ATLANTIC ZONE PROGRAMME

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EXPLORATORY SURVEY IN THE ATLANTIC ZONE OF COSTA RICA

Contribution of the land group

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I. Introduction

A good review of the different soils and vegetations is one of the main data, necessary in the framework of the project. During the exploratory survey, the land-group was in charge of that subject. The idea was to prepare a map on which soils and vegetations were indicated. For that reason the decision has been made, to prepare a physiographical map, consisting of landscape units (easy to distinguish on airphotos and in the field), in which all the aspects that determine the landscape would be described.

As a basic principle for the mapping, an adapted form of the "landscape-guided method", as developed by the ITC in Enschede (Holland), has been used. That includes a combination of airphoto-interpretation and stratified sampling. Advantages of the method:

- The method is efficient, because of the presence of strata.
- The coincidence of land units on the one side and soil units or vegetation units on the other side is generally recognized.
- The approach has advantages for projects where a quick knowledge of other than soil or vegetation units is also wanted. (Van Gils & Zonneveld, 1982).

On the 22nd of April 1986, the preliminary photo-interpretation of the Atlantic Zone on the basis of aerial photographs started. The photographs used for this purpose were false-color photographs on a scale of 1:80.000, flown in 1984. A preliminary legend was prepared, merely based on photo-characteristics. Hereby, the landscape forms the selection standard and determines the division of legend units. The main division was based on the land system (geology, morphology, altitude). The other divisions were based on relief, drainage density, drainage pattern and vegetation form.
Topographical maps of the IGN (Instituto Geográfico Nacional), scale 1: 50.000, were reduced to a scale of 1:100.000. With the help of the sketch master, the preliminary legend units were indicated on these maps and so they were ready for use in the field.

The field-work took place, during the sondeo, from the 29th of May 1986 until the 13th of June 1986. Every day a different area in the Atlantic Zone was visited, in order to sample the distinguished preliminary physiographical units. Almost 100 of those checks have been done, at which the most important

(read: conspicuous) data were noted down. Each check-point was also indicated on the field-map, so that the notitions and the field-map together fully recorded the units.

II. Description of the legend units

This chapter offers descriptions for each of the 18 distinguished physiographical units that occur in the Atlantic Zone of Costa Rica. Their distributions can be found on the enclosed map. For each unit, data are given on the field of:

- geology/geomorphology
- topography
- altitude (above sea level)
- soils
- vegetation
- land-use.

To be totally clear some supplementary remarks are made on the descriptions of soils and vegetation.

Soils:

<special issue from the hand of W.G. Wielemaker>

Vegetation:

In the sections on vegetation, several aspects are treated. First, some reflections are given on the ecological life zones, that put their stamp on the mentioned unit. For that purpose, use has been made of the ecological map, prepared by J.A. Tosi Jr. in 1969, according to the classification of the life zones of the world by L.R. Holdridge. Figure II-1 is a reduced version of that map. Further, a review is given on the actual state of the vegetation, by which the forest vegetation is stressed especially. The primary sources for that review are the own observations in the field, combined with the map of the forest cover of Costa Rica (1983). The latter is given in figure II-2. Ultimately, a comprehensive description of the structure, physiognomy and floristic composition of the vegetation concludes the sections on vegetation.

The physiographical map, on which all the landscape units are indicated is enclosed in this contribution as appendix B. The legend, belonging to that map, can be found in appendix A.

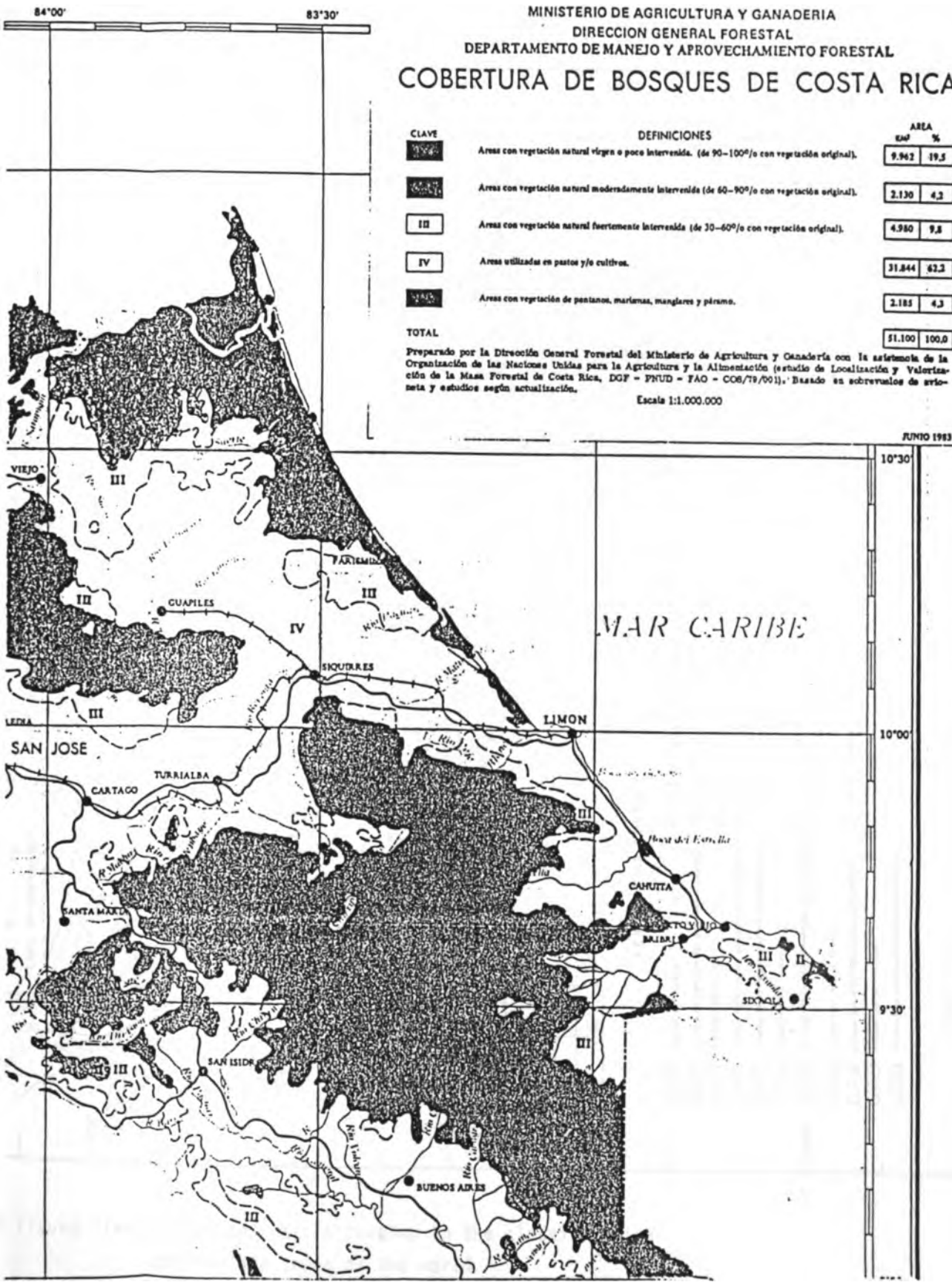

Figure II-2. Map of the forest cover of Costa Rica

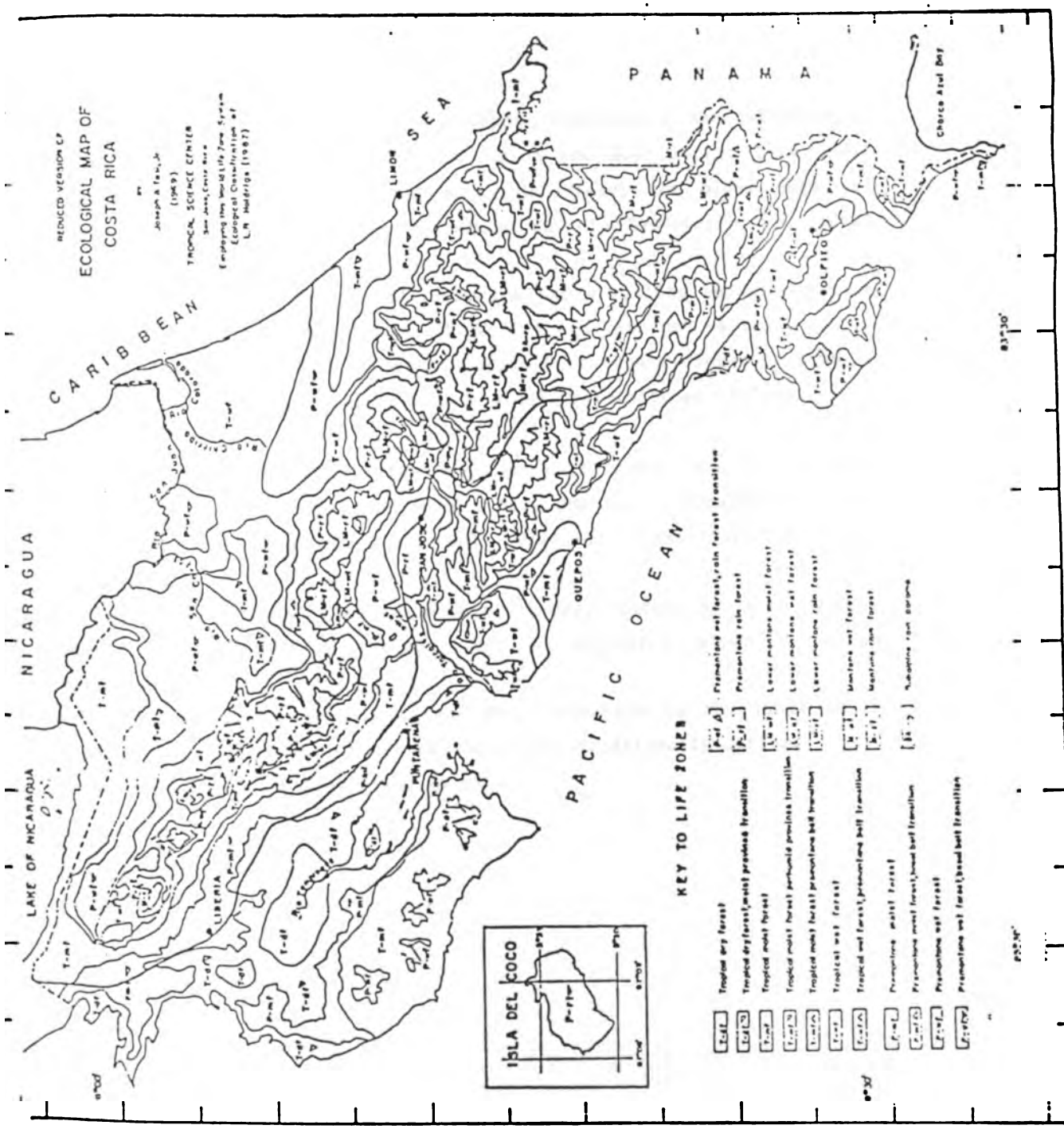

Figure II-1. Ecological map, according to the classification of the life zones of the world

C. Landsystem of the Cordillera Central.

CLi. Lahar landscape of the volcano Irazú.

Geology/geomorphology: Footslope of the volcano Irazú with a general slope of 10-20% composed of lahar streams of which the most recent (e.g. near Cervantes) consist of rocky and stony materials; the older ones are covered by volcanic ash deposits. Along the Rio Reventazón some level surfaces are recognizable.

Topography: The volcanic ash-covered landscape has a rolling topography with convex slopes of 20-50%, a length of 30-50 m and V-shaped valleys.
The lahar streams consist of broken ridges with convex slopes of 60-80%, a length of 10-30 m and small (10-30 m wide) flat-bottomed valleys.

Altitude: 800 - 1500 m.

Soils: 1. In volcanic ash: A horizon 30-50 cm dark brown loam to clay loam over yellowish brown clay loam with a fine angular to subangular blocky structure. Soils are deep and well drained. Classification: Andic Argiudolls.
2. Lahar soils are well drained, moderately deep, porous and stony with a 10-20 cm deep dark A horizon over a yellowish brown B-horizon (Vitrandept).

Land-use: Pasture, maize, beans, coffee. Near Cervantes on the lahar soils occur pasture with trees, potatoes, beans and occasionally coffee.

Vegetation: No information available, as yet.

CLt. Lahar landscape of the volcano Turrialba.

Geology/geomorphology: Footslope of the volcan Turrialba with a general slope of 10-20% composed of deeply weathered materials. The footslope is deeply incised by parallel running streams. Along the Reventazón west of Turrialba some level terraces occur. East of Turrialba terraces are dissected with an intricate drainage pattern.

Topograhy: Steep-sided ridges have slopes of over 100% and a length of 70-100 m. The lower ridges towards Turrialba have slopes of 40-70% and a length of 20-70 m.

Altitude: 600 - 1400 m.

Soils: 900 - 1400 m; well drained very deep soils with saprolite down to 10 m or more, that have a 60-100 cm deep very dark A-horizon over a yellowish brown to reddish brown B-horizon. Soils are porous and thixotropic (Dystrandepts).

600 - 900 m: as above, but the A-horizon is only dark brown and the B-horizon reddish brown. The texture is clayey; the structure porous and very fine subangular to angular blocky. Soils are not thixotropic (Paleudult or Dystropept).

Land-use: Above 900 m mainly sugar-cane; below 900 m coffee, pejibaye, fruit trees, bananas and sugar-cane.

Vegetation:

Occurs in the following life zones, according to the classification of L.R. Holdridge (1982):

- Premontane rain forest
- Premontane wet forest
- Tropical wet forest, premontane belt transition.

In this landscape-unit extensive virgin forest areas are still left on the northern and northwestern footslopes of the volcano. These forest types are very much alike the ones occurring at lower altitudes, with an average maximum canopy height of 30-35 meters and emergents up to 45 meters. Butresses, stilt roots and spreading surface roots are present. The ground cover is uniform and sparse, consisting mostly of seedlings, fallen logs and a big variation of palms. Epiphytes in tree crowns as well as on tree trunks low down and ferns are abundant. Vines are present in all size classes, from the thin, wiry ones up to the woody, robust vines with their crowns in the main canopy. Ocasionally a strangler or a

tree fern can be found. Some canopy species of these forest types:

- Carapa guianensis (Meliaceae)	cedro macho
- Virola koschinyi (Myristicaceae)	fruta dorado
- Vitex cooperii (Verbenaceae)	manú plátano
- Apeiba membranacea (Tiliaceae)	tapa botija
- Inga coruscans (Mimosaceae)	guabo colorado
- Pouteria sp. (Sapotaceae)	zapotillo
- Goethalsia meiantha (Tiliaceae)	guácimo blanco
- Hieronyma oblonga (Euphorbiaceae)	pilón
- Vochysia hondurensis (Vochysiaceae)	chancho
- Cecropia spp. (Moraceae)	guarumo

The structure and floristic composition of the vegetation are very much related to the altitude.

As distinct from the tropical forests at lower altitudes, Pentaclethra macroloba (gavilán), seldom occurs in the premontane forest types, because the natural dispersion of this species goes up to about 500 m above sea level.

On the southern footslopes of volcano almost all virgin forest is gone. Areas with heavily logged-out forests and secondary growth are still present, especially above 1000 meters.

CA. Intra montane valleys.

Geology/geomorphology:

Topography:

Altitude:

Soils:

Land-use:

Vegetation:

One life zone and a transition zone are found in this physiographical unit, i.e. - Premontane wet forest
- Tropical moist forest, premontane belt transition.

At present no undisturbed, virgin forest is left. Some hills with sleep slopes and the slopes bounding the valley in the south contain logged-out forests or secondary growth. In the first case components of the original forest might still be there, like e.g. left-over trees which used to be part of the main canopy. They form the emergents now, with an average height of 30 meters. The canopy height is at about 15-20 meters and its surface is fairly uneven or very broken. There is a uniform and sparse ground cover, but locally it can be clumped and dense, consisting mainly of ferns, seedlings and vines. Epiphytes are abundant, including hanging mosses in the tree crowns. Tree ferns are conspicious. Stranglers are present but rare. Because of the secondary character of the forest Cecropia spp. appear.

Some emergents and canopy species of this forest:

- Cecropia obtusefolia (Moraceae) guarumo
- Virola sp. (Myristicaceae) fruta dorada
- Simaruba amara (Simarubaceae) aceituno
- Cordia alliodora (Boraginaceae) laurel
- Ceiba pentandra (Bombacaceae) ceiba
- Miconia spp. (Melastomataceae)
- Brosimum sp. (Moraceae) ojochillo

CFo. Landscape of alluvial fans, relatively old.

Geology/geomorphology: Fans with a slope of about 15% in its upper part, decreasing to almost 0 in its lower part. Interfluves are convex in the upper part to nearly flat in the lower part. The interfluves are being dissected and eroded as a result of backwearing by streams at the foot of the ridges. The smaller streams at the foot of the ridges are in flat-bottomed and poorly drained valleys. The deposits originate from the volcano Turrialba.

Deposits in the upper part of the fan near Alegria are poorly sorted and very stony. Lahar deposits are noteworthy as well.

Topography: Rolling in the upper part with rather flat valleys of major streams; differences in altitude are from 8-20 m. In the lower part the difference in altitude between the dissected plain and the flat bottomed valleys is 4 to 8 m.

Altitude: 50 - 300 m.

Soils: Well drained, very deep soils with saprolite down to more than 5 m, have in the upper 30 cm brown to dark brown clay (A horizon) over a yellowish brown to yellowish red clayey B-horizon. The structure of the A is fine subangular blocky and of the B fine angular blocky. They may be classified as Paleudults. Soils in the upper part of the fan are stony. They may be classified as Tropudults or Tropudalfs.

Land-use: Pasture, fruit trees, maize, cassava and beans, ornamentals. In the part above the road Siquirres-Guapiles also coffee, pineapple, macadamia nut, coco an guanábana were observed.

Vegetation: The following ecological life zones occur in this physiographical unit:

- Tropical wet forest.
- Tropical wet forest, premontane belt transition.
- Premontane wet forest, basal belt transition.
- Tropical moist forest, perhumid province transition.

Only remnants of the original virgin vegetation are left over, be it small areas of selectively logged forest or be it heavily logged-out forest with a strong secondary character. In all cases the canopy is not higher than 20-25 meters with emergents up to 35 meters. Not more than one or two different tree layers (excluding emergents) build up the forest vegetation. The ground cover, consisting mostly of ferns, vines,

palms, gingers, seedlings and fallen logs, is often dense or very dense. Vines are abundant, especially the thin and slender ones. The emergents often with plank butresses or spreading surface roots and commonly filled with epiphytes on the trunks and in the crowns, still remind of the original forest. Occasionally, tree ferns are present.

Occurring canopy species and emergents:

- Pentaclethra macroloba (Mimosaceae) gavilán
- Virola koschnyi (Myristicaceae) fruta dorada
- Goethalsia meiantha (Tiliaceae) guácimo blanco
- Vochysia ferruginea (Vochysiaceae) bota rama
- Inga coruscans (Mimosaceae) inga colorado
- Inga spp. (Mimosaceae)
- Dipteryx panamensis (Papilionaceae) almendro
- Laetia procera (Flacourtiaceae) guácimo manga larga
- Pithecellobium sp. (Mimosaceae)
- Protium sp. (Burseraceae) alcanfor
- Dussia sp. (?) targuayugo

CFy Landscape of alluvial fans, relatively young.

Geology/geomorphology and topography: Fans with a slope of 20% in their upper part, which decreases gradually to nearly 1% in its lower part. The volcanic material is in the upper part poorly sorted and consists of stones and big boulders (up to 2 m Ø) in a groundmass of gravel and sand. The lower part of the fan is well sorted and without stones. The upper part is deeply incised by rivers, which in the lower part nearly reach the surface.

Altitude: 100 - 150 m.

Soils: Thixotropic 60-80 cm very dark brown loamy topsoil over a yellowish brown thixotropic subsoil. Soils are stony in the upper part of the fan and not stony in the lower part. They are probably Dystrandepts.

Land-use: Mostly pasture and (fruit) trees. Bananas occur particularly in the lower part of this unit.

Vegetation:

The actual state of the vegetation cover is about the same as in the landscape of the relatively old alluvial fans. The original vegetation can be found in several stages of disturbance with inclining secondary character and it only covers some small, dispersed areas. This physiographical unit lies in the same ecological life zones as the previous unit. Structure and floristic composition of the forest are similar, provided that the grade of disturbance is about the same. While sampling, it seemed that Goethalsia meiantha (guácimo blanco) is more abundant in this unit.

Species in the highest layers of the forest:

- Pentaclethra macroloba (Mimosaceae) gavilán
- Goethalsia meiantha (Tiliaceae) guácimo blanco
- Cecropia obtusifolia (Moraceae) guarumo
- Cupania sp. (Sapindaceae)
- Casearia sp. (Flacourtiaceae)
- Guarea sp. (Meliaceae)

CFr Floodplain of braided riversystem.

Geology/geomorphology: Floodplain composed of many braided rivers originating from the Central Cordillera. Materials are stony and at slightly higher elevations sandy (CFr 1).

Downslope (past Río Frío) deposits are sandy to silty. That part is poorly drained and often flooded (CFr 2).

Topography: Plain with differences in altitude of 1-3 m.

Altitude: 300 m down to 50 m.

Siols: Well drained stony or sandy soils with 20 cm sandy loam. The upper 50 cm of the soil is usually thixotropic (Fluventic Vitrandepts). Downslope of Río Frío where drainage is impeded, soils are grayish mottled silty loams with a low pH over sandy material (Fluventic Tropaquept).

Land-use: The well drained parts are used for bamboo, cassava, maize, beans, dry rice, banana, pasture and ornamentals. The poorly drained part is mainly under pasture.

Vegetation:

This floodplain landscape is to be found in the same ecological life zones as the previous mentioned landscapes of alluvial fans, belonging to the land system of the Cordillera Central. The natural or semi-natural vegetation mainly occurs in the riverbeds and their surroundings (old riverbeds, periodically flooded areas, etc). It is an open scrub vegetation with dispersed trees of about 15 meters high, mainly Albizzia carbonaria (Mimosaceae) with its umbrella shaped crown. The ground cover is mostly composed of ferns, seedlings and grass ("caña brava") and has a uniform density. In the riverbeds the ground cover is less dense and the vegetation is lower. The girth sizes of the trees are mostly equal there. Some species of shrubs/little trees have a sclerophyll leaf texture.

CM Mountainous landscape.

CMs Very steep slopes of the crater (description valid for the crater of the volcano Turrialba).

Geology/geomorphology: The crater of the volcano Turrialba consists of scoria, pumics and lava rocks. The crater of the Irazú is similar in shape (not checked).

Topography: Slopes of the crater are 50-100%, the bottom of the crater is flat.

Altitude: 2700 - 2900 m.

Soils: 30 cm black, highly thixotropic loamy sand over coarse rocky and pumiceous material. More downslope the subsoil is stony. Classification: Hydric Vitrandept.

Land-use: none.

CMr Rolling to steep slopes.

Geology/geomorphology: Rocks consist of volcanic ash, pumice, lava and lahar in which formed an irregular topography with convex-concave slopes and differences in altitude between valleys and ridge crests of 100 - 200 m. The general slope is 30-45%.

Altitude: 1300 - 2700 m.

Soils: Moderately well drained to imperfectly drained soils with black to very dark brwon highly thixotropic sandy loam in the upper 50 cm over brown to grayish mottled highly thixotropic loam to sandy loam. Below 80 cm gray highly thixotropic loamy sand continues downwards. Buried A-horizons are common; Placic horizons are common. Classification: Aquic Hydrandept. From 1300 - 2000 m soils are well drained thixotropic and clayey with a yellowish brown B-horizon.

Soils are tentatively classified as Aquic Hydrandepts in the part above 2000 m and as (Hydric) Dystrandepts in the part below 2000 m.

Land-use: Pasture with trees down to 1500 m. 1300 - 1500 m: pasture, cabbage, maize, green beans and a little coffee.

Vegetation:

Two ecological life zones cover this area, consisting of the higher slopes of the volcano Turrialba:

- Lower montane rain forest.
- Montane rain forest.

These two zones coincide more or less with the previously mentioned units CMr and CMs respectively. They occur above the critical temperature line, which seperates these zones from the premontane zone. Occasional frosts can take place at these altitudes, resulting in big changes in natural vegetation and land-use. Plant species that tolerate the cold can be found there. In the submontane zone the low temperature reduce the height of the trees (max. 15-20 meters). In this zone there is still some forest left on the very steep slopes, particularly the ones bounding the small riverstreams. But the majority of the area is composed of pasture with spreaded trees and locally occuring Chusquea sp.-bushes. The trees have a sclerophyll leaf texture and support a heavy load of epiphytes and hanging mosses/lichens.

In the montane zone the trees gradually make place for shrubs and herbs, resulting in a kind of "páramo".

Species in the mountainous landscape:

- Oreopanax sp. (Araliaceae)
- Sambucus sp. (Caprifoliaceae)
- Psidium sp. (Myrtaceae)
- Salvia sp. (Labiatae)
- Chusquea sp. (Graminae) bambú

Lower on the mountain the vegetation gets higher and other species appear, like e.g.:

- Alnus spp. (Betulaceae)
- Salix spp. (Salicaceae)
- Rhus sp. (Anacardiaceae)

R Landsystem of the "Rift Valley" (Depresión tectónica).

RAp Relatively young alluvial plain.

Geology/geomorphology: Very gently sloping alluvial plain. North of the Río Reventazón alluvial materials originate from the Central Cordillera; south of this river they originate from the Talamanca hills and mountains.

All deposits are presumably of Holocene age.

Topography: The overall slope is less than 1 percent. In the part north of the Río Reventazón the plain is dissected by numerous rivers, which stream in narrow valleys. In the part south of the Río Reventazón the plain is hardly dissected and consists of river levees and backswamps.

Altitude: 50 m - 120 m.

Soils: In the southern part of this unit soils are imperfectly to poorly drained grayish clays. Along rivers soils are better drained and medium textured. (Tropaquepts and Aquic Eutropepts).

To the north of the Río Reventazón soils are better drained with a darkbrown topsoil of 20-30 cm over a yellowish brown subsoil , which may become sandy at depths of >60 cm. These soils are loamy and thixotropic. Some areas carry imperfectly drained soils, which are mottled with a loam to clay loam texture, but not thixotropic. Soils can be classified as Aquic Dystropepts or Eutropepts.

Land-use: Banana-plantations, pasture, citrus, coco, papaya, annual crops. In general: any crop grown in the region.

Vegetation:

The ecological life zones encountered in this unit are:

- Tropical wet forest
- Premontane wet forest, basal belt transition.
- Tropical moist forest, perhumid province transition.

They are the same as in the alluvial fan landscapes of the Cordillera Central.

Since the soils within this physiographical unit are very fertile and suitable for any crop grown in the region, large areas have already been deforested a long time ago. And even during the last decade the extensive forest areas northeast of Puerto Viejo, along the Río Sarapiquí, have been largely cleared or logged out. In the extreme north, near the Río

San Juan there is still primary forest left.

North of the line Limón-Siquirres-Río Frío only small parcels (max. 100 ha.) of forest are still present.

Samples have only been made in the disturbed forests, located in the better accessible areas and more representative for this unit.

Structure and life forms of the vegetation are similar to those in the alluvial fan landscapes of the Cordillera Central, provided that the grade of disturbance is about the same. There are only small differences, in the sense that epiphytes are rare in the logged-out forests and free ferns are almost absent. The actual canopy height can be up to 25-30 meters, with emergents of 35-40 meters. Pentaclethra macroloba (gavilán) is abundant in the heavily logged-out areas, because the loggers left this species.

Species which are present in the highest layers of the forest:

	- Pentaclethra macroloba (Mimosaceae)	gavilán
	- Carapa guianensis (Meliaceae)	cedro macho
	- Simarabu amara (Simarubaceae)	aceituno
	- Inga sp. (Mimosaceae)	
	- Cecropia sp. (Moraceae)	guarumo
1	- Pterocarpus officinalis (Papilionaceae)	sangrillo
	- Spondias mombin (Anacardiaceae)	jobo
	- Castilla elástica (Moraceae)	hule
	- Quararibea sp. (Bombacaceae)	carrocho
	- Luehea seemannii (Tiliaceae)	guácimo colorado
	- Ficus sp. (Moraceae)	chilamate
2	- Terminalia chiriquensis (Combretaceae)	

Remarks: 1. indicator species for poor drainage

2. indicator species for good drainage

RAu Undulating terrace landscape, relatively old.

Geology/geomorphology: The unit consists of ridges and isolated low hills which are the remnants of a former plain. Ridges are particularly noteworthy north of Puerto Viejo. They are associated with well drained valleys (RAu 1) and have a characteristic drainage pattern. The unit RAu 2, located east of this unit has the same drainage pattern, but ridges are lower and the flat-bottomed valleys are poorly drained or ponded. More to the south east near Palmitas low hills occur only here and there. Ridges and hills are formed in usually fine grained deposits, which near the Cocori hills resemble volcanic ash. Rounded stones were observed in hills near Palmitas.

Topography: Hills and ridges have convex summits. The difference in altitude between the ridge crests and the valley bottom is from 10 m in unit RAu 1 to 5 m in unit RAu 2.

Altitude: 30 - 60 m.

Soils: On hills and ridges soils are well drained and deep. The top 30 cm is a brown clay overlying yellowish brown to reddish brown clay. Soils are tentatively classified as Paleudults.

The soils of the poorly drained valleys are grayish silt loams to clay loams with brown orange mottles. Some soils, especially in the better drained parts, are thixotropic. Soils are tentatively classified as Fluventic Tropaquepts and Andic Dystropepts.

Land-use: Pasture and natural forest. In the better drained parts of the valleys, all kind of crops are grown.

Vegetation:

The ecological life zones present in this unit are more or less the same as in the RAp-unit. Only the tropical moist forest, perhumid province transition is absent here, i.e. the average precipitation exceeds 4000 mm. a year in the whole unit.

Large areas still contain natural, virgin vegetation or little intervened vegetation, especially the area between the Río Colorado and the Río Chirripó in the north and the Río Suerte in the south. In the RAu-units south of the Lomas de Sierpe, only relics of the natural vegetation are left and the little forest present there is already logged-out. In the heavily logged forests the few left-over trees form the emergents, with a max. height of 45 meters. The canopy height varies between 10 and 25

meters, resulting in a fairly uneven or very broken canopy surface. Not more than two tree layers are obvious and many gaps occur in the vegetation. The ground cover is dense and mostly composed of palms, ferns, vines, gingers and seedlings, Vines are abundant in the whole vegetation. Epiphytes and tree ferns are present, but rare.

Identified species:

- Goethalsia meiantha (Tiliaceae) guácimo blanco
- Carapa guianensis (Meliaceae) cedro macho
- Astrocaryum alatum (Palmae) coquillo
- Jacaratia costaricensis (Caricaceae) papayillo
- Hieronyma alchorneoides (Euphorbiaceae) pilón
- Pentaclethra macroloba (Mimosaceae) gavilán
- Cordia sp. (Boraginaceae)

In the primary forests within this unit a totally different picture reveals itself. The canopy surface is closed and more or less smooth and even, without obvious emergents. The maximum canopy height varies between 30 and 40 meters and the girth sizes of the main canopy trees are unequal throughout. It's not possible to indicate exactly the number of different tree layers which merge, but in any case the vegetation structure is more complex than in the former forest type. Plank butresses, stilt roots and spreading surface roots are common, just like epiphytes, especially on tree trunks. Vines are present in all size classes and more robust woody vines appear, than in the previously discussed forest type. The ground cover is uniform and sparse, consisting mainly of seedlings, palms, fallen logs, vines and ferns, although ferns are sometimes rare.

Identified species:

- Pentaclethra macroloba (Mimosaceae) gavilán
- Pterocarpus sp. (papilionaceae) sangrillo
- Ceiba pentandra (Bombacaceae) ceiba
- Minquartea guianensis (Olacaceae) manú
- Guarea sp. (Meliaceae)
- Quararibea sp. (Bombacaceae) carrocho
- Terminalia chiriquensis (Combretaceae)
- Inga coruscans (Mimosaceae) guabo colorado
- Brosimum sp. (Moraceae)
- Lonchocarpus sp. (Papilionaceae)
- Luehea seemannii (Tiliaceae) guácimo colorado
- Apeiba sp. (Tiliaceae)

RH. Landscapes of hills formed in Tertiary volcanic rocks.

Geology/geomorphology: Hills up to 300 m high, which are the remnants of Tertiary volcanoes. Rocks are composed of basaltic lava and tuff.

Topography: Slopes are 20-50% and straight or slightly convex with a length of 50 to over 100 meter.

Altitude: From about 30 m at the base to 334 m at the highest top.

Soils: The steeper slopes carry well drained, deep, somewhat stony soils with 10-20 cm dark brown clay over reddish brown clay down to depths of over 100 cm from where saprolite increases downwards. At gentler slopes soils are reddish (2,5 YR) and not stony. Soils on steeper slopes are probably Tropudults or Tropudalfs and on the gentle slopes Paleudults.

Land-use: Cleared slopes are cultivated with pasture, maize, beans, cassava and other crops.

Vegetation:

These Tertiary hills lie within only one ecological life zone:

- The tropical wet forest.

Except in the National Park "Tortuguero", deforestation is in full progress now, since these hills are largely covered with the original virgin forest. And even at the borders of the National Park little parcels have been cleared. Big parts are logged-out, resulting in a forest with a more secondary character.

Normally, the canopy surface isn't closed. It is uneven en locally very broken, at an average height of 30 meters. Emergents can reach up to 40 meters. Mostly, more than two tree layers aren't obvious. Spreading surface roots as well as plank butresses occur. Stilt roots are present, but more in the forest with a strong secondary character, due to the presence of Cecropia spp.. The undergrowth mostly consists of seedlings, dwarf palms, ferns, vines and fallen logs. Vines are abundant throughout the whole vegetation and even in the main canopy. The same counts for epiphytes.

Identified species:

- Pentaclethra macroloba (Mimosaceae) gavilán
- Cecropia sp. (Moraceae) guarumo
- Inga coruscans (Mimosaceae) guabo colorado
- Trichilia sp. (Meliaceae)
- Pouteria sp. (Sapotaceae) zapotillo

- Minquartea guianensis (Olacaceae) manú
- Virola sibifera (Myristicaceae) fruta dorada
- Nectandra sp. (Lauraceae)

RS Landscape of backswamps.

Flat very poorly drained to ponded areas behind beach ridges along the coast consisting of unripened reduced clays or peat.
Altitude: 0 - 10 m.
Soils: Hydraquents and Tropofibrists.
Vegetation:

The backswamps occur along the whole coast, traversing several ecological life zones, from the tropical wet forest in the north to the tropical moist forest in the south via two transitional zones. More important, however, in defining the structure and floristic composition of the vegetation types within this unit, are the local relief and the hydrology.
Slight differences in the altitude above sealevel cause big differences in the floristic composition of the swamp forest.
One can roughly distinguish three types of swamp forest, based on the hydrology.

1. Forest on (almost) permanently flooded areas, consisting of mainly one species, the "yolillo" (Raphia taedigera). The result is a palm forest, about 6-10 meter high with a sparse ground cover. Sometimes other species are present in very small quantities, like:

- Pachira aquatia (Bombacaceae) popenjoche
- Pterocarpus sp. (Papilionaceae) sangrillo
- Pentaclethra macroloba (Mimosaceae) gavilán

2. Forest on periodically flooded areas, with the "cativo" (Prioria copaifera) as the predominant species. The average maximum canopy height varies between 35 and 40 meters. Not more than one or two tree layers are obvious. Plank butresses are occasionally present, just like stilt roots. The ground cover is uniform and can be dense or sparse, depending on the grade of disturbance. It consists of seedlings, palms, fallen "Yolillo-leaves, ferns and a herbaceous species called "sanillo", containing a sap that affects the human skin. Epiphytes and vines are abundantly present.
Identified species:

- Prioria copaifera (Caesalpiniaceae) cativo

- Pterocarpus sp. (Papilionaceae) sangrillo
- Spondias mombin (Anacardiaceae) jobo
- Brosimum sp. (Moraceae) lechosa
- Luehea seemanii (Tiliaceae) guácimo colorado
- Raphia taedigera (Palmae) yolillo
- Astrocaryum alatum (Palmae) coquillo
- Cespedesia macrophylla (Ochnaceae) tabacón
- Sickingia maconii (Rubiaceae) guaitil

Large areas are selectively logged or partially cleared already, and then also other species occur, like:

- Cecropia spp. (Moraceae) guarumo
- Ficus spp. (Moraceae) chilamate
- Goethalsia meiantha (Tiliaceae) guácimo blanco

3. Forest on occasionally flooded areas; high forests in which "cedro macho" (Carapa guianensis) and "gavilán" (Pentaclethra macroloba) predominate. These forests are more complex in structure and more diverse in floristic composition, than the previously mentioned types. Next to the species ocurring in the periodically flooded areas, one can also find:

- Carapa guianensis (Meliaceae) cedro macho
- Pentaclethra macroloba (Mimosaceae) gavilán
- Quararibea sp. (Bombacaceae) garrocho
- Dussia sp. (?) targuayugo
- Virola spp. (Myristicaceae) fruta dorado
- Sickingia maxonii (Rubiaceae) guaitil

Some species of the second type do not occur in this type or only in small quantities, like:

- Prioria copaifera (Caesalpiniaceae) cativo
- Astrocaryum alatum (Palmae) coquillo

RB Landscape of beach ridges.

Sandy ridges at 2 - 4 m above mean sealevel consisting of yellowish to black sand, depending on the mineralogy of the deposits. Soils are psamments.
Land-use: Coco and natural vegetation.
Vegetation:

This physiographical unit occurs right along the coast, traversing the same ecological life zones as the backswamps. On the physiographical map these two units are combined (RB), because of cartographic reasons. The beach ridges form a narrow strip, in which cultivated coco (Cocos nucifera) or natural vegetation occur. Species naturally present here are:

- Cocos nucifera (Palmae) cocotero
- Terminalia catappa (Combretaceae)
- Coccoloba uvifera (Polygonaceae) sea-grape

RC Coral terraces.

Genesis: The Quarternary started with a sealevel rise in the Pleistocene. Thick layers of coral were formed. The rising of the Pleistocene limestones passed off shaking, with as result several terraces.

The terraces along the coast attract attention, because of their vertical walls.

The last sealevel drop in the Holocene caused the lowest terrace.

Land-use: Coco and natural vegetation.

Soils: - parent rock --> coral reef.
- texture --> clayey.
- colour --> yellowish brown (weathered limestone).
- drainage --> good.

Vegetation:

The coral terraces occur in the area of Portete, just near Limón, in the premontane wet forest, basal belt transition. The last piece of natural vegetation can be found in the National Park "Cariari", where some intervened primary forest occurs. It is already selectively logged, only covers a small area and some coco is planted in between.

The canopy surface is fairly uneven and locally descends to near ground level. It is closed or dense and the height varies between 20 and 30 meters. Palms (mainly coco) form a great part of the canopy trees. Stilt roots, plank butresses and spreading surface roots are present, but rare. The undergrowth is mostly composed of seedling, ferns and gingers and can be dense, sparse or nearly absent. Epiphytes and hanging mosses haven't been perceived. Vines are present but not abundant.

Identified species:

- Cocos nucifera (Palmae)	cocotero
- Simaruba amara (Simarubaceae)	aceituno
- Guarea sp. (Meliaceae)	caobilla
- Virola sp. (Myristicaceae)	fruta dorado
- Inga sp. (Mimosaceae)	
- Calophylum brasilensis (Guttifereae)	cedro maría
- Genipa americana	guaitil blanco
- Ficus sp. (Moraceae)	chilamate

T. Landsystem of the "Talamanca".

TF. Alluvial fan.

This unit is part of the pied de monte of the Talamanca range. It occurs where rivers of intra-montane valleys enter the plain. Alluvial deposits and soils developed on them are similar to those of the youngest terraces in the intra-montane valleys. Land-use is also similar.

Vegetation:

Since the soils, developed here, are very fertile, these areas have already been cultivated a long time ago. Except the left-over trees above pasture or cacao, not much reminds of the original vegetation which covered these areas. Of the left-over trees Cordia alliodora (laurel) is the most conspicuous one. Often also caused by natural regeneration, they are striking because of their physiognomy, being leafless during part of the year.

TA Intra montane valleys.

Geology/geomorphology: The valley slopes are formed in sand, silt and claystone of which the sandparticles consist of weatherable minerals, partly of volcanic origin. In the valleys several (alluvial) terraces of different ages occur, of which the older ones are strongly dissected.

Topography: Valley slopes are 50 - 100% with a length of 50 - 150 m. The older dissected terraces, if present, have slopes of 40 - 80% with a length of 30-50 m and convex tops. The terraces at 1-5 m above the river are level.

Altitude: 20 - 1000 m (Moravia).

Soils: On valley slopes: well drained, stony, brown, moderately deep clay loam (Tropumbrepts). On older terraces and low hills: well drained deep reddish clays with fine angular blocky structures (Paleudults).

On recent river terraces and in alluvial (flood) plains: deep, sometimes stony, alluvial soils, locally poor drainage (Tropofluvents and Argiudolls).

Land-use: On valley slopes above 600 m: sugar-cane, pasture, coffee, secondary forest; below 600 m:.....

On older terraces above 600 m: sugar-cane, coffee, pasture;
below 600 m:.....

On recent terras above 600 m: sugar-cane, pasture, some coffee;
below 600 m: bananas, cacao, platano, cassava, pasture, annuals like maize and beans.

Vegetation:

The intramontane valleys of the Talamanca-system are located where big rivers intersect the foothills, all around the Cordillera de Talamanca. Consequently, their situation is within many different ecological life zones, since they depend on the temperature regime and the average annual rainfall.

Two examples: 1. The valley of Moravia lies in the zone of the premontane wet forest.

2. In the valley of the Rio Chirripó de Atlántico three life zones are traversed, when going upward:

- Tropical wet forest.
- Tropical wet forest, prementane belt transition.
- Premontane wet forest, basal belt transition.

The result would have been a big variation of vegetation types, if it

weren't for the fact that the majority of these intramontane valleys are in use for agriculture and cattle-breeding, since long ago. But usually the valley slopes and the braided river systems still contain some natural vegetation.

In the latter, one can find a vegetation type very much alike the one already found in the braided river system of the Cordillera Central. The trees are a bit higher here (max. 20 meters) and except Albizzia carbonaria, we found Cecropia obtusefolia (guarumo), Ochroma lagopus (balsa) and Parmentiera sp. (Bignoniaceae). The undergrowth is denser and gingers form a part of it. Thin wiry vines occur in the undergrowth as well as in the trees.

The forests on the valley slopes are cleared or logged-out already. On the extremely steep slopes (150%) near the Río Pacuare in the Suiza-watershed, the forests have a very broken canopy, not closed, with a maximum height of 15 meters (emergents up to 20 meters). Only one or two tree layers are obvious. These forests exist under extreme edaphic conditions and are heavily logged-out.

For descriptions of the vegetation on the other slopes of the intramontane valleys, see TH (Hilly landscape).

TH Hilly landscape.

Geology/geomorphology: Hills with irregular slopes and sharp summits, developed in layered clay, silt and sandstone with intercalations of stony, mostly andesitic materials. Deposits are sometimes fossiliferous.

Topography: Hillslopes are 30 - 100% with a length of 30 - 70 m. Numerous spoon-shaped excavations on slopes are the result of land-slides.

Altitudes: 100 - 700 m.

Soils: Deep, moderately well drained soils with a 10-20 cm dark clayey horizon over a reddish yellow (mottled) compact clay with a laminated to massive structure. The soil is sensitive to landslides and erosion. Rootability is limited (Oxic Dystropept).

Land-use: Pasture, occasionally coffee and bananas and at lower altitudes some cacao.

Vegetation:

Mainly 3 ecological life zones are present in the hilly landscape of the Cordillera de Talamanca:

- Tropical wet forest.
- Tropical wet forest, premontane belt transition.
- Premontane wet forest, basal belt transition.

It's good to remember that the alluvial fans of the Cordillera Central, as well as the undulating terrace landscape, lie in the same life zones as this unit. However, the actual state of the natural vegetation is fairly different. Primary forest still occupies large areas and secondary forest is present in many stages of succession. Especially on the slopes and hills around the intramontane valleys, crops have been grown, like bananas and cacao. Lots of those places have been abandoned. resulting in secondary growth of thew forest.

Some shifting-cultivation, as practiced by the indians, also has to be mentioned. The amount of primary forests is increasing, when going from the coastal plain further into the hills. Those undisturbed forests have an average maximum canopy height of 25 - 30 meters and emergents are up to 35 meters high. It's hard to distinguish more than two tree layers, that merge. Most canopy trees and emergents have a big vertical extension of the crown, from the upper third until about half the tree. Plank butresses and stilt roots are present but rare.

Spreading surface roots are more often perceived. The variation in vines

is bigger, than in the corresponding secondary forests, although the smallest diameters are far better represented. Tree ferns and epiphytes are present but inconspicuous. Ferns, seedlings, gingers and fallen logs mainly form the undergrowth, that is normally uniform and sparse, but can locally be dense or almost absent.

Identified tree species:

- Apeiba membranaceae(Tiliaceae) — tapa botija
- Manilkara achras — níspero
- Protium sp. (Burseraceae) — mango rosa
- Brosimum sp. (Moraceae)
- Cecropia obtusefolia (Moraceae) — guarumo
- Vochysia sp. (Vochysiaceae)
- Erythrina sp. (Papilionaceae) — porõ
- Nectandra sp. (Lauraceae)
- Jacaratia sp. (Caricaceae) — papayillo
- Chimarrhis sp. (?)
- Pouteria sp. (Sapotaceae) — zapotillo

Remark: Vochysia sp. is typical for an altitude of 400-800 meters above sea-level (Veiman, pers. inf.).

The early secondary forests usually still contain some trees of the former original vegetation, that play the role of emergents now, with an average height of 30 meters. After some years the secondary growth can have a canopy height of, say 10-15 meters. Not more than one or two tree layers are obvious and the girth sizes of the main canopy trees are mostly equal, resulting in a "pole forest". Stilt roots are common, because of the presence of many "guarumos" (Cecropia obtusefolia). As far as the vines are concerned, only the thin and wiry ones are present, many of them with prickles. Epiphytes are absent.

Identified tree species:

- Cecropia obtusefolia (Moraceae) — guarumo
- Croton sp. (Euphorbiaceae)
- Heliocarpus popayanensis (Tiliaceae) — burío
- Hampea apendiculata (?)
- Miconia spp. (Melastomataceae) — lengua de vaca
- Rollinia microcephala (Annonaceae) — anonillo

TM Mountainous landscape.

Geology/geomorphology: Steeply dissected land in deposits of clay, silt and sand.

Topography: V-shaped valleys with slopes of over 100% and narrow convex ridge tops.

Altitude: > 500 m.

Soils: Well drained, moderately deep, stony brown clayloam. (Tropumbrepts)

Land-use: Indigenous reserves (shifting cultivation)

Vegetation:

Not less than 5 ecological life zones put their stamp upon the mountainous landscape, i.e.:

- Premontane wet forest	< 1500 m.
- Premontane rain forest	
- Lower montane rain forest	1500-2500 m.
- Montane rain forest	2500-3500 m.
- Suibalpine rain paramo	> 3500 m.

As one can see, the variation is formed by an altitude gradient and its corresponding temperature regime. The critical temperature line lies between the premontane zone and the lower montane zone. Above this line occasional frosts occur, resulting in plant species that are tolerant to the cold. The low temperatures reduce the height of the trees and the amount of species also decreases. Evergreen shrubs with broad leaves predominate the inferior tree layer. The whole forest supports a heavy load of epiphytes. In the montane zone one can find the evergreen oak forests with Quercus costarricensis, Q. copeyensis and Q. borucasana. The undergrowth contains many bamboos (Chusquea spp.). Orchids, mosses, ferns and lichens are abundant in the whole montane zone.

From about 3000 meters upwards, the trees gradually make place for shrubs and herbs, resulting in a "páramo" similar to that in the Andes. Actually, the vegetation of the Andean "páramo" reaches its most northern limit on the tops of the Cordillera de Talamance. Most species in the costarican "páramo" are of Andean origin; some are northamerican (Hall, 1984).

Because of its inaccessibility the mountainous landscape of the Cordillera de Talamanca contains the most extensive areas of undisturbed forest. Large parts of this unit are under protection, being situated in National Parks, like "La Amistad" Bi-National Park, the only one that has been created after preceding ecological and cadaster studies.

TV Volcanic landscape.

Geology/geomorphology: Numerous rounded hills formed in conglomerates and tufs, which are mainly of andesitic composition.

Topography: Hills have slopes of 100% and more, with a length of 30-125 m. Valleys are V-shaped.

Altitude: 600 - 900 m.

Soils: Well drained, very deep soils with saprolite down to depths of > 8 m. The dark brown clayey A-horizon overlies at 30-40 cm, a reddish brown to yellowish brown, clayey, fine angular blocky argillic B, which is deep and stony (Argiudoll or Tropudalf).

Land-use: Coffee, sugar-cane, ornamentals and pasture.

Vegetation:

The last remnants of primary forest are only left on the extremely steep hill slopes. They are already selectively logged and often the operation has been so intensive, that it's more correct to speak of secondary forest. The ecological life zones found in this small unit are:

- Tropical wet forest, premontane belt transition.
- Premontane wet forest.
- Premontane rain forest.

But the forested parts only occur in the premontane zone. Epiphytes are occasionally found in those forests but conspicuous, just like tree ferns. Strangler trees are occasionally found but rare, since they are typical representants of the lowland forests. Sometimes the crowns of the canopy trees and emergents contain hanging mosses. Those tree crowns have a big vertical extension, from the upper third to about half the tree. The canopy height varies between 10 and 25 meters, depending on the history of the forest, with emergents up to 30 meters.

Cecropia obtusefolia is always present, often abundant. Canopy surface, canopy density and prominence of different tree layers vary from place to place. The ground cover can be sparse or dense, mostly consisting of seedlings, gingers, ferns, vines (many Araceae) and fallen logs.

III. Research proposals

The baseline-survey consists of three interrelated parts, as mentioned in the "informe preliminar". Taking this into consideration, vegetation science can contribute in several ways.

1. It must play a role in the inventory of the ecological resources. On a more detailed scale, than in the exploratory survey, a thorough inventory of vegetation units should be undertaken.
2. As a part of the multidisciplinary research in the selected areas, the production of geomorphological maps, soil maps and vegetation maps are mentioned.
3. The effects of land-use on the development and change of soil characteristics after deforestation is a very important research-topic. How can we come to sustained land-use systems, on an ecologically sound base if no efforts will be taken into this direction?
   Vegetation science can contribute in this topic.
4. Further research can be done, in order to give answers to the following questions:
   a. Which species are indicators for certain environmental factors and for certain interferences or stages in the development of the vegetation?
   b. What is the rate of degradations and how are the chances for recovery?
   c. What are the ecological processes, that underlie the productivity of an ecosystem?
   d. What is the influence of certain interferences on the production capacity of ecosystems and the adjoining systems?
   e. How will the vegetation development succeed in time?

The department of VPO (Vegetation science, Plant ecology and Weeds science) won't have too much research time available, to be directly involved in the project. Whenever knowhow on vegetation matters of this department is needed, all efforts will be taken to recrute students, who can participate within the framework of their practical period or as part of their M.Sc.-thesis.

Implementation.

1/2. Of the subjects mentioned above the vegetation mapping must have

priority, within the baseline-studies. This vegetation mapping should be based on the following questions:

- Which vegetation units can be distinguished and what is their structure and floristic composition (inventory)?
- What is the spatial relationship between the plant communities or vegetation units (geographical distribution - mapping)?

The inventory and the production of the maps are both included then. Since two preliminary sample-areas are chosen, two teams can work on this topic, each within a different area. The topic is suitable for 2 students, working together, each one of them for a 6 or 9 months thesis subject. A thorough photo-interpretation should preceed the fieldwork.

3. Analysis of the effects of different land-use systems on the development and change of soil characteristics can be investigated together with soil scientists and agronomists. Usually, the vegetation gives amongst others a fair indication of soil conditions. Specified subjects are already mentioned in the contribution from soil science (internally presented A4-sheets):

   a. Participating in the "Proyecto Silvopastoril" of CATIE and MAG, e.g. investigating the vegetation development under different pasture treatments.
      + 1 or 2 students, 6 months.

   b. Study on the relation between weed species and different soil types, crops and cropping systems. Different vegetation units?
      + several students (practical period or thesis); after consultation with the other disciplines involved.

   c. Effect of pesticides, used in banana cultivation, on weeds and other plant species.
      What changes in the floristic composition will take place?
      + 1 student, 6 months.

   d/e. Soil compaction and erosion, caused by specific clearing methods or land-use systems. Does the natural or semi-natural vegetation give an indication about the extent of soil compaction in a certain area?
      + to be specified after consultation with the other disciplines involved.

4. Vegetation succession and regression are especially important features in

forest areas and around the borders of the fading forest. Jacobs (1981) distinguishes 4 categories in forest regression:

- undisturbed forest; parts of it belonging to certain stages of regeneration.
- modified forest; caused by selective logging, cattle-grazing, shifting-cultivation, partial clearings, etc.
- arable land; areas on which the forest has been replaced (almost) totally by another vegetation cover.
- useless land; where the soil is even too much exhausted to grow crops.

All these 4 categories are present in the studied area. In an environment as dynamic as the Atlantic Zone of Costa Roca, much can be done in this field of interest:

a. Which interferences have taken place?
How far did degradation progress? An investigation should be made then of the structure and floristic composition and the primary production in relation to the rate of interference. Whenever possible indicator species or species groups should be given. How are the chances for recovery? History of interference.
+ several students, practical period or thesis work.

b. How will the vegetation develop in time? Series of pioneer vegetation to undisturbed climax forest should be studied, and if possible, in different areas.
+ students (and staff?); experience required.

Supplementary information.

- The physiographic map, made during the exploratory survey can only serve as a base for the detailed soil maps and vegetation maps. Supplementary airphoto-interpretation will be inevitable, using a larger photo scale, e.g. 1:30,000. Since the ideal ratio between photo scale and final map scale is 1:2 (Van Gils & Zonneveld, 1982), the result will be a final map scale of 1:50,000 or 1:60,000. Taking into consideration the size of the sample-areas, as decided so far, that appears to be a suitable final product.

- Apart from their intrinsical research value, the soil maps and the vegetation map also have a supplying function, providing information

for the other disciplines involved in the project. Therefore, a logical sequence of interdependent research activities in the future will be necessary. Whenever possible, soil maps and vegetation maps should be made available, be it in a preliminary form, before the in-depth studies can proceed.

- The majority of the mapping work will consist of field-sampling. It should be stressed, that the team executing the field-sampling be composed of the same persons, who did the airphoto-interpretation. The field team will have to work independently and sufficient transport facilities are therefore of the utmost importance.

IV. Literature

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Appendix A. Legend belonging to the physiographical map

C. Landsystem of the "Cordillera Central"

Cli - Lahar landscape of the volcano Irazu

Clt - Lahar landscape of the volcano Turrialba

CA - Intramontane valleys

CFo - Alluvial fans, relatively old

CFy - Alluvial fans, relatively young

CFr - Floodplain of braided river system

CM - Mountainous landscape

R. Landsystem of the "Rift-valley"

RAp - Alluvial plain, relatively young

RAu - Undulating terrace landscape, relatively old

RH - Hilly volcanic landscape

RS - Backswamps

RB - Beach ridges

RC - Coral terraces

T. Landsystem of the "Talamanca"

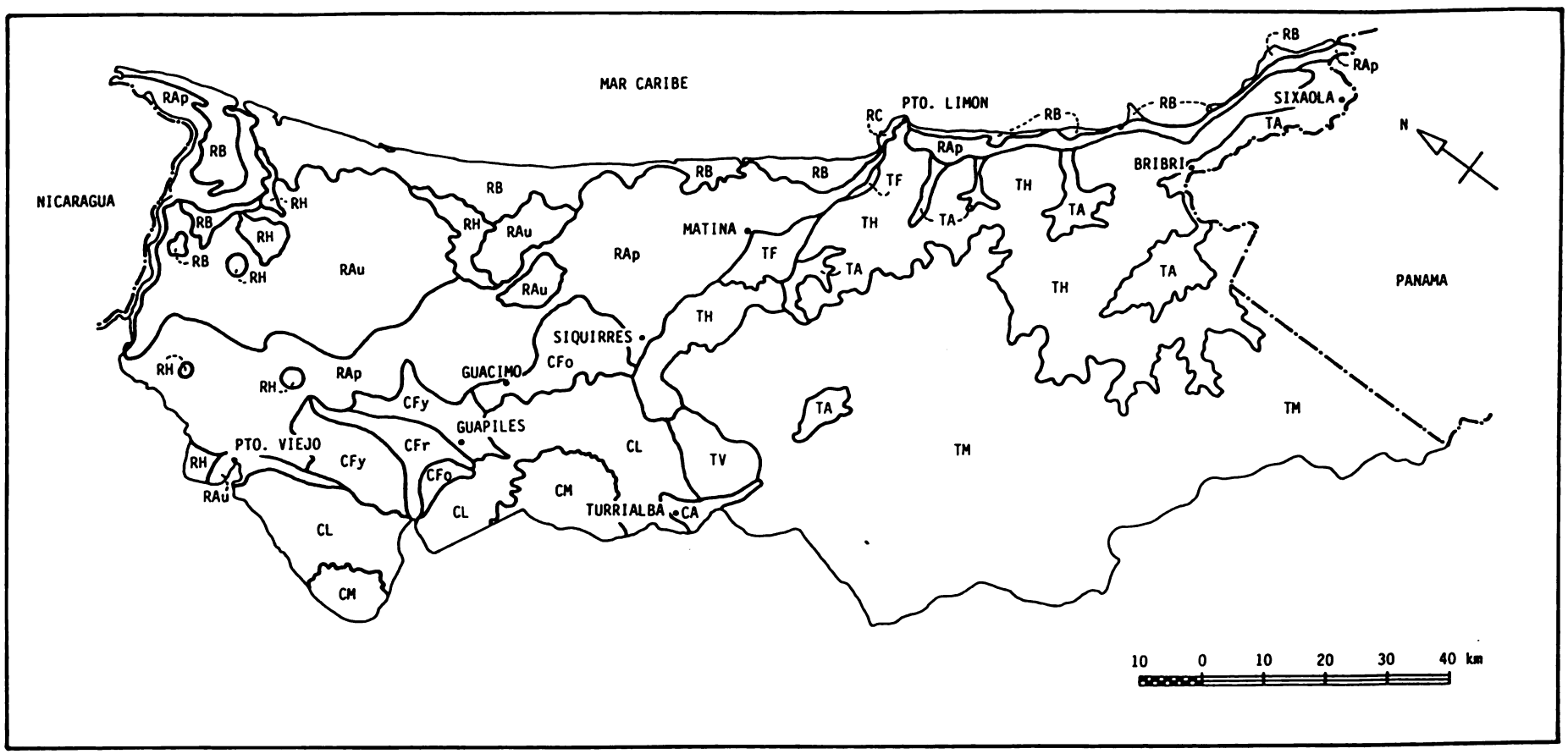
TF - Alluvial fans

TA - Intramontane valleys

TH - Hilly landscape

TM - Mountainous landscape

TV - Volcanic landscape



Appendix B. Physiographical map of Huetar Atlantica, the district of Puerto Viejo and the canton Turrialba.