35	26	9.4	6	1	+100
5.50	0.0	0.8	0.16	39	2.0	1	1	82
1.70	0.0	0.6	0.15	25	0.6	1	1	67

Depth (cm)	Min. (%)	Org. (%)	Dry bulk dens. (g/cm3)
38-0	14.7	85.3	
0-3	67.1	32.9	0.99

--- Chemical and physical analyses - profile 25 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
0-22	O/Ah	-	-	-	19.4
22-34	Ah/(E)	55	25	20	9.9
34-35	Bs	-	-	-	-
35-45	BC	-	-	-	1.3

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
4.6	4.2	9.5	80
5.1	4.4	10.8	89
-	-	-	-
5.5	4.6	9.2	43

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
52.25	0.81	0.29	0.32	-	-	4.0
25.85	0.50	0.10	0.13	-	-	0.5
-	-	-	-	-	-	-
11.00	0.56	0.11	0.10	-	-	0.2

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---				--- ug/ml ---				
4.00	0.0	0.7	0.19	11	0.6	1	1	+100
2.00	0.5	0.7	0.19	10	1.0	1	1	+100
-	-	-	-	-	-	-	-	-
0.50	1.0	0.7	0.16	11	1.2	2	1	40

Depth (cm)	Min. (%)	Org. (%)	Dry bulk dens. (g/cm3)
0-22	56.7	43.3	1.09
22-34	80.3	19.7	

--- Chemical and physical analyses - profile 26 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
55-40	O1	-	-	-	-
40-25	O2	-	-	-	58.96
25-0	O3	-	-	-	48.24
0-10/20	Ah	58	24	18	12.05
10/20-30	Bw	-	-	-	-

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	4.3	8.0	-
-	4.1	7.8	-
4.5	3.8	7.8	74
4.6	4.0	8.4	65
-	-	-	-

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
56.65	1.38	1.08	-	-	-	-
82.50	0.69	0.24	0.39	-	-	4.5
35.70	1.00	0.29	0.13	0.11	4	4.8
-	-	-	-	-	-	-

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	2.0	1.6	0.89	45	5.6	67	1	55
-	2.0	1.5	1.07	39	3.6	46	1	+100
6.50	2.0	1.3	0.21	20	2.0	3	1	+100
11.80	2.0	1.0	0.16	29	1.0	1	2	+100
-	-	-	-	-	-	-	-	-

Depth (cm)	Dry bulk dens. (g/cm3)
55-40	0.14
40-25	0.29
25-0	0.68

--- Chemical and physical analyses - profile 27 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
61-58	O1	-	-	-	-
58-45	O2	-	-	-	-
45-38	O3	-	-	-	56.8
38-20	O4	-	-	-	54.7
20-0	O5	58	22	20	48.2
0-12/26	Ah/Bw	25	55	20	12.1
12/26-32	Bw/C	43	39	18	7.0

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
-	4.4	-	-
-	3.6	7.5	-
4.2	3.5	7.4	35
4.5	3.6	7.5	44
4.6	4.0	8.3	63
4.7	4.0	9.3	91

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
92.40	-	0.75	0.83	0.27	-	5.5
84.70	-	0.49	0.45	0.22	-	4.0
34.65	1.31	0.29	0.10	0.10	5	3.0
31.90	0.75	0.39	0.13	0.12	4	6.5

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---				--- ug/ml ---				
-	-	-	-	-	-	-	-	-
-	9.0	2.7	1.03	83	4.8	88	1	23
-	4.5	2.5	0.52	72	6.2	28	2	67
5.50	2.5	1.5	0.37	39	2.8	3	1	+100
4.50	2.0	1.1	0.21	26	2.0	1	1	+100
6.00	2.0	0.8	0.12	32	1.4	1	4	+100
14.00	0.0	0.8	0.12	36	2.6	2	6	+100

Depth (cm)	Min. (%)	Org. (%)	Dry bulk dens. (g/cm3)
58-45	8.4	91.6	
45-38	5.1	94.9	
38-20	15.1	84.9	0.27
20-0	35.9	64.1	0.63
0-12/26	80.5	19.5	

--- Chemical and physical analyses - profile 28 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
43-38	O1	-	-	-	-
38-20	O2	-	-	-	-
20-0	O3	-	-	-	66.5
0-15	Ah1/(E1)	67	22	21	21.4
15-22	Ah2/(E2)	31	45	24	14.7
22-22.3	Bs	-	-	-	-
22.3-45	Bw1	71	15	14	7.0

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
4.4	3.3	7.5	-
3.9	2.8	7.2	13
4.0	3.7	8.5	88
4.3	3.5	7.5	35
-	-	-	-
5.1	4.3	10.4	99

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
94.60	1.31	-	0.90	-	-	-
29.25	1.03	0.88	0.58	0.23	9	3.0
59.45	2.00	0.69	0.27	0.22	5	9.0
33.55	0.94	0.41	0.16	0.12	5	3.5
-	-	-	-	-	-	-
47.85	0.81	0.30	0.10	0.12	3	2.5

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
-	-	-	-	-	-	-	-	-
1.80	0.2	1.2	0.44	41	4.6	5	1	40
4.00	0.0	1.4	0.26	32	20.2	2	1	77
12.00	1.5	1.3	0.13	8	2.8	1	4	+100
4.00	0.0	1.1	0.15	25	4.0	1	1	+100
-	-	-	-	-	-	-	-	-
2.20	0.0	0.8	0.10	8	2.4	1	9	+100

Depth (cm)	Min. (%)	Org. (%)	Dry bulk dens. (g/cm3)
38-20	2.4	97.1	
20-0	7.6	92.4	0.64
0-15	61.0	39.0	

--- Chemical and physical analyses - profile 29 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
27-17	01	-	-	-	-
17-0	02	-	-	-	63.24
0-2	Ah1/(E1)	59	13	28	18.22
2-14	Ah2	61	28	12	6.16
14-14.2	Bs	-	-	-	-
14.2-53	Bw	-	-	-	-

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
-	-	-	-
4.9	3.9	7.5	-
4.6	3.9	8.5	84
5.9	4.5	10.2	98
-	-	-	-
-	-	-	-

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	-
-	-	-	-	-	-	-
41.80	3.81	-	0.39	-	-	3.5
40.70	2.69	-	0.29	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3 ---				--- ug/ml ---				
-	-	-	-	-	-	-	-	-
0.50	4.0	1.8	0.50	30	3.4	34	1	+100
6.00	0.0	1.1	0.18	26	3.4	3	4	+100
1.50	0.0	1.0	0.10	7	2.4	1	4	+100
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Depth (cm)	Min. (%)	Org. (%)
17-0	10.9	89.1

--- Chemical and physical analyses - profile 30 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
21-2	O1	-	-	-	-
2-0	O2	-	-	-	46.1
0-3	Ah1/(E1)	45	25	30	15.0
3-10	Ah2	65	17	18	9.6
10-10.2	Bs	-	-	-	-
10.2-44	Bw	73	19	8	5.1

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
4.9	3.3	-	-
4.1	3.4	7.5	46
4.1	3.7	8.0	75
4.3	3.9	8.7	89
-	-	-	-
4.8	4.2	9.0	98

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
31.90	-	-	0.61	0.17	-	-
30.80	0.88	-	0.58	0.23	-	3.4
37.40	-	0.60	0.77	0.30	-	5.5
38.50	-	-	0.55	0.22	-	2.5
-	-	-	-	-	-	-
33.00	-	-	0.39	0.19	-	1.5

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3			---------	--- ug/ml			----------	
2.00	2.0	1.8	0.35	29	4.6	41	1	+100
3.00	0.0	1.1	0.29	21	3.6	2	1	+100
3.70	0.0	0.6	0.12	29	2.0	2	4	+100
4.70	0.0	0.7	0.09	10	2.0	4	7	+100
-	-	-	-	-	-	-	-	-
1.00	0.0	0.7	0.10	7	1.0	4	3	+100

Depth (cm)	Min. (%)	Org. (%)
21-2	6.3	93.7
2-0	34.2	65.8
0-3	74.6	25.4

--- Chemical and physical analyses - profile 31 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
25-41	O1	-	-	-	-
4-0	O2	-	-	-	51.5
0-15	Ah	79	7	14	19.6
15-58	Bw1	79	11	10	6.4

pH(H2O)	pH(KCl)	pH(NaF)	Phos. ret. (%)
-	-	-	-
-	3.9	7.7	-
4.3	4.0	7.8	91
4.7	4.2	9.3	97

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
---	cmol(+).kg-1					
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	0.88	0.74	0.48	0.18	-	3.0
-	1.00	0.61	0.26	0.12	-	2.2

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
---	cmol(+).dm3			---	ug/ml			
-	-	-	-	-	-	-	-	-
-	2.5	2.5	0.50	17	5.4	73	2	+100
3.00	0.0	1.3	0.19	7	2.0	5	1	+100
1.30	0.0	1.0	0.10	5	1.2	2	1	+100

Depth (cm)	Min. (%)	Org. (%)	Dry bulk dens. (g/cm3)
4-0	25.9	74.1	
0-15	65.4	34.6	0.36
15-58			0.45

--- Chemical and physical analyses - profile 32 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
12-2	O1	-	-	-	68.6
2-02	O2	-	-	-	-
0-1	Ah1	55	19	26	16.6
1-23	Ah2	79	10	11	10.2
23-55	Bw	75	23	12	4.6

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
4.5	3.2	7.3	10
4.1	3.3	7.7	-
4.3	3.5	8.4	79
4.6	4.0	9.7	97
5.0	4.4	10.8	98

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
---	cmol(+).kg-1					
-	2.50	3.13	0.51	0.23	-	3.3
30.25	5.63	2.75	0.51	0.30	30	-
25.85	1.06	0.38	0.26	0.14	7	-
30.25	1.06	0.48	0.26	0.12	6	0.9
-	0.94	0.43	0.13	0.09	-	0.5

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
---	cmol(+).dm3			---	ug/ml			
2.30	0.5	1.3	0.19	33	4.0	5	1	+100
5.00	1.0	1.3	0.16	19	3.0	3	2	+100
4.50	0.0	0.8	0.12	22	2.8	3	3	+100
2.50	0.0	0.6	0.13	10	1.6	1	4	+100
0.50	0.0	0.6	0.09	10	1.4	1	3	+100

Depth (cm)	Min. (%)	Org. (%)
22-12	5.5	94.5
2-0	46.3	53.7

--- Chemical and physical analyses - profile 33 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
20-2	01	-	-	-	60.0
2-0	02	33	50	27	34.3
0-22	Ah	79	8	13	16.1
22-60	Bw	87	6	7	9.1

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
4.0	3.3	7.6	-
3.9	3.5	8.3	74
4.5	4.1	10.3	98
5.1	4.4	10.7	99

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
---	cmol(+).kg-1					
-	1.75	1.88	1.25	0.29	-	-
30.25	1.50	1.00	0.48	0.22	11	3.2
29.70	1.06	0.66	0.29	0.14	7	1.4
33.00	0.94	0.33	0.16	0.10	5	0.2

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
---	cmol(+).dm3			---	ug/ml			
5.50	1.5	1.6	0.39	17	7.0	8	2	+100
7.60	1.5	1.3	0.15	19	4.2	3	2	+100
3.50	1.0	0.9	0.09	3	1.8	1	2	+100
1.00	0.0	0.6	0.09	3	1.6	2	1	75

Depth (cm)	Min. (%)	Org. (%)
20-2	14.9	85.1
2-0	48.1	51.9

--- Chemical and physical analyses - profile 34 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
3-0	O1	-	-	-	64.3
0-20	Ah1	67	22	11	11.0
20-27	Ah2/Bw1	79	12	9	7.0
27-77	Bw	37	42	21	1.1

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
4.8	3.7	7.7	-
4.5	4.0	9.7	94
4.9	4.3	10.6	98
5.0	4.3	9.9	89

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
---	cmol(+).kg-1					
-	4.75	4.13	1.60	0.26	-	-
24.75	1.13	0.40	0.26	0.16	8	2.8
24.20	0.94	0.34	0.19	0.11	7	1.5
-	1.13	0.30	0.16	0.13	-	1.5

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
---	cmol(+).dm3			---	ug/ml			
3.50	3.0	2.0	0.42	22	5.0	24	1	+100
4.50	1.0	1.0	0.10	7	2.0	2	3	+100
2.00	1.0	0.8	0.07	3	1.4	1	2	+100
3.00	1.0	0.8	0.09	3	1.4	2	1	+100

Depth (cm)	Min. (%)	Org. (%)	Dry bulk dens. (g/cm3)
3-0	11.2	88.8	
0-20			0.50

--- Chemical and physical analyses - profile 35 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
7-0	O1	-	-	-	54.7
0-23	Ah	43	50	7	7.0
23-43	Bw1	31	56	13	2.4
43-63	Bw2	31	56	13	0.5

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
4.9	3.9	7.8	-
4.8	4.1	9.8	93
4.9	4.1	9.5	81
5.2	4.0	9.2	60

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
---	cmol(+).kg-1					
-	4.00	6.25	1.64	0.13	-	2.3
-	1.13	0.88	0.19	0.34	-	3.3
-	1.63	1.20	0.29	0.14	-	0.3
-	-	-	-	-	-	-

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
---	cmol(+).dm3			---	ug/ml			
0.50	3.5	3.5	0.31	12	8.6	26	1	+100
4.00	1.0	2.1	0.09	7	3.0	2	3	+100
6.50	1.0	1.8	0.15	3	1.4	4	4	+100
8.00	1.0	1.9	0.12	5	1.6	6	1	65

Depth (cm)	Min. (%)	Org. (%)
7-0	18.9	81.1

--- Chemical and physical analyses - profile 36 ----------

Depth (cm)		Sand (%)	Silt (%)	Clay (%)	Org. Mat. (%)
17-0	Oi	67	26	7	49.3
0-63	Ah/Bw	73	16	11	7.8

pH H2O	pH KCl	pH NaF	Phos. ret. (%)
5.2	4.8	9.7	70
5.7	5.3	8.8	19

CEC	Ca	Mg	K	Na	BS	Extract. Acid.
--- cmol(+).kg-1						
-	-	-	-	-	-	0.1
-	1.31	1.23	0.16	0.12	-	0.1

Al	Ca	Mg	K	P	Zn	Mn	Cu	Fe
--- cmol(+).dm3				--- ug/ml				
0.10	15.0	3.2	0.18	12	1.0	9	3	55
0.10	36.5	7.0	0.29	11	2.4	13	1	10

Depth (cm)	Min. (%)	Org. (%)
17-0	28.6	71.4