AN APPLICATION OF A GEOGRAPHIC INFORMATION SYSTEM IN LAND DEGRADATION
A case in the Caqueta area, Colombia

by

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INTERNATIONAL INSTITUTE FOR AEROSPACE SURVEY AND EARTH SCIENCES

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Thesis submitted to the International Institute of Aerospace Survey and Earth Sciences (ITC), Enschede, The Netherlands, as a partial fulfillment of the requirements to achieve a degree of Master of Science (M.Sc.) in soil survey using Aerial Photography and other Remote Sensing Techniques.

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THE NETHERLANDS
September 1991

ACKNOWLEDGMENTS

I would like to express my sincere thanks to the IGAC-ITC project for sponsoring and granting me a fellowship to carry on this studies, to Mr. Alvaro Gonzalez Fletcher Director of the Colombian National Geographic Institute for allowing me the necessary time, to Dr. Dimas Malagon Castro head of Soil Survey Department for his valuable help and supporting with the necessary data.

I would especially like to express my gratitude to the following staff of ITC for personal and academic support in all different steps of my study: Dr. Carlos Valenzuela for his supervision and constructive criticisms, Dr.Alfred Zinck for his valuable theoretical orientations Dr. G. W. Elbersen for his efficient assistance in all matters related to administration.

Finally I am grateful to all friends at the ITC, for their comments, support and friendship.

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SUMMARY

In this study a design of a general soil database, a preliminary land degradation model and its implementation in the Caqueta area (Colombia) were carried out.

The soil database contain description of spatial (soil and cover maps scale 1:250.000) and non-spatial database (external and internal soil profile characteristics).

The preliminary land degradation model was made using of ALES; decision trees were created to make decisions for severity levels for biological, physical and the combination of these two types of land degradation.

The actual land degradation map obtained from the above procedure shows that 40% of the area is no degraded, 15% has moderate degradation and 45% of the area is severely degraded.

1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The deforestation of the tropical rain forest is destroying a valuable natural resource throughout much of the developing world and is driving countless plant and animal species to extinction, and it may well have significant effects on world climate (Repetto, 1990).

Among the reasons of the devastation are inefficient commercial logging operations and the conversion of forested areas to cattle ranching and agriculture. Data collected by numerous investigators indicate that both the logging and the conversion are largely the result of government policies (Tyler, 1990).

The destruction of tropical rain forest and consequently the land degradation is a more serious problem than it was thought to be only a decade ago, judging by recent estimates based on remote sensing from satellites and on careful field surveys.

Deforestation at this rate poses extreme risks to natural ecological systems. The release of carbon dioxide to the atmosphere is estimated to account for 15 to 30 percent of annual global carbon dioxide emissions, and so it contributes substantially to the build up of greenhouse effect (Repetto, 1990). Moreover, the loss of tropical forest is rapidly eliminating the habitat of large numbers of plants and animal species, and the soil is exposed to degradation.

Many investigators of the Amazon area concluded that without some tree cover, the very fabric of the nations can be washed away by the strong tropical rains because in the tropical rain forest nutrient availability is a dominating limiting factor; leaching of the soil and the irreversible fixation of the few nutrients becomes an overwhelming problem whenever the enormous biomass of the forest is removed (Chamorro and Garcia, 1989; Tyler, 1990).

In Colombia the tropical forest covers an area of approximately 60% of the national territory and in this area socio-economic and cultural factors give rise to the destruction of the rain forest and consequently the land degradation (i.e. shallowing soil depth, soil erosion, deterioration of soil physical properties, etc)

According to what has been stated above, every day becomes more evident the fragility of tropical rain forest, specially soil degradation is becoming a major problem to the survival of the human race. In the Caqueta area this provides a strong reason for the development of an information system capable of delivering accurate, useful and timely information to decision-makers and planners.

Land degradation is usually a complex process in which several features can be recognized as contributing to a decrease of production capacity (FAO, 1983), or any process which reduces the capacity of land to produce crops (Riquier, 1982).

The procedures for evaluating the effect of the attributes on land degradation would be tedious and time consuming to carry out manually. Therefore, a geographic information system (GIS) was used because of its capability to handle and update spatial and attribute data in a short time.

Secondly, the use of such system contributes to develop a soil database for general use in Colombia.

The database could in fact be used to help many aspects of land use planing in this area: location of colonization projects, selection of land for ecological protection and recreational reserves, the design of new roads and basic infrastructure to better serve agricultural development, to indicate the relative fragility of lands, the soil conservation needs, the relative land values, etc.

Another benefit of the database is the instantaneous capability to add new data whenever such data become available and to delete incorrect, obsolete and irrelevant data, and also improve the capability to deliver accurate information on qualitative and quantitative soil degradation processes for national and regional agricultural planning purposes.

A geographic information system is a computerized system designed to store data that are related to the specific geographic areas in a data base, and to process and analyze these data with a package of designed computer programs, in order to derive information for decision making and planning.

For this study the Integrated Land and Water Information System (ILWIS), a Relational Database Management System (ORACLE) and the Automated Land Evaluation System (ALES) were used. ITC's ILWIS system is a knowledge-based system combining human expertise and problem-solving capabilities and providing a structure by means of which subroutines and programs can be combined and used flexible. The ILWIS structure also incorporates a soil information system providing data necessary to answer questions about soil resources/potentialities of a given area, through a flexible combination of GIS-manipulations with a relational database management system (ORACLE).

The database management system (DBMS) has capabilities to solve many of the conflicting problems which arise in large integrated databases subject to continuous changes. The software provides a desirable level of database interface with a suitable language to query/update information and offering simultaneous access for many users (with immediate response for their information requests) in a relational data model. This high-level language is called SQL (Structured Query Language), uses a block-structured format of English words and was developed by IBM (Aronoff,1989).

ALES is a computer program that allows land evaluators to build expert system to evaluate land according to the method presented in the Food and Agriculture Organization (Rossiter and Van Wambeke, 1989).

1.2 OBJECTIVES

This study focuses on the conceptualization and design of a soil database and a soil degradation model which can be implemented using the Integrated Land and Water Information System (ILWIS), ORACLE and ALES.

The aims of this study are:

1. Develop a soil database for general use in Colombia
2. Develop a preliminary Land Degradation Model
3. Implementation of the database and model using a case study in the Caqueta area.

2. LITERATURE REVIEW

2.1 SOIL DEGRADATION

Riquier (1982) defines soil degradation as any process which reduces the actual or potential capacity to produce crops (quantitatively and/or qualitatively) goods or services.

FAO (1983) defines a land degradation as a complex process in which several features can be recognized as contributing to a decrease of production capacity.

Lal et al., (1989) defines soil degradation as a diminution of soil quality (and thereby its current and potential productivity), and/or a reduction in its ability to be a multi-purpose resource due both to natural and man-induces causes.

Lal and Stewart (1990), define soil degradation as an outcome of depletive human activities and their interaction with natural environments. They distinguish three principal types of degradation: physical, chemical and biological. Each of these types has different processes of soil degradation as follow:

2.1.1 Physical degradation

Physical degradation refers to the deterioration of the physical properties of soil. This includes the following:

Compaction and hardsetting: Densification of soil is caused by the elimination or reduction of structural pores. Increase in soil bulk density is caused by natural and man-induced factors. Hardsetting is a problem in soils of low-activity clays and soils that contain low organic matter content. Soils prone to compaction and hardsetting are susceptible to accelerated runoff and erosion (Lal and Stewart, 1990).

Soil erosion and sedimentation: Worldwide erosion of topsoil by wind and water exceeds formation at an alarming rate. Decertification, the spread of desert-like conditions, is a direct consequence of wind erosion.

Laterization. Laterite is a hard sheet of iron and aluminum-rich duricrust. Laterization, therefore, refers to the desiccation and hardening of plinthitic material on exposure and desiccation.

2.1.2 Biological Degradation

Reduction in soil organic matter content, decline in biomass carbon, and decrease in activity and diversity of soil fauna are ramifications of biological degradation. Because of prevailing high soil and air temperatures, biological degradation of soil is more severe in the tropics than in the temperate zone. Biological degradation can also be caused by indiscriminate and excessive use of chemicals and soil pollutants.

2.1.3 Chemical degradation

Nutrient depletion is a major cause of chemical degradation. In addition, excessive leaching of cations in soils with low-activity clays causes a decline in soil pH and a reduction in base saturation. Chemical degradation is also caused by the buildup of some toxic chemicals and an elemental imbalance that is injurious to plant growth.

2.2 FACTORS AFFECTING SOIL DEGRADATION

Factors that induce or set in motion the soil degradative processes are intensive land use necessitated by increasing demographic pressure; poverty; harsh climatic conditions, e.g., continuously high temperatures and high intensive tropical rains; and marginal soils that are shallow, steep, or acidic and devoid of essential plant nutrients. Over and above these, human intervention by deforestation, mechanized tillage, monocropping and simplification of the ecosystem are major factors responsible for soil degradation.

2.2.1 Deforestation

Deforestation and forest conversion, major factors of soil degradation in the tropics , are proceeding at the rate of 0.58% per year (Harrison, 1984). Roose (1970), observed in the humid region of Ivory Coast that runoff and erosion increased 50 and 1000 times by deforestation. Lal (1981) reported that mechanized land clearing increased runoff and soil erosion more than manual clearing methods.

2.2.2 Inappropriate land use

Fire

Fire is widely used as a management tool in the traditional farming systems of the tropics and subtropics , and thus it is an important ecological factor. Fire has both short and long-term effects. The short-term or immediate include a sudden rise in soil and air temperature, depletion of surface cover by denudation, exposure of soil to climatic elements, changes in soil structure and wettability, alterations in soil texture by intense heat, and destruction of soil fauna. San Jose and Medina (1975) observed a decrease in silt and an increase in sand in a burned soil, and changes in its moisture retention properties and water balance. The long-term effect of repeated fires is the change in climax vegetation from forest to savanna. Changes in water balance and loss of soluble bases are partly responsible for the widespread occurrence of plinthite and hardened ironpans.

In tropical rain forest the most traditional form of land use consists of clearing, removing the economically important trees, and burning the remaining aerial biomass. Besides numerous climatic and ecological alterations (Queiroz Neto and Betancourt, 1979; Sioly, 1980; Baiardi, 1981; Fearside, 1982; Salati, 1983; Martins et al, 1989). Burning brings about a temporary increase in available nutrients (Brinkman and Nascimento, 1973), but soil productivity dramatically decreases after two or three years, and the area has to be left under fallow for several years.

Monoculture

The stability of an ecosystem is related to its diversity. The most stable systems (e.g., rainforests) are diverse systems. Simplification of a community decreases its stability. The problems of soil erosion and compaction, nutrient depletion, and shifts in floral and faunal species occur after introduction of monoculture over large tracts of land. The soil erosion is greater on monocropped than on mixed cropped land (Aina et al., 1977).

Agrochemicals

Indiscriminate use of chemicals has important ecological significance because they adversely influence soil biological activities. Soil fauna activity influences soil physical properties and crop residue decomposition. The important effect of faunal activity on soil properties include humification of organic residue, soil mixing and turnover, and the burrowing and tunnelling that create macrochannels and water transmission pores. These activities affect soil aggregation and porosity. The fauna are confined to the top few centimeters of the soil, the zone that also receives most agricultural chemicals and plant growth regulators.

Motorized farm operations

Soil compaction is inevitable consequence of the introduction of mechanized agriculture in the tropics. Silva (1981) reported the effects of mechanized cultivation on the bulk density and porosity of an oxisol. The mechanized cultivation decreased total porosity at 0 to 30 cm depth from a mean value of 55% to 27%.

For an Alfisol in Nigeria Lal (1985) observed significant reductions in water infiltration rate at head points. Maize grain yield for the compacted region was 58% lower than that for the uncompacted soil.

Motorized tillage operation is also a major factor responsible for accelerated soil erosion. Tillage exposes the soil to raindrop impact, enhances the mineralization rate of soil organic matter, and speeds the decline in soil structure.

2.3 PROCESSES

Processes of soil degradation are the mechanisms responsible for the decline in soil quality. Lal and Stewart (1990) define three principal types of degradation: physical, chemical and biological. Each of these types has different processes of soil degradation (figure 1).

The soil degradation processes influence edaphic factors that result in low crop yields. The more important soil degradation processes in the tropics are:

2.3.1 Natural processes

Mineral material is exposed at the Earth's surface as a result of: erosion, eolian deposition, fluvial deposition, colluviation, volcanism, or a combination of these physical processes. Upon exposure to the atmosphere many chemical and physical processes begin to alter the mineral material. The result of these processes are often distinctive soil layers or horizons which have been considered diagnostic (Soil Survey Staff, 1975).

Some of the initial processes can be considered as desirable for plant growth but the majority of the processes lead to less-desirable physical and chemical conditions and thus may be considered to cause degradation of the soil (Hall et al., 1982).

Laterization

Laterization is a general term to describe the process of iron accumulation in soils. Kaolinite is the dominant clay mineral formed as a result of intense weathering, and the soils are very low in nutrients needed for plant growth. The high iron an aluminum content result in complex fertility management problems, and where the iron has hardened into ironstone, roots are restricted to the upper portion of the soil.

Claypan formation

Translocation of clay, particularly fine clay, to the subsoil (B-horizon) or in situ formation of clay in the B-horizon, result in a physical barrier to roots and to the movement of water. In general the degree of degradation attributable to a clay-pan soil is a function of the B:A clay ratio and the distance over which the increase in clay takes place. The abrupt increase in clay would limit rooting, particularly where the soil lacks strong structure. The presence of sodium in the clay-pan or argillic horizon of the soil creates

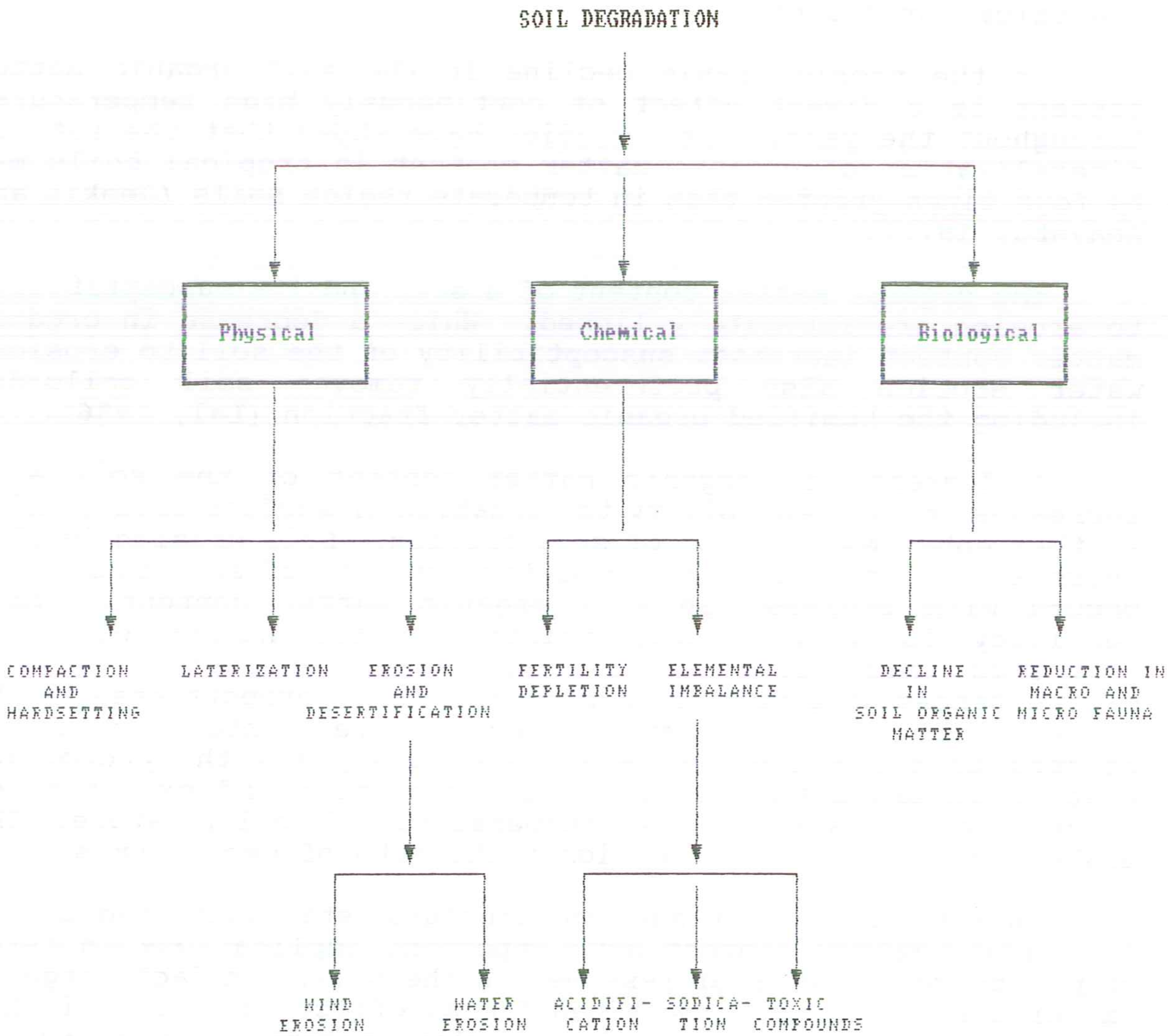


Figure 1.Types and processes of soil degradation (Lal and Stewart, 1990)

an even more limiting environment for rooting, and is restrictive to water movement because of dispersion of the clay (Lal et al., 1989).

2.3.2 Man-induced processes

Biological processes

In the tropics rapid decline in the soil organic matter content is a direct effect of continuously high temperatures throughout the year. Some studies have shown that the rate of mineralization of organic matter content in tropical soils may be four times greater than in temperate region soils (Jenkis and Anayaba, 1977).

The organic matter content of a soil and its susceptibility to erosion are intimately linked. While a decrease in organic matter content increases susceptibility of the soil to erosion, water erosion also preferentially removes soil colloids, including the humified organic matter fraction (Lal, 1986).

A decrease in organic matter content of the soil also increases its susceptibility to formation of surface crust, which further enhances the risk of soil erosion. Soil erosion is also increased by the reduction in biotic activity of soil fauna that occurs with decrease in soil organic matter content. Soil fertility is very closely related to the number of micro organisms which live in it and, except in certain unusual circumstances, the size of this population is proportional to the soils organic matter content. Organic matter content is in turn related to the volume of vegetative cover, and the proportion that is returned to the soil. Decomposition and oxidation of organic matter is affected by temperature and soil moisture. The higher the temperature the higher the rate of decay humus.

In addition to decreases in structural stability, reductions in organic matter content have important implications in terms of plant-available water reserves in the soil. In fact, organic matter content may have more beneficial effects on the available water-holding capacity than in the clay content. Rapid decline in soil organic matter content reduces the soil structural stability, increases susceptibility of soils to crusting, increases soil erosion hazards, and decreases plant-available water reserves. Also important are the nutritional implications like decreases in effective cation exchange capacity (ECEC), acidification and plant nutrients.

Under forest cover the activity of soil fauna, e.g., earthworms and termites, plays an important role in bringing the fine particles to the soil surface. Nye (1955) stated that termites transport annually about 0.025 mm of the fine earth fraction to the soil surface. Reductions in soil biological activity decrease the net clay movement to the soil surface, decrease soil porosity, and increase the surface runoff and sediment transport in the overland flow.

Nutrient depletion and leaching

Nutrient depletion by vegetation removal, leaching runoff erosion and volatilization results in the loss of soil fertility. Loss of bases and increases in acidity by leaching are direct results of decline in soil colloids. The leaching losses of nutrients to the subsoil are increased when deep-rooted perennials, which would otherwise effectively recycle them, are absent.

Leaching is more likely to be a problem where rainfall is high, on sandier soils, and where there is little slope, so that drainage is through the soil.

In many high rainfall regions the soils are already quite seriously leached, and low in plant nutrients (tropical rain forest). But under natural conditions many such areas have a heavy vegetation cover, especially when temperatures are high. A large proportion of the available nutrients are retained by this vegetative cover. If the vegetation is removed the fertility of the soil falls very rapidly (FAO, 1983).

Soil compaction and surface crusting

An important process leading to soil degradation is the deterioration of the structural properties of a soil and of its ability to regulate water and air movement through the profile. Structural degradation, caused by a decline in soil organic matter and clay content and reduction in biotic activity, leads to crusting, compaction, reduced infiltration rate and low available water-holding capacity, increased soil detachability, and accelerate runoff and soil erosion. High erosion risk is a direct consequence of deterioration of soil structure.

Decline in soil organic matter content, degradation of soil structure, and drying accompanied by high soil temperatures generally lead to consolidation and compression by mechanisms not well understood yet. A hard and compact soil can limit the penetration of plant roots, it will also be poorly aerated and therefore a less favorable environment for plant roots and micro organisms.

When the vegetative cover is removed and the structure breaks down due to cultivation and oxidation of organic matter, the finer soil particles are more easily washed downwards to fill and plug the pores and spaces in the subsoil.

Soil erosion

Soil erosion is an important process responsible for widespread soil degradation and decertification. According to some estimates the topsoil of the world is being depleted at the rate of 0.7% per year (Brown and Wolf, 1984). The FAO (1984) estimated that if soil erosion continues unchecked between 1975 and the year 2000, about 18% of the rain-fed cropland of the developing countries of the tropics will be lost and the rained crop productivity will fall by about 29%. According to Lal, et al., (1989) the solution to the problem of erosion and soil degradation lies in (i) quantifying erosion rates for different ecologies, (ii) establishing cause and effect relationships for various land uses, (iii) determining the acceptable level of erosion for different soils and ecologies, (iv) determining economic and ecological implications of both on-site and off-site damages, and (v) developing farming systems to prevent soil erosion (Lal, et al, 1989).

Sheet erosion is the more or less uniform removal of soil from the whole surface of the land, and it is often not very noticeable, even when it is taking place at a fairly rapid rate. Rill erosion is generally the next stage after sheet erosion. Where there is a concentration of water, rills or channels, a few centimeters deep, are formed. These are small enough to be removed by cultivation, and the fact that serious erosion is taking place and that the whole land surface is being lowered, may be not be realized. Gully erosion means the widening and deepening of channels which are already so large as to be uncrossable in normal cultivation.

Erosion by water may be considered as consisting of two parts; first the separation of the particles, and second their transport or removal by runoff. The major physical factors controlling the rate of erosion by water are:

- Rainfall. The power of rainfall to produce erosion (erosivity) is related to its amount, intensity and distribution, and is therefore a factor of climate.

- Vegetation or soil cover. Where there is vegetation growth of they intercept and absorb the force of the rainfall, and the amount of energy thus intercepted and neutralized is directly proportional to the amount of land surface covered by the vegetation (FAO, 1983). In addition fallen litter and plant roots protect the soil and improve its structure, infiltration rate and moisture storage capacity, and retard runoff. Vegetative cover also influences the effect of sun and wind on the soil surface and these in turn affect its erodibility.

- Topography. The degree of land slope has a very strong influence on the amount of erosion. Soil losses from steep slopes are much greater than from gentle slopes. Length of field and slope are also important. Both effects (slope and length) are probably related to an increase in the quantity, velocity, and turbulence of runoff. Surface roughness will retard runoff and decrease its quantity because of increased surface ponding.

- Soils. Soils vary in their resistance to erosion (erodibility). Part of this resistance is inherent in the soil, and is related to texture (mainly clay content) and amount of organic matter, and part depends on soil condition and depth.

2.4 RESEARCH RELATED TO SOIL DEGRADATION IN TROPICAL RAIN FOREST (AMAZON BASIN)

There is little information about the nature of changes in soil characteristics after deforestation and its variability in time; most of the data concern forest production and structure (Klinge, 1983). However, it was reported that deforestation induces a decrease in the activity of soil microorganisms (Santos and Grisi, 1981; Cerri et al., 1985; Chamorro and Garcia, 1989), in soil porosity (Chauvel, 1982; Chauvel et al., 1991), and modifies the amount and nature of soil organic matter (Manarino et al, 1982). The absence or modification of plant cover also brings about changes in soil temperature (Mauri, 1979; Diniz and Bastos, 1980; Santos and Grisi, 1981) as well as in infiltration (Franken et al, 1982).

Eden et al., 1991 examined the effect of clearance of evergreen forest for cattle pasture in the northern of Roraima (Brasil). In this area Coloniao (Panicum maximum Jacq.) and Kikuyo grass (Brachiaria humidicola) are commonly established on cleared forest land. They found that topsoil bulk density increases over time in new pastures, and also available nutrients decline from the enhanced levels that prevail after initial clearance and burning. In particular available P is low in the acid soils and probably limiting to pasture growth.

Cerri et al., 1991 in a research carried out in the central Amazon rain forest, near Manaus (Brasil), about the nature and behavior of organic matter in soils under natural forest, and after deforestation, burning and cultivation, found by means of lysimeter studies that burning and subsequent decomposition of the above-ground organic residues resulted in a loss of water - soluble nutrients, mainly nitrate and mineral cations, together with soluble organic anions. Even though a well-managed pasture of Brachiaria humidicola was installed following burning, the organic matter content of the 0-0.2 m soil layer decreased by 25% in two years, because the decomposition of the humus of forest origin was faster than the input of humus of pasture origin. After this time, these two processes were reversed, and soil organic-matter content was stored in about eight years. measurements of natural carbon 13 show that the proportion of soil carbon of grass origin was about 20% after two years, and 50% after eight years of pasture.

Plamondon et al, 1990 studying the effects of different land uses on soil fertility and water quality in Oxapampa (Peru), found that replacing the natural forest by pastures and crops decreased the organic matter, nitrogen, phosphorus, and potassium content of the soil. In addition, the increase in exchangeable aluminum caused a substantial decrease in fertility three or more years after land-clearing.

3. GENERAL DESCRIPTION OF THE STUDY AREA

3.1 LOCATION

The study area is situated in the southern part of Colombia, in the Caqueta department within coordinates 74°31 and 76°22'W longitude and 0°5' and 2°58'N latitude. Covering an area of about 2'500.000 has (approximately 35% of the Department and 3% of the Colombian Territory). The location of the area under consideration is shown in figure 2. Its northwestern limits are the Departments of Meta and Huila while the southern boundary is the Putumayo intendencia, and its western limit is approximately the subcatchment of the Caguan river.

3.2 HYDROLOGY

All main rivers draining in the area belong to the Caqueta river basin. Two tributaries of the Caqueta river are the main courses in the study area: Orteguaza and Caguan both draining in NW to SE direction. (Figure 2).

The main tributaries of the Orteguaza river are: Peneya, San Pedro, Hacha, Bodoquero, Pescado and Fragua and the main tributaries of the Caguan river are: Guayas, Pato, Riecito, Nemal, Sunciya and Anaya rivers.

3.3 GEOLOGY AND GEOMORPHOLOGY

The major past events that have contributed to the geological development of the region have been the epirogenetic movements occurred since the Cretaceous and related to the Cordillera Oriental formation, ending at the boundary between the Pliocene and Pleistocene. During this uplifting period, erosive processes dominated the formation of the Tertiary Landscape.

During the late Pleistocene and Holocene periods the formation of the actual landscape continued with the erosion and redeposition of sediments down slope onto the broad excavated valleys.

Tectonism, erosion and sedimentation influenced the actual shape of the area and the main landscapes distinguished in the area are: mountain, piedmont, hilland and valley. See figure 3.

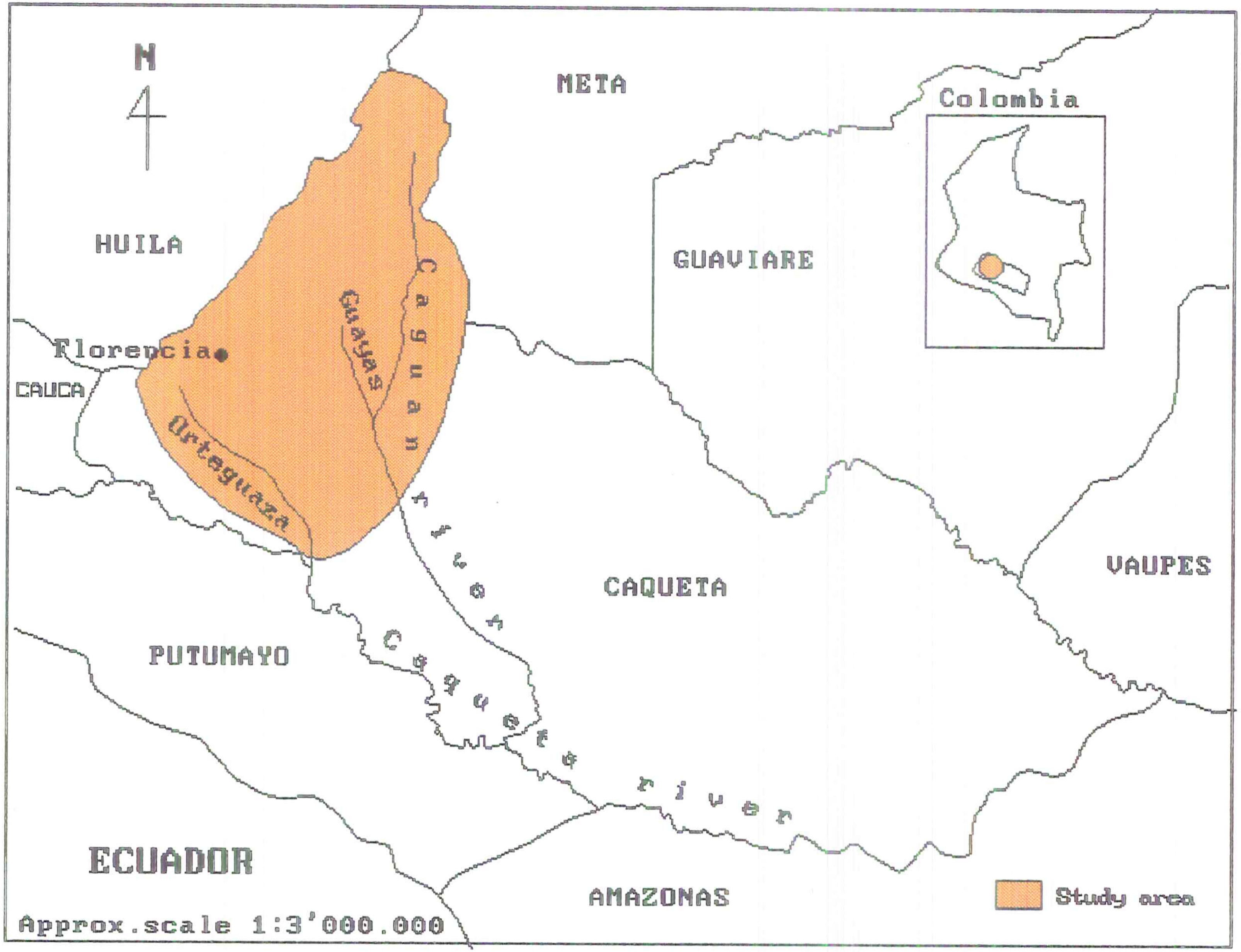


Figure 2. Location of the study area

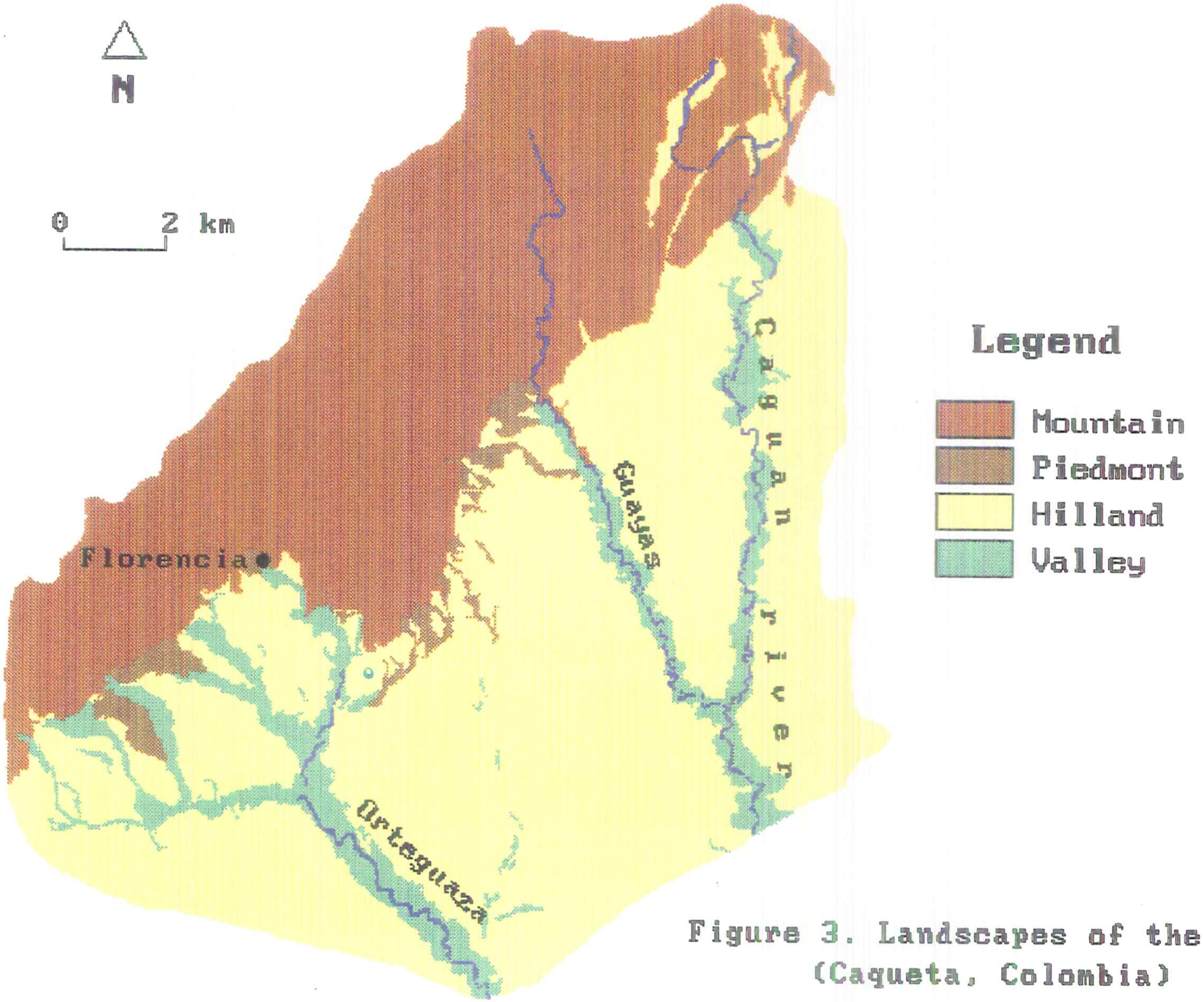


Figure 3. Landscapes of the area
(Caqueta, Colombia)

3.3.1 Mountain

The mountain landscape consist of igneous metamorphosed formations, mainly precambrian characterized lithologically by quartzite, amphibolites, migmatites, charnoquites and gneisses.

There are sedimentary, metasedimentary and igneous rocks. The main relief forms are: Ridge and chevron, creston and hogback. See figure 4.

3.3.2 Piedmont

The piedmont is mainly a depositional area formed during the pliopleistocene, this landscape has been dissected and is composed by colluvial-alluvial sediments. The main relief units are glacis and fans and vale. See figure 4.

3.3.3 Hilland

These unit is composed by variegated claystones deposited over sandstone and some conglomerates.

The main relief forms are hill, vale and mesa. Between the hills there are narrow colluvio-alluvial vales formed by the work of the drainage and are the consequence of high dissection. See figure 4.

3.3.4 Valley

This unit was formed by the accumulation of alluvial sediments deposited by the streams during the quaternary. In this landscape two main relief forms are present: terraces and Floodplain. See figure 4.

3.4 CLIMATE

The climate of the area varies from cold pluvial in the mountain to warm very humid in the piedmont, hilland and valley. See figure 5.

3.4.1 Precipitation

The distribution of the rainfall is monomodal. The highest amount of rainfall is registered in June and the lowest values are found between December and January. The highest value is 3624 mm mean annual in the western part of the area and 2572 mm mean annual in the northeastern region. The mean annual precipitation for the entire area is approximately 3300 ml. See Figures 6 and 7.

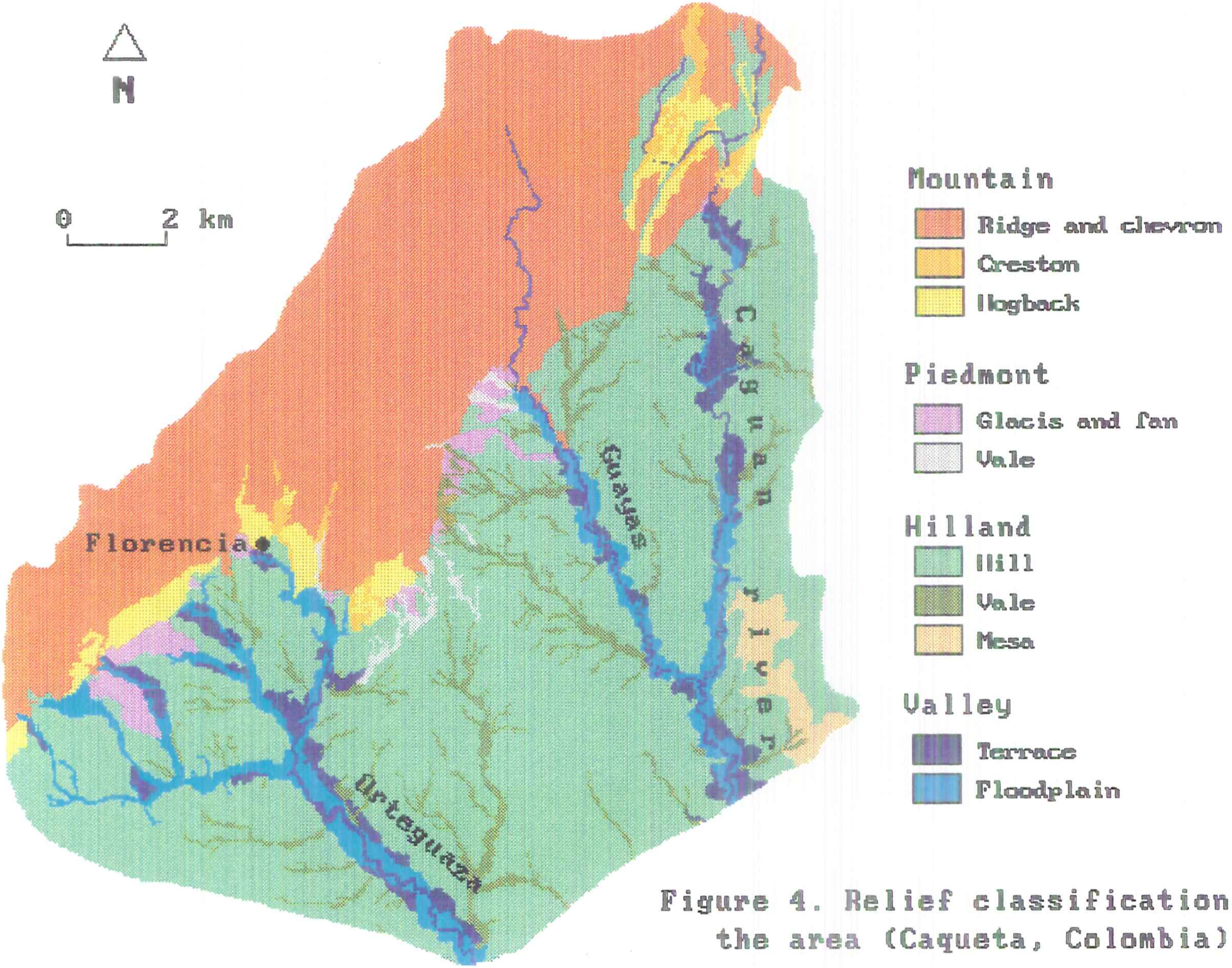


Figure 4. Relief classification of the area (Caqueta, Colombia)

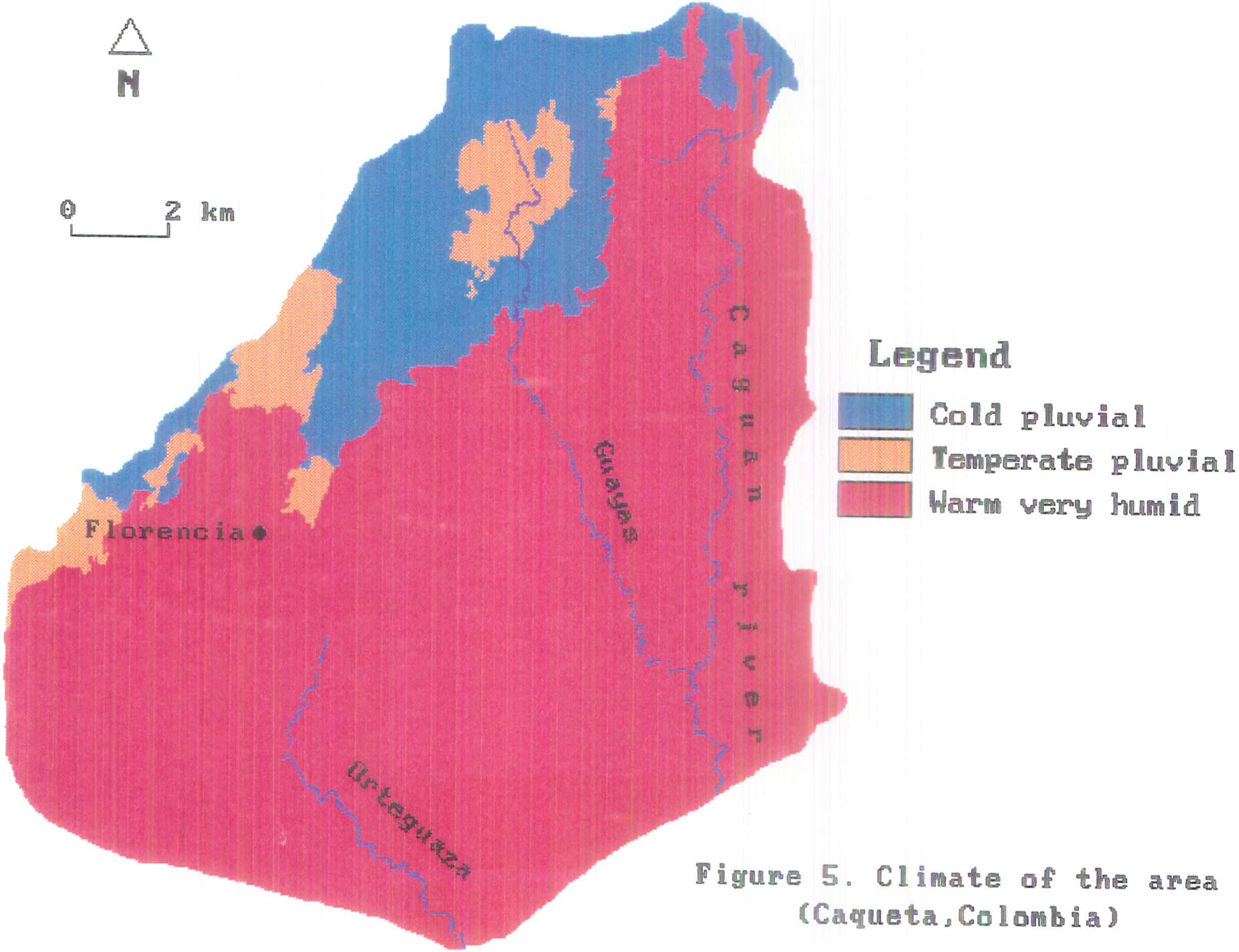


Figure 5. Climate of the area
(Caqueta,Colombia)

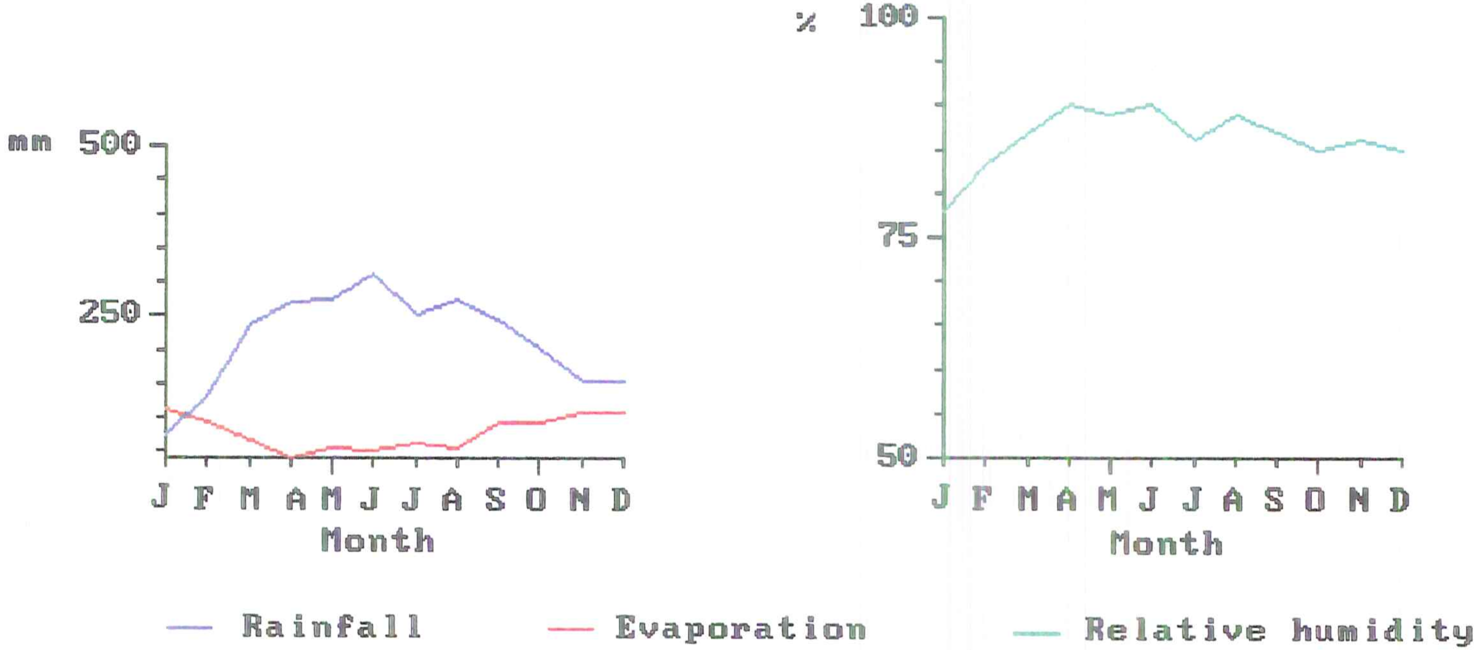


Figure 6. Annual Distribution of Climate
Tres Esquinas Station 1975 - 1987
(Caqueta, Colombia)

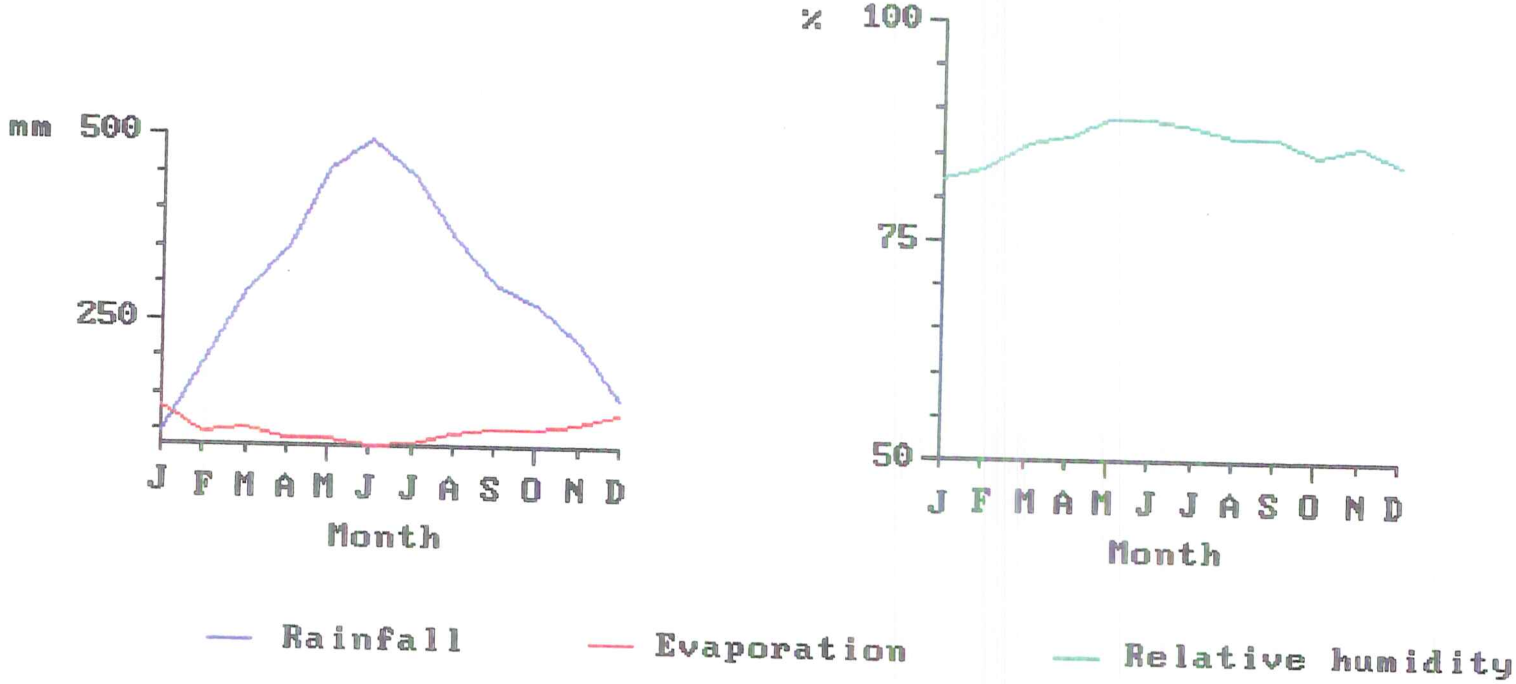


Figure 7. Annual Distribution of Climate
Aeropuerto Station 1972 - 1988
(Caqueta, Colombia)

3.4.2 Temperature

The temperature throughout the area is very constant during the year, does not vary in more than 4°C. The lowest temperature value is 23°C in the western area and 26°C is the highest value in the southern part of the area. See tables 1 and 2.

The period with the lowest temperature is in july and the highest in december, January and February. The mean annual temperature is 25°C.

3.4.3 Relative humidity

The behavior of the relative humidity is similar to the precipitation, the highest values occur during the highest precipitation time and the other way around. The values of the relative humidity are between 78 and 90%. In general the area has a relative humidity of 86%. See figures 6 and 7.

3.4.4 Evaporation

In general the area has less evaporation when the precipitation is high and temperature is low. The highest value is 125 mm and the lowest is 41.4 mm. See tables 1 and 2 and figures 6 and 7.

Table 1. Meteorological data for Tres Esquinas station, located in the south part of the study area, for the period of 1975-1987.

Month	Rainfall mm	Temperature °C	Relative humidity(%)	Evaporation mm
January	74.1	26.1	78.0	110.1
February	130.8	25.8	83.0	94.5
March	235.6	25.3	87.0	65.6
April	271.7	25.1	90.0	41.4
May	272.8	24.8	89.0	56.7
Jun	311.7	24.0	90.0	52.8
July	252.1	23.8	86.0	64.4
August	273.1	24.3	89.0	56.6
September	243.3	25.4	87.0	91.8
October	201.3	25.8	85.0	91.8
November	153.6	25.5	86.0	106.2
December	153.6	25.8	85.0	109.9
	-------	------	-------	--------
Mean annual	214.4	25.1	86.0	78.4

Table 2. Meteorological data for the Aeropuerto Station located in the west part of the study area, for the period of 1972-1988.

Month	Rainfall mm	Temperature °C	Relative humidity(%)	Evaporation mm
January	98.6	26.0	82.0	132.1
February	188.6	25.9	83.0	98.9
March	290.4	25.3	86.0	103.4
April	349.0	25.0	87.0	89.9
May	456.9	24.8	89.0	91.3
Jun	493.2	24.3	89.0	81.5
July	446.6	23.8	88.0	82.3
August	363.4	24.3	87.0	96.4
September	298.8	24.6	87.0	102.9
October	273.1	25.3	85.0	104.1
November	220.0	25.5	86.0	110.0
December	145.2	25.6	84.0	124.9
Mean annual	302.0	25.03	86.0	101.5

3.5 LAND USE AND VEGETATION

There is a high diversity in the vegetation of the area and it depends on the degree of human influence.

The most common species of the secondary forest are guarumo (Cecropia sp), guamo(Inga sp) and palma canangucha(Mautia flecuosa).

In areas where the human influence is less due to inaccessible areas it is usual to find more commercial species like sangre toro (Virola sp), laurel(Nectandra sp) and guarupayo (Tapirica guianensis). In general the most common species in the area are yema de huevo (Brosimun sp), palma cachuda (Liatea coneto), palma mil pesos (Jessenia batua), caimo blanco (Pouteria sp) and guamo (Inga sp), etc.

Approximately 40% of the area is used for cattle ranching in natural grassland while agriculture is constrained to a 20% of the area. The main crops are rice, maize, cassava, African palm (Elaeis sp.), and caucho (Hevea guianensis).

In general the main land use in the area is cattle ranching, followed by forest and then agriculture.

3.6 SOILS

3.6.1 Mountain

The dominant soils in this landscape are Entisols, Inceptisols and Oxisols. These soils have been developed from granites and gneisess in the ridge and chevron relief form. Having slopes ranging from 25 to 50% and in some parts greater than 50%, they are generally dark brown to brown yellowish soils, well to excessively drained, with acid reaction, low fertility and high interchangeable aluminum.

The main subgroups found in these area are: Oxic Dystropepts, Typic Troporthents, Typic Kandiudox, Typic Humitropepts, and Typic Dystropepts. In general these soils are susceptible to erosion because of the steep slopes in the area.

3.6.2 Piedmont

The soils that occur in Glacis and Fan are developed from colluvio-alluvial sediments. The main soils of the area are Oxisols, Ultisols, Inceptisols and Entisols, they have, in general, brown to dark brown colors, they are deep and well drained soils with high Al content and low fertility. The main subgroups are: Oxic Dystropepts, Inceptic Hapludox, Typic Paleudults, Aquic Dystropepts, Fluventic Dystropepts and Typic Tropofluvents.

3.6.3 Hilland

The soils located in the Hills are developed from tertiary variegated claystone from the Pliopleistocene period. Sheet and rill erosion occur on these soils. The slope ranges from 7 to 25%. These soils are moderately fine textured in the first horizon and fine in the subsoil, well drained, very acid and with low fertility. The main soils that can be found in this relief-form are Entisols and Ultisols and the main subgroups are Typic Paleudults and Typic Hapludults. Typic Paleudults are moderately deep and Typic Hapludults are deep and limited by high interchangeable Al content.

In the Hills, soils are developed from quartzitic sandstone and tertiary variegated claystone in slopes that vary from 7 to 50%. These soils are susceptible to erosion, very acid with high interchangeable Aluminum content and low fertility. The main soils are Entisols and Ultisols and the main subgroups are Typic Quartzipsamments, Typic Hapludults and Plinthic Paleudults.

3.6.4 Valley

Most of the soils in the terraces are developed from fine to moderately fine alluvial sediments in slopes that vary from 3 to 7%. The main soil orders are Ultisols, Inceptisols and Entisols and the main subgroups are: Typic Kandiudults, Typic Paleudults, Oxic Dystropepts, Aeric Tropaquepts, Fluventic

Eutropepts, Aquic Dystropepts, Typic Dystropepts and Typic Quartzipsamments.

In this relief-form, soils are developed from deposits of quartzitic sandstone. These soils are Typic Quartzipsamments and are characterized by coarse textures, brown to dark brown colors, well drained, deep and very acid, high Al saturation and low fertility

In the floodplain soils developed from alluvial sediments are present. These soils have in general brown and grey colors, moderate fertility and are poorly drained on slopes smaller than 3%. The main soils are Entisols and Inceptisols and the main subgroups are: Fluvaquentic Eutropepts, Typic Tropofluvents, Aquic Dystropepts, Typic Tropaquents, and Aeric Tropic Fluvaquents.

4. SOFTWARE PACKAGES AND METHOD

4.1 SOFTWARE PACKAGES

The database implementation for land degradation was performed at ITC using ILWIS, ORACLE and ALES.

4.1.1 Ilwis

The interaction between expert knowledge and natural resources has been the main ITC interest in developing ILWIS. The general objective of ILWIS is to contribute to the improvement of the availability and quality of information on which watershed management can be based (a watershed being the "best delimitable unit in which [humans and natural resources] interrelationships could be observed and modelled"; Valenzuela, 1988).

ITC's ILWIS system is a knowledge-base system combining a structure by means of which subroutines and programs (packages) - including its own digital image processing program- can be combined and used flexibly. These subroutines/programs are here in called "methods". The ILWIS structure also incorporates a soil information system providing the data necessary to answer questions about soil resources/potentialities of a given area.

Geometric (spatial) attribute data

Digitalization, i.e. the transformation of spatially-oriented (analogue or geometric) data from maps into a computer-compatible (digital) form is usually a time-consuming, costly operation in the development of a geographical information system (GIS) as it requires editing operations to verify the digital data against the original map in order to subsequently correct analyst or hardware/software induced errors.

Graphics database: analogue data (maps) are converted into a digital format using a table digitizer (digitizing is done in a free-hand format) and entered into the Graphics database with easy-to-use menu driven procedures. The data are captured and stored in vector format and converted into a raster format. Raster-to-vector conversion routines are also available in the system. Cartographic modelling uses the raster data structure.

Remote sensing products are also part of this database, making possible to overlay remotely-sensed data with GIS-derived data. The integration of image-processing techniques with conventional GIS manipulations offers the possibility of optimising the information extraction (data-to-information transformation) and improving the data quality for modelling or rule-base operations.

Attribute data base: this database provides facilities to perform the following operations commonly required in manipulation of attribute data:

1. Adding new data sets to the database
2. Inserting new data into existing data sets
3. Retrieving data from existing data sets
4. Deleting data from existing data sets
5. Removing data sets from the database

The system's database includes data corresponding to each of the modules which have a graphic representation and the related attribute data. The graphics data (maps) are entered into the system in a vector format using the digitizing capabilities. Remote sensing products, as a source of data,can be also automatically entered into the cellular (raster) graphical database. The main system's modules are:

- the base module: including data on administrative boundaries, transportation and communications facilities, settlements, subwatersheds and other related information.

- the soil mapping unit (SMU) module: describing and explaining the main land units and their corresponding soils.

- the land cover/land use (CUMU) module: has the main characteristics of the vegetative cover and the dominant land use type in the watershed, including a classification of cover types (based on nature, density and height) in addition to the generally-accepted land use classification.

- the water module: presenting information useful in hydrologic models and water balance calculations (including station data like rainfall, evaporation factors, discharges, etc). A large number of standard processing methods are included, which are used for hydrologic analysis and to supply input data to other operations and models (such as agro-climatology, crop yield modelling, erosion and others).

- the socio-economical model: providing information concerning social and economic characteristics in the area. Farming systems are the basis of the economic evaluation and planning function of the system. Data concerning the nature of the farming system are collected on the basis of the land cover/land use map to include geographic variations.

4.1.2 Oracle

Non-geometric (descriptive) attribute data

The data base management system (DBMS) ORACLE has capabilities to solve many of the conflicting problems which arise in large integrated databases subject to a continuous changes. The software provides a desiderable level of database interface with a suitable language to query/update information and offering simultaneous access for many users (with immediate response for their information requests) in a relational data model. This high-level language is called SQL (structured Query Language), uses a block-structured format of English words and was developed by IBM (Aronnoff, 1989).

The data model, on which a database system is based, consist of both the types of data structure used to represent data entities and associations between data entities in the database, and the set of primitive operations, commonly referred to as data manipulation (sub) language.

Figure 8 shows the configuration of the ORACLE relational DBMS.

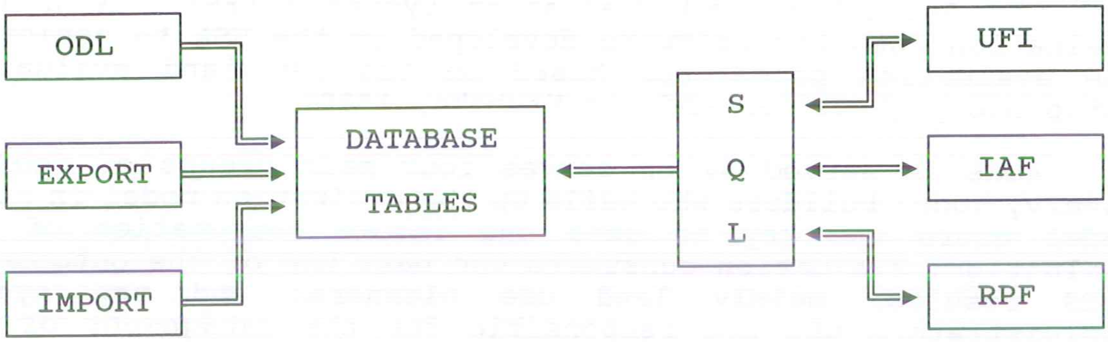


FIGURE 8. Configuration of the ORACLE relational DBMS

The description of the above-shown components is as follows:

1. STRUCTURED QUERY LANGUAGE (SQL). Developed by IBM researchers in 1974 provides conversational English communication between the user and the database for data query and manipulation operations (data retrieval, insertion, updating and deletion) as well as data definition (creation of tables) and control (securing private data).

2. USER FRIENDLY INTERFACE (UFI). Is the component for using SQL commands, transfer them to the database system and receive the answers to the queries on the screen.

3. INTERACTIVE APPLICATION FACILITY (IAF). Permits the creation of forms for inputting, updating a making queries in the database using the Interactive Application Generator (IAG) to define those forms and the Interactive Application Processor (IAP) to interact with the database.

4. ORACLE DATABASE LOADER (ODL). Provides input capabilities to load large quantities of data (stored in ASCII files) directly into the database. In addition to the data file ODL uses a control file which describes both the data file and the table into which data are to be inserted. Data modified or created by cartographic manipulations can also be written into the database using ODL, as this facility also acts like and interface between the graphics database and the ORACLE DBMS.

5. REPORT WRITER FACILITY (RPF). Automatically formats the result of any SQL query into a report with column headings and footings, specify totals and other calculations. It is also used to transfer data from the database into the graphics database for cartographic manipulations.

4.1.3 Ales

The Automated Land Evaluation System (ALES) is a land evaluation computer software developed in the USA to assist in the evaluation procedures based on the FAO land evaluation methodology (Rossiter and van Wambeke, 1989).

ALES is served by or serves four main groups of people, namely, model builders who build up the evaluation model in ALES; model users who key in data and invoke computation of the evaluation; evaluation consumers who make use of the outcome of ALES results, mainly land use planners; and the system administrators who are responsible for the management of the system. In reality model builders and model users and system administrators are the same people doing the same job.

The basic feature of the system is that it is an "empty shell, a framework" and for that reason allows an evaluator to build his own expert system based on local knowledge, conditions and objectives.

In ALES the aspect of inferring the value of land characteristic from other discrete land characteristics is also possible whereby a model builder sets up severity levels in which the decision entities are land characteristics but the decision values are land characteristic classes of the target land characteristic for which the tree is defined (Rossiter and van Wambeke, 1989).

Some of the important features of the system are summarized below.

4.1.3.1 Models

This is the most important part of the program. Under models there are six submodels which an evaluator has to construct.These include Land Use Requirement reference list, Output reference list, Input reference list, Land Characteristic descriptions (includes name, units, class abbreviations, class names, class limits, LC>LC decision tree, infer from commensurate LC);Land Utilization Type specification (with subcomponents like name, length of rotation, interest rate, annual and one time inputs, land use requirements, outputs, physical suitability subclass decision tree, economic class limits and land units not rated). Under land units not rated the system allows the evaluator to specify which land units should not be evaluated (units not relevant for the purpose eg. municipality area or very rugged country). Within model building the most gruesome part is the construction of decision trees.

Decision trees

In ALES land suitability is assessed by a set of decision procedures called "decision trees". Decision trees are logical hierarchical multiway keys in which the leaves are results like land quality ratings and the interior leaves are decision criteria such as land characteristic values (Rossiter and van Wambeke,1989). Trees are constructed by the model builder and by use of land data are traversed in the computation process.

According to the Framework for Land Evaluation a land quality is "a complex attribute of land which acts in a manner distinct from the actions of other land qualities in its influence on the suitability of land for a specified use". A land characteristic is defined as an "attribute of land that can be measured or estimated and which can be employed as a means of describing land qualities or distinguishing between land units of differing suitabilities for use."

In building the model the evaluator uses "classified data", that is, data values from a small finite set of possibilities either ordinal (eg. slope classes) or nominal (eg. texture classes).

In ALES it is recommended to cut down on the number of factors under consideration in order to avoid having complex decision trees. Trees grow exponentially with the number of factors and so the more factors considered, the more the number of decision trees to be constructed.

4.1.3.2 Data

This is one of the components of ALES in which the system user defines and enters data into the system. ALES evaluates map units and does so for both homogeneous as well as heterogeneous map units(ie consociation, association or complex). In the case of compound units the evaluator has to specify the proportion of each constituent of the map units so that the respective constituents are evaluated separately.

4.1.3.3 Evaluations

This is the component of ALES which involves computation of the evaluation. ALES can be asked to evaluate a set of combination of LUTS and mapping units. The most important aspect of ALES under this component is the mechanism of the "why" functions which allows the evaluator to asses his own reasoning why certain suitability decisions were made. The system allows an evaluator to query and edit his model and the user his data and LUT specifications.

The other components of the system include printing of evaluation results (possibility to choose results), reporting of results (possibility to choose reports).

4.1.3.4 Evaluation results

In ALES, the evaluation results can be presented in terms as recommended in the FAO methodology, that is, either physical or economic or indeed both. While it has long been argued that the advantage of physical evaluation over economic one is that the results of the former remain valid longer than for the latter, in ALES it is possible to edit economic data that has changed (eg. sudden price changes) and then recompute the evaluation within a few days.

The results are presented in an evaluation matrix. Basically the matrix shows the rating of each mapping unit for each LUT in terms of:-

- physical suitability subclass.
- economic suitability classes.
- predicted gross margin.
- expected yields of crops or other outputs.
- rating for single land qualities.

4.1.4 Materials

The materials for the study included:

- Soils Survey of the area scale 1:250.000 made by IGAC Soil Survey Staff in 1989 (IGAC, 1990)
- Cover map scale 1:250.000 derived from a image of a thematic mapper computer compatible type of 2nd January 1988 and aerial photographs scale 1:30.000 and 1:40.000 (IGAC, 1990).

4.2 METHOD

The methods used in this study can be broadly classified under the following headings:

- Design of a general soil database
- Definition of land degradation variables
- Assessment of land degradation in the Caqueta area in the Colombian Amazon.

4.2.1 Design of a general soil database

The testing of various environmental degradational factors may require a wider approach. Nevertheless this study treats the problem with emphasis on tropical humid condition of the region. The approach adopted in this study is based on the use of existing data from a Soil Survey besides new information that was gained during the execution of the study.

The design of the database must be sensitive to the end user; be appropriate considering the information which is already available; and be sensitive to manpower, financial and resources available for creating such a database. A three-step method for approaching a database design is outlined below:

a. Data need assessment
b. Collection and evaluation of existing data
c. Database design and implementation.

4.2.1.1. Data need assessment

It begins by developing a clear definition of specific uses for inventory information. Typically, this involves meetings and interviews with the users to analyze the exact information types and outputs that are desired.

During these meetings, it is valuable to review the types of information which already have been identified, make a breakdown of the various levels of information currently used; become familiar with the methods of handling, storing and retrieving information, user libraries and catalogues and get an overall understanding of the graphic and thematic areas for user data needs.

Arrangements should be made to collect any data which the user can contribute to the inventory. These data may be in form of maps, reports, bibliographies, aerial photos, satellite images, interviews (useful, but typically not enough). It is necessary to review the existent data in order to analyze the exact data requirements. The data need assessment process is greatly assisted by clearly documenting needs and having users review, discuss and creatively participate in the final definition.

4.2.1.2. Data Collection

This involves the acquisition of graphic information sources such as maps, books, reports, imagery, aerial photography and related documents supplied directly in order to achieve the aim of the study. Data are first grouped into general data need categories.

After a through review of data has been completed and results compared to the data needs, data categories for which reliable coverage do not exist across the study area are identified. Separate data gathering or mapping projects are then designed to ensure that these categories are not omitted from the database.

The fieldwork was carry out in november-december 1990. At this time the data collection that were grouped under 5 headings: general information, physical characteristics, cover characteristics, erosion, degradation and land use data was performed.

4.2.1.3. Database Design

Data file design involves the design of the database. It is based on information needs identified in step one and an assessment of existing information as developed in step two.

The linking of spatial and non-spatial data was done using identifiers, which are common attribute occurrences in both data types . The logical design of the database is illustrated in figure 9.

In order to meet each of the data need requirements, general categories of information and detailed classifications were developed. The data collected were carefully reviewed and consideration was given to the level of detail needed for each category. The classification schemes are structured hierarchically to allow aggregation of classes at different levels of detail, at a variety of map output scales or tabular summary levels.

All classifications developed for GIS need to be expressed as codes to facilitate computerized handling of data. Classification represent descriptive, qualitative or quantitative groups of individual data occurrences in a systematic order. The codes developed to represent each classification can be used as values to generate tabular listing, draw maps, or produce analytical models.

4.2.2 Definition of Land Degradation variables

Figure 10 shows the sequential approach for soil degradation. It involves the factors, processes and the soil properties that change due to the interaction between processes and factors. From this list of soil properties, the relevant soil properties are employed to evaluate the degradation in the Caqueta area.

The status of soil degradation is described by 2 elements:

a. Type

The process causing the displacement of soil material by water and wind; in-situ deterioration by physical, and biological processes.

b. Degree

The present state of the degradation process (none, moderate severe and extreme).

4.2.3 Assessment of Land Degradation in the Caqueta area

Variables of land degradation were structured according to database design concepts. The land degradation database describes the information that are considered relevant for the area.

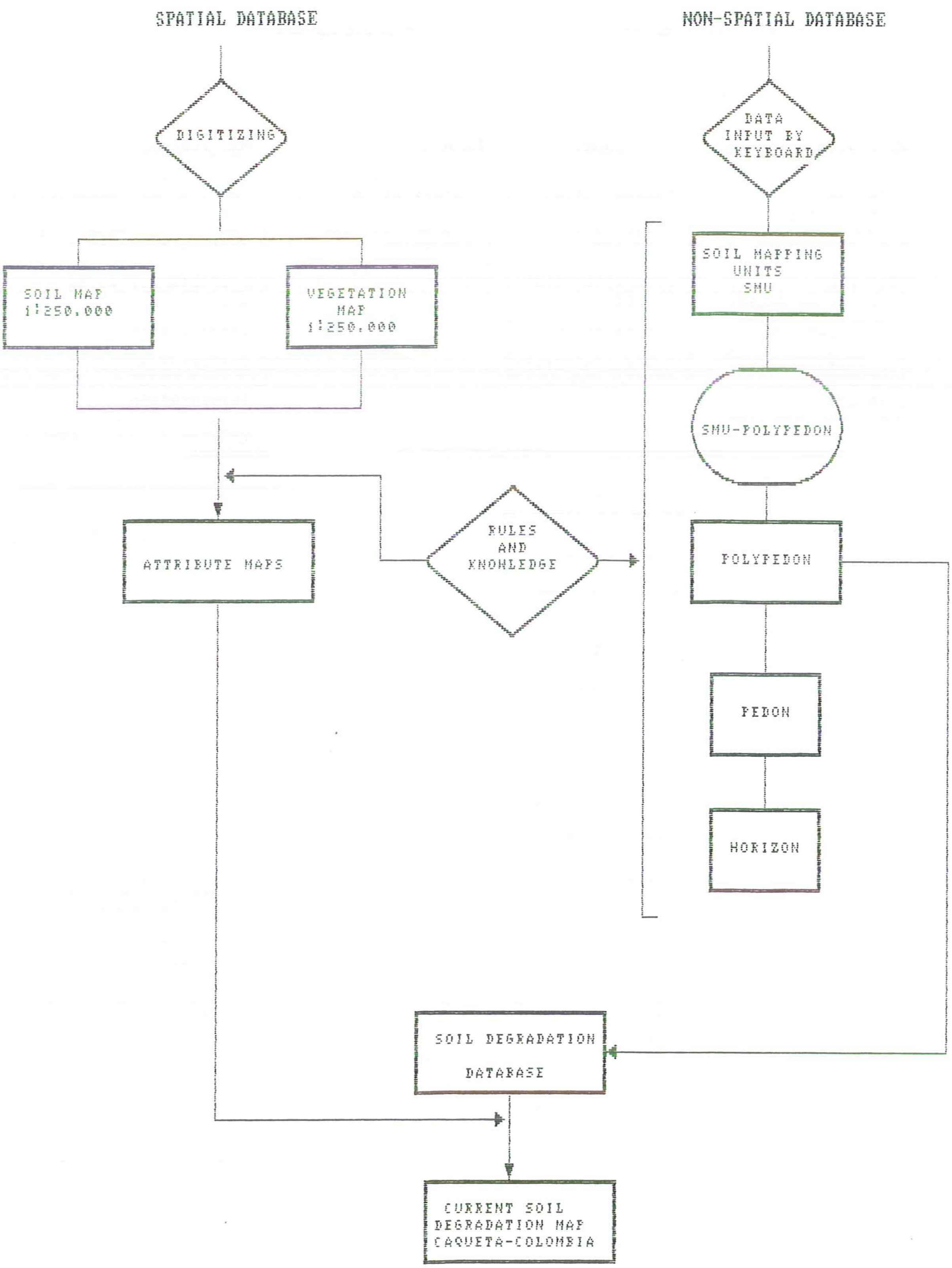


Figure 9. Design of the general soil database

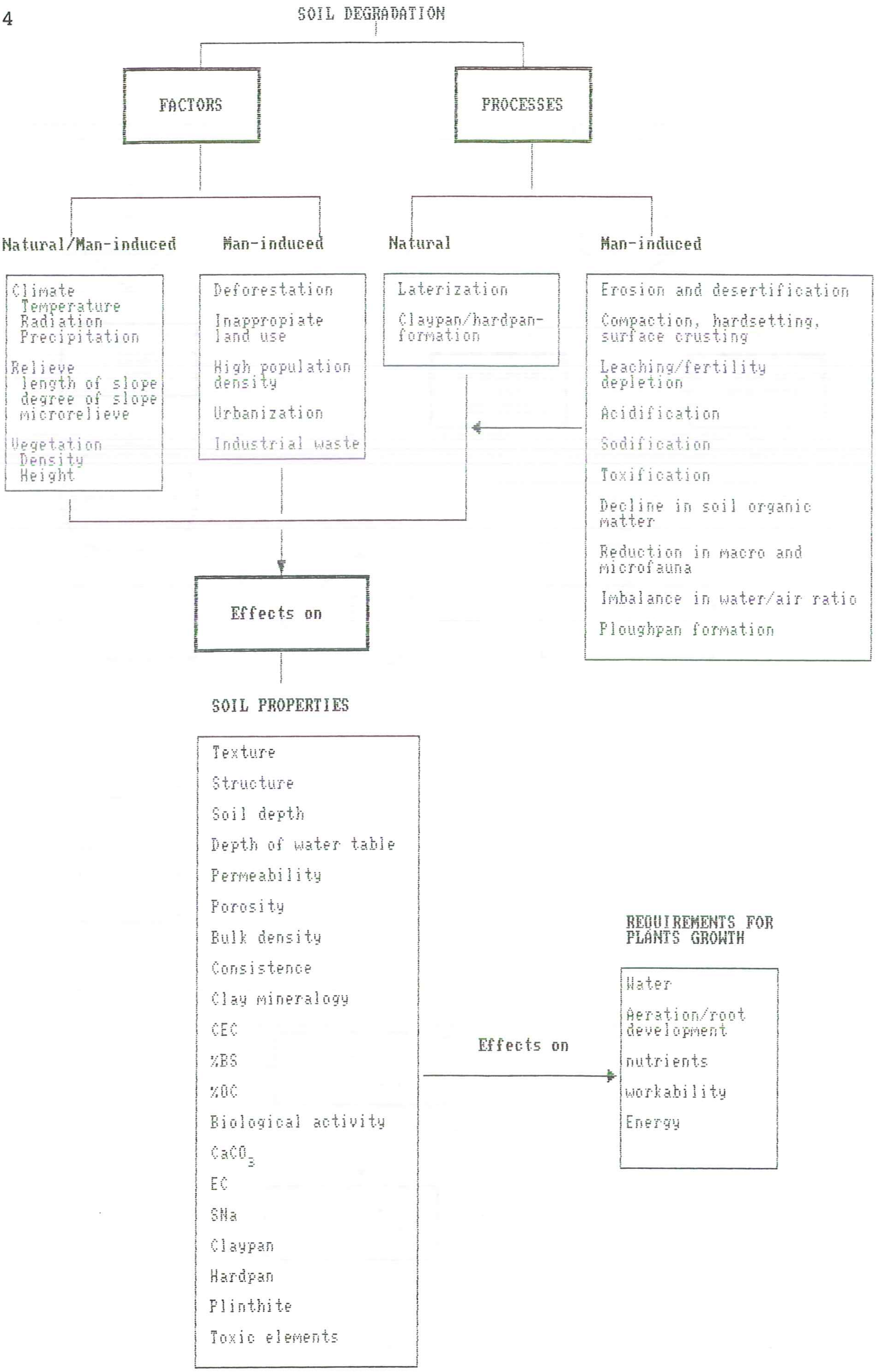


Figure 10. Factors and processes of soil degradation

For the model building some assumptions were made, based on the literature review and the present natural conditions of the area. These assumptions are:

1. The land degradation used in this present model refers to the degradation induced by men,

2. The areas under primary forest are considered as areas with no man induced degradation.

3. Chemical land degradation is not considered due to the natural conditions throughout the area (the soils are low in plant nutrients, with high aluminum saturations and very low pHs).

Figure 11 shows the sequential approach for soil degradation in the Cockade area and the soil properties used as a determining land characteristics in the model.

The main land characteristics are indicated in table 3.

Table 3. Land degradation types, processes and their determining land characteristics for the Caqueta area (Colombia).

SOIL DEGRADATION Type	Processes	Land characteristics
Biological	Biological	Presence of organic layer Biological activity
Physical	Imbalance in water/ air ratio	Permeability Water table depth
	Compaction	Porosity Effective soil depth
	Water erosion	Surface features/patterns

4.2.3.1 Development of land degradation model in ALES (for the Caqueta area)

The Automated Land Evaluation System (ALES) was used for the building of the land degradation model. ALES is a land evaluation computer program based on the FAO land evaluation methodology. The unique feature about the system is the development of a "model" and in particular the building up of decision trees.

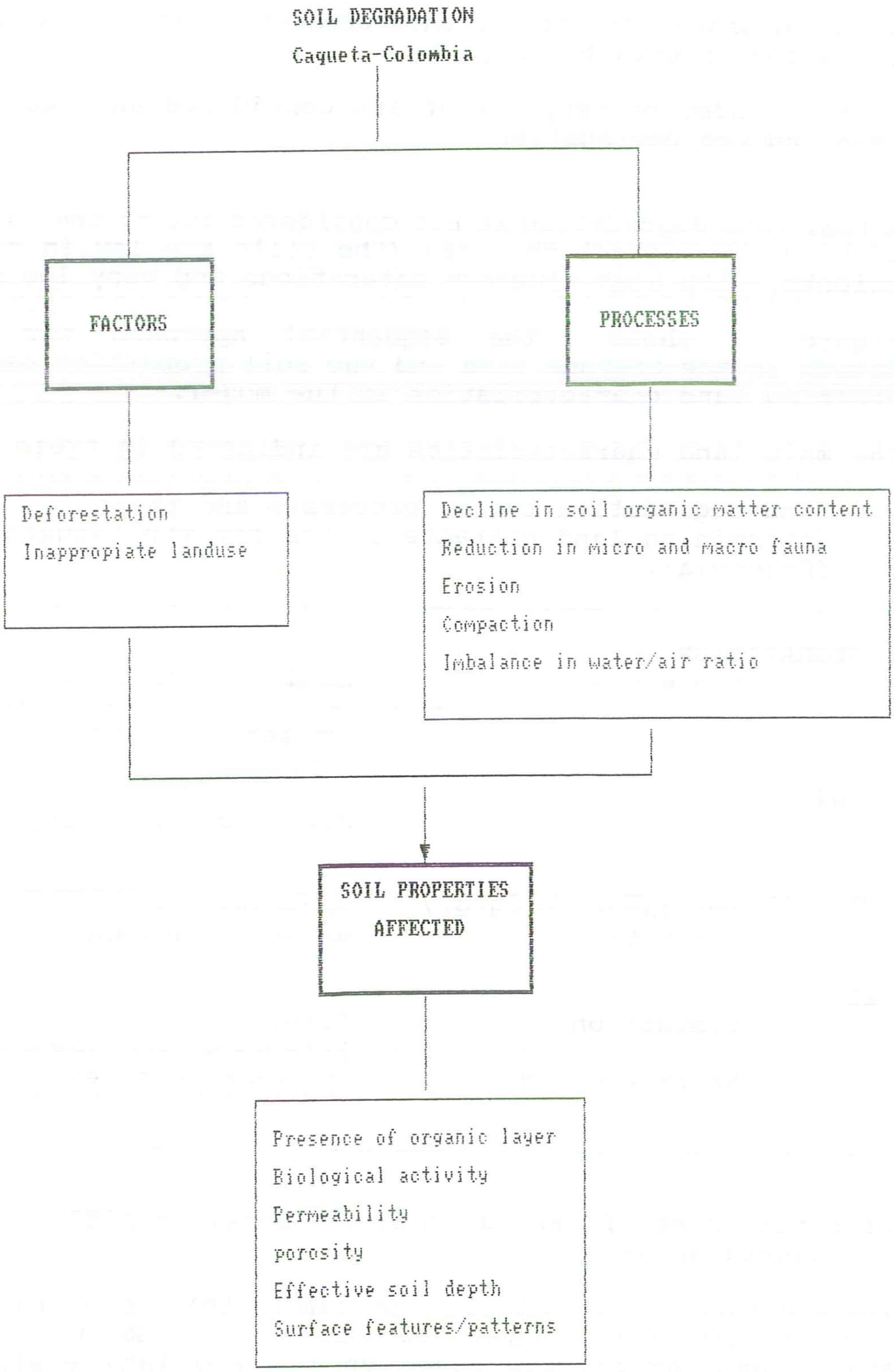


Figure 11. Soil degradation model for the caqueta area (Colombia)

The term model as used in ALES refers to "a set of decision procedures not to a process model or to a statistical analysis. The ALES model is a representation of the judgement of the land use expert, which in turn is a mental model of reality" (Rossiter and van Wambeke, 1989).

DEFINITION OF LAND UTILIZATION TYPE (LUT)

For this study a unique land utilization type was defined, namely land degradation.

DEFINITION OF LAND USE REQUIREMENTS FOR A LUT.

Land use requirements (LUR) were defined in order to get the physical suitability. In this study three land use requirements were adopted: biological, physical and chemical soil degradation.

SEVERITY LEVELS OF LAND USE REQUIREMENTS.

Severity levels of land qualities corresponding to land use requirements refer to degrees of limitations or land quality classes dependent on the specific land utilization type.

The number of severity levels for each land quality were chosen based on the range of variations of the corresponding land characteristics as shown by soil survey data. See table 4.

LAND CHARACTERISTICS.

Land characteristics were used in the model to determine the severity levels of the land qualities listed as land use requirements for the LUT. The term land characteristics is used to refer to diagnostic factors of a LUR.

The selection of land characteristics was based on the same criteria as for LUR.

The definition of classes and class limits for each land characteristic was based on the range of variations shown by the soil survey data of the area.

DECISION PROCEDURES

In this model three decision procedures under land utilization type specification were followed. Decision procedures also called "decision trees" are the means by which land degradation is assessed, and are the heart of an ALES evaluation model. Decision trees were built for each land use requirement and for the overall physical suitability for the LUT.

Table 4. Land characteristics ranges for the Caqueta area (Colombia).

Type of degradation	Diagnostic characteristic	Degree of degradation N	M	S	E	Source
Biological	Organic layer (cm)	>5	1-5	0-1	-	1
	Biological activity	Very high	high	low	Very low	1
Physical Compaction	Effective soil depht (cm)	>150	100-150	50-100	<50	2
	Porosity	Very High	High	Low	Very low	1
Imbalance water/ air ratio	Permeability	moderate	Mod.slow Mod.rapid	Slow Rapid	Very slow very rapid	2
	Water table depth (cm)	>150	80-150	30-80	<30	2
water erosion	Surface features/ patterns	none	sheet	rill	gully	1

N= none M=moderate S=severe E=extreme

1= Data shown by the soil survey of the area (INPA, 1989)

2= Land evaluation for rainfall agriculture. FAO, Soils bullletin 52.

LAND USE REQUIREMENT SEVERITY LEVEL DECISION TREE.

Having defined severity levels for each land degradation requirement, a severity level decision tree was thereafter built for each land degradation requirement. Severity levels of each land quality corresponding to a land use requirement were inferred from a set of discrete land characteristics through a decision tree.

Figures 12 and 13 show the decision trees made for biological, and physical land degradation (land degradation requirements).

PHYSICAL SUITABILITY SUBCLASS DECISION TREE.

In order to determine the final physical suitability of each mapping unit from the set of severity levels of land qualities a physical degradation subclass decision tree was built. This allows ALES to assign a composite physical degradation to a mapping unit.

In this model physical degradation classes on the scale "1", "2", "3", "4" were used. (1=No degradation, 2=Moderate, 3=Severe, 4=Extreme)

In order to reflect the kinds of limitations, the final suitability at subclass level was denoted by lower-case letters or subclass suffixes. The suffixes correspond to the codes of the respective land use requirements (biological and physical) as shown in figure 14.

Only those land use requirements known to have an effect on physical land degradation of the area were employed in building the physical suitability subclass decision trees (since decision trees can become too complex as they grow exponentially with the number of factors used and the number of severity levels per factor).

DEFINITION OF MAPPING UNIT DATA.

In ALES the definition of mapping unit data on which the evaluation is done involves description of mapping units in terms of map unit name, whether it is "homogeneous" or "compound" and the total area it occupies in the survey area; definition of data entry templates which specify the land characteristics for which data is to be entered, and their order in the data entry form that will be filled in by the model builder; entering of data values from the keyboard using one or more data entry templates.

DESCRIPTION OF MAPPING UNITS

Mapping units were described as tabulated on the legend of the soils map in terms of taxonomic classification, relief,

Figure 12. Decision tree scheme for biological degradation (Caqueta, Colombia)

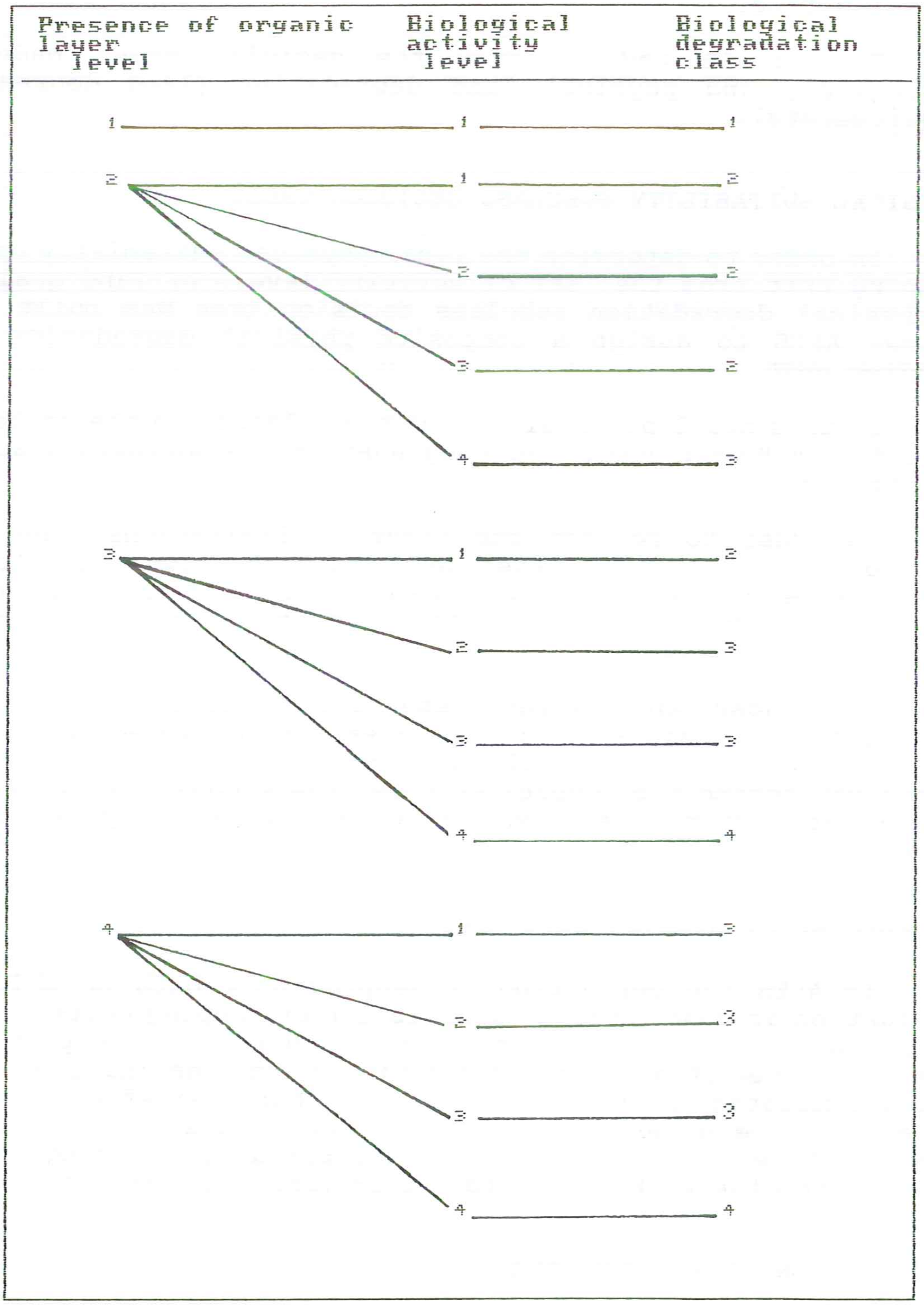


Figure 13. Decision tree scheme for physical degradation
(Caqueta, Colombia)

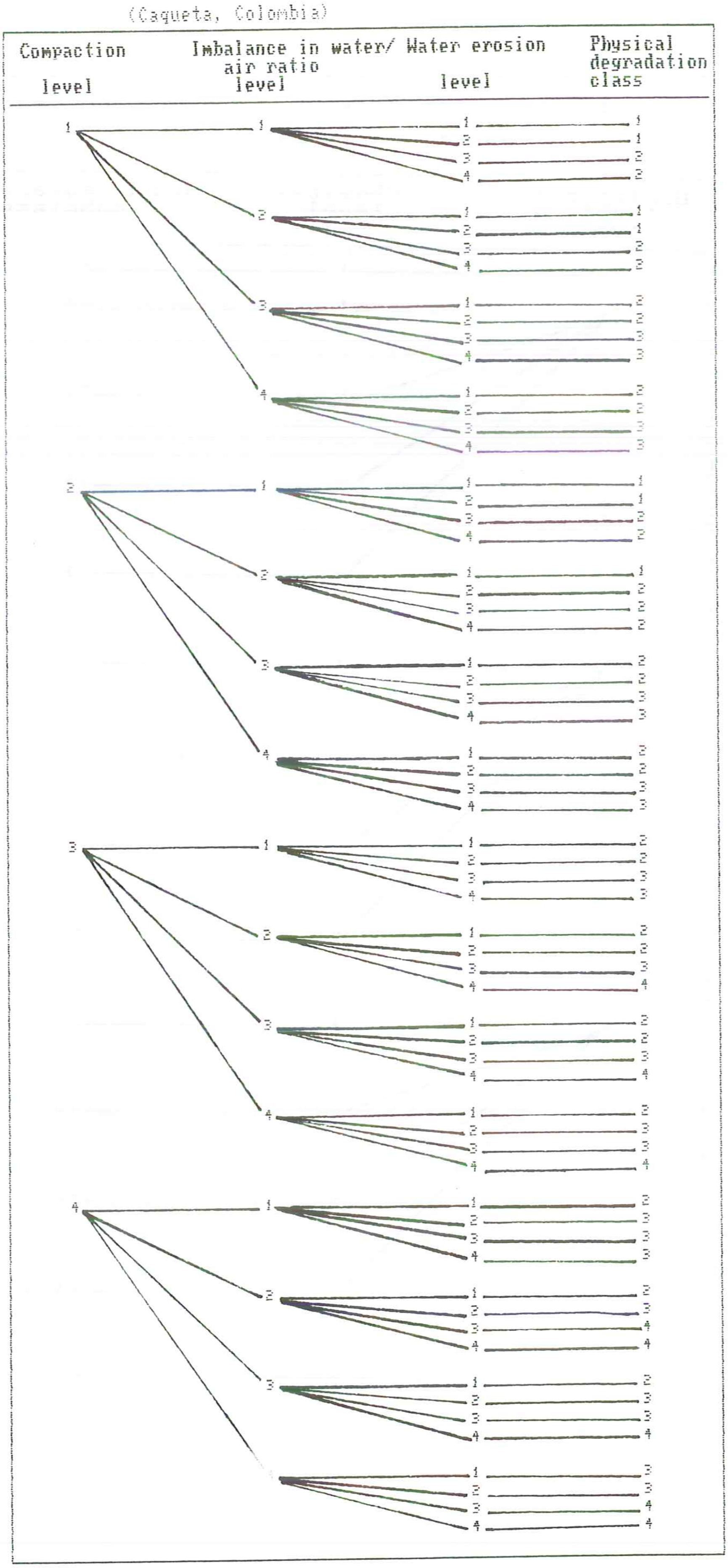
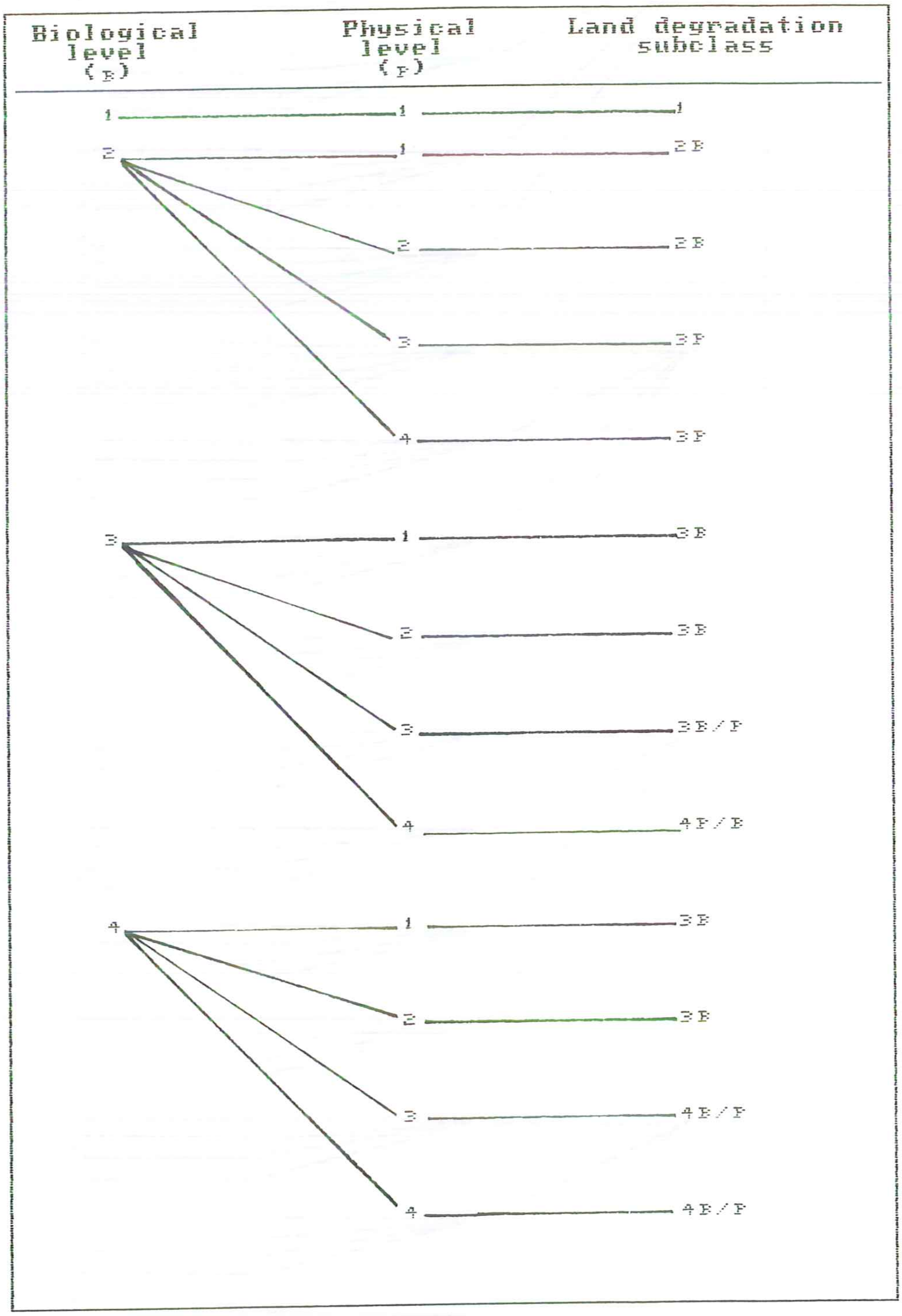


Figure 14. Decision tree scheme for land degradation (Caqueta, Colombia)



5. RESULTS

5.1 NON-SPATIAL SOIL DATABASE

It was decided to use Oracle as a Database Management System (DBMS), for reasons of being a relational DBMS, suitable for use on a micro computer and the possibility to link it to the Integrated Land and Watershed Management Information System (ILWIS), which is being used at the Colombian National Geographic Institute and for practical reasons it was made in spanish.

In oracle the data is stored in tables made up of vertical columns and horizontal rows.

5.1.1 The data model

All data available to the users of the information system are stored in the database. These data describe the external and internal characteristics of the soil which are considered relevant.

The components considered in the design of the soils database were the relationships between:

-Soil mapping units
-Polymorphon
_Polypedons
-pedons
-Horizons

The database structure that was used in order to build up the soils database is shown in figure 15.

Using the entity-relationship approach is necessary to create an entity matching SMU and Polypedon in order to obtain one to one or one to many relationships, because in a logical data structure of a relational database many to many relationships are not allowed.

The entities were created and the pedon and horizon data were coded using the USDA system for taxonomic soils classification and for the others attributes the codification was made (see appendix 1).

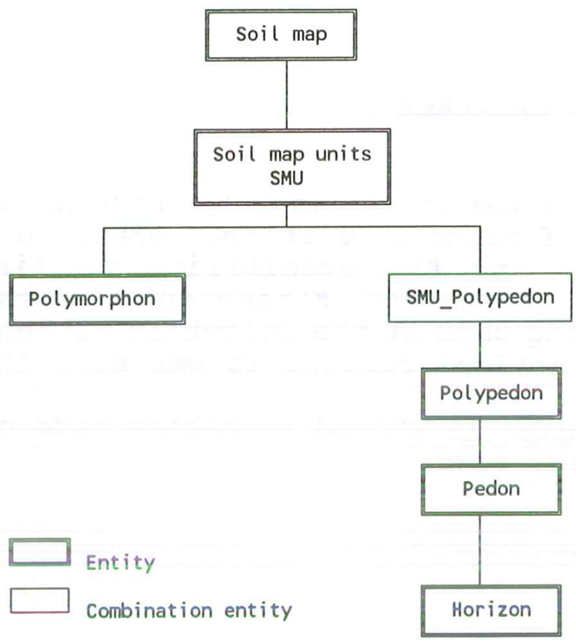


Figure 15. Soil database structure

The data are stored in tables and links between the tables are maintained through key fields, so-called primary keys; identification labels that occur throughout all tables. All primary key fields are printed in bold in table 5. Data records are linked to each other through their primary keys. Table 5 shows the scheme of the database tables. The original columns name are in appendix 2.

Table 5. Non-spatial attributes of a soil database

UFI> describe external

#	size	csize	type	name
1	**6**	**1**	**1 character**	**Perfil No**
3	30	1	1 character	TAXCLAS
4	30	1	1 character	TAXCLAS2
5	64	1	1 character	FAMILIA
6	22	1	1 character	DESCRITO POR
7	8	1	1 character	FECHA
8	56	1	1 character	LOCALIZACION
9	22	40	2 numeric	ALTITUD
10	12	1	1 character	FOTO
11	22	40	2 numeric	PROFUNDIDAD EFECTIVA
12	22	40	2 numeric	LIMITANTE DE PROFUNDIDAD
14	22	40	2 numeric	REGIMEN DE TEMPERATURA
15	2	1	1 character	REGIMEN DE HUMEDAD
16	22	40	2 numeric	DRENAJE EXTERNO
17	22	40	2 numeric	DRENAJE INTERNO
18	22	40	2 numeric	DRENAJE NATURAL
21	20	1	1 character	MICRORELIEVE
22	20	1	1 character	PENDIENTE GRADO
23	20	1	1 character	PENDIENTE LONGITUD
24	20	1	1 character	PENDIENTE FORMA
25	20	1	1 character	PENDIENTE POSICION
26	71	1	1 character	MATERIAL PARENTAL
27	2	1	1 character	HORIZONTE DIAGNOSTICO SUPERFICIAL
28	2	1	1 character	HORIZONTE DIAGNOSTICO SUBSUPERFICIAL
29	8	1	1 character	FERTILIDAD

```
UFI> describe soilcomp
  # size csize type                      name
  1    6     1  1 character              PERFIL No.
  2    3     1  1 character              PAIS
  3    3     1  1 character              DEPARTAMENTO
  4   20     1  1 character              MUNICIPIO
  5   22    40  2 numeric                PORCENTAJE UNIDAD TAXONOMICA
  6   21     1  1 character              TIPO DE UNIDAD CARTOGRAFICA
  7   22     1  1 character              NOMBRE
  8    3     1  1 character              SIMBOLO
  9   20     1  1 character              FASES
 10   20     1  1 character              EXTENSION

UFI> describe uso
  # size csize type                      name
  1    6     1  1 character              PERFIL No.
  2   22     1  1 character              SUELO
  3    4     1  1 character              USO PRINCIPAL
  4    4     1  1 character              USO SECUNDARIO
  5    3     1  1 character              OTROS USOS
  7   20     1  1 character              LIMITANTES DE USO
  8   20     1  1 character              PRACTICAS DE MANEJO

UFI> describe erosion
  # size csize type                      name
  1    6     1  1 character              PERFIL No.
  3    1     1  1 character              CLASE DE EROSION
  4    2     1  1 character              TIPO DE EROSION
  5   22    40  2 numeric                GRADO DE EROSION
  6   20     1  1 character              EVIDENCIAS DE EROSION

UFI> describe geomor
  # size csize type                      name
  1   33     1  1 character              UNIDAD CARTOGRAFICA
  2    6     1  1 character              PERFIL No.
  3   20     1  1 character              GEOESTRUCTURA
  4   20     1  1 character              AMBIENTE MORFOGENETICO
  5    1     1  1 character              PAISAJE
  6    1     1  1 character              CLIMA
  7    4     1  1 character              TIPO DE RELIEVE
  8  119     1  1 character              SUBSTRATO
  9   20     1  1 character              FORMA DEL TERRENO

UFI> describe fisqin
  # size csize type                      name
  1    6     1  1 character              PERFIL No.
  2   22    40  2 numeric                HORIZONTE No.
  3   22    40  2 numeric                No.DE LABORATORIO
  4   22    40  2 numeric                LIMITE SUPERIOR
  5   22    40  2 numeric                LIMITE INFERIOR
  6   22    40  2 numeric                % ARENA
  7   22    40  2 numeric                % LIMO
  8   22    40  2 numeric                % ARCILLA
  9    4     1  1 character              TEXTURA
 10   22    40  2 numeric                PH
 11   20     1  1 character              CAO3
 12   22    40  2 numeric                % HUMEDAD
 13   22    40  2 numeric                CAPACIDAD DE INTERCAMBIO CATIONICO
 14   22    40  2 numeric                BASES TOTALES
 15   22    40  2 numeric                Ca
 16   22    40  2 numeric                Mg
 17   22    40  2 numeric                K
 18   22    40  2 numeric                Na
 19   22    40  2 numeric                % OC
 20   20     1  1 character              N
 21   22    40  2 numeric                P
 22   22    40  2 numeric                AL
 23   20     1  1 character              CONDUCTIVIDAD ELECTRICA
 24   20     1  1 character              SATURACION DE SODIO
 25   20     1  1 character              CLASE SALINA
```

```
UFI> describe perfil
  # size csize type                                 name
  1    6     1  1 character                         PERFIL No.
  2   22    40  2 numeric                           HORIZONTE No.
  3    4     1  1 character                         NOMENCLATURA
  4   22    40  2 numeric                           LIMITE SUPERIOR
  5   22    40  2 numeric                           LIMITE INFERIOR
  6   11     1  1 character                         COLOR EN HUMEDO
  9   20     1  1 character                         COLOR EN SECO
 10   22    40  2 numeric                           CANTIDAD DE MOTEADOS
 11   22    40  2 numeric                           TAMANO DE LOS MOTEADOS
 12    1     1  1 character                         CONTRASTE DE LOS MOTEADOS
 13    1     1  1 character                         FORMA DE LOS MOTEADOS
 14   20     1  1 character                         NITIDEZ DE LOS MOTEADOS
 15    8     1  1 character                         COLOR MOTEADOS
 17    8     1  1 character                         TEXTURA
 18    9     1  1 character                         MODIFICADOR DE LA TEXTURA
 19    5     1  1 character                         TIPO DE ESTRUCTURA
 20   22    40  2 numeric                           CLASE DE ESTRUCTURA
 21    1     1  1 character                         GRADO DE ESTRUCTURA
 22    3     1  1 character                         CUTANES ESPESOR
 23   20     1  1 character                         CUTANES CANTIDAD
 24   20     1  1 character                         CONSISTENCIA EN SECO
 25    3     1  1 character                         CONSISTENCIA EN HUMEDO
 26   22    40  2 numeric                           PEGAJOSIDAD
 27   22    40  2 numeric                           PLASTICIDAD
 28   20     1  1 character                         FLUIDEZ
 29   20     1  1 character                         TIXOTROPIA
 30   20     1  1 character                         PEDS NATURALEZA
 31   20     1  1 character                         PEDS CANTIDAD
 32   20     1  1 character                         PEDS LOCALIZACION
 33   20     1  1 character                         PEDS CLARIDAD
 34   20     1  1 character                         AGENTE CEMENTANTE
 35   20     1  1 character                         GRADO DE CEMENTACION
 36   22    40  2 numeric                           POROS MUY FINOS
 37   22    40  2 numeric                           POROS FINOS
 38   22    40  2 numeric                           POROS MEDIOS
 39   22    40  2 numeric                           POROS GRUESOS
 40   20     1  1 character                         POROS FORMA
 41   20     1  1 character                         POROS SUBFORMA
 42   20     1  1 character                         POROS ORIENTACION
 43   20     1  1 character                         POROS CONTINUIDAD
 44   20     1  1 character                         POROS LOCALIZACION
 45   20     1  1 character                         FRAGMENTOS DE ROCA TIPO
 46   20     1  1 character                         FRAGMENTOS DE ROCA FORMA
 47   20     1  1 character                         FRAGMENTOS DE ROCA VOLUMEN
 48   20     1  1 character                         FRAGMENTOS DE ROCA GRADO DE ALTERACION
 49   20     1  1 character                         FRAGMENTOS DE ROCA NATURALEZA
 50   20     1  1 character                         CONCRECIONES CLASE
 51   20     1  1 character                         CONCRECIONES CANTIDAD
 52   20     1  1 character                         CONCRECIONES TAMANO
 53   20     1  1 character                         CONCRECIONES FORMA
 54   20     1  1 character                         CONCRECIONES CONSISTENCIA
 55   20     1  1 character                         CONCRECIONES DISTRIBUCION
 56   20     1  1 character                         CONCRECIONES COMPOSICION
 57   22    40  2 numeric                           ACTIVIDAD DE MACROORGANISMOS
 58   20     1  1 character                         CLASE DE MACROORGANISMOS
 60    1     1  1 character                         MATERIALES ORGANICOS DENOMINACION
 61    1     1  1 character                         MATERIALES ORGANICOS ESTADO DE DESCOMPOSICION
 62   20     1  1 character                         RAICES MUY FINAS
 63   22    40  2 numeric                           RAICES FINAS
 64   22    40  2 numeric                           RAICES MEDIAS
 65   22    40  2 numeric                           RAICES GRUESAS
 66    1     1  1 character                         RAICES ESTADO
 67   20     1  1 character                         RAICES DISTRIBUCION
 68   20     1  1 character                         RAICES LOCALIZACION
 69    1     1  1 character                         TIPO DE REACTIVO
 70   22    40  2 numeric                           GRADO DE LA REACCION
 71   20     1  1 character                         CONTINUIDAD DE LA REACCION
 72    1     1  1 character                         LIMITE DEL HORIZONTE NITIDEZ
 73    1     1  1 character                         LIMITE DEL HORIZONTE TOPOGRAFIA
 74   22    40  2 numeric                           PH
```

5.1.2 Components of the soil database

1. Pedons, Polypedons and soil map units

The pedon is the starting entity, in which the description and sampling of soil material take place. A cluster of adjacent and similar pedons, fitting within the class limits of a taxonomic unit, is a polypedon. This is the classification entity for which the range of variations of the most important properties is established. An association of similar or distinct polypedons in a given landscape unit forms a soilscape entity. Soilscape units are represented cartographically as a soil map unit.

Five SMU types are stored in the soil database: consociation, association, complex, undifferentiated group and unassociated soils. The degree of impurity of Soil Mapping Units increases from consociation to unassociated soils. The SMU nomenclature applies to any categoric level of the soil taxonomy system used.

2. Polymorphon

In order to have geomorphic information in the soils database, the geopedologic (Zinck and Valenzuela, 1990) approach was followed. In this approach four classes of attributes are used for identification and classification of geoforms:

1. morphographic attributes (describing the geometry of geoforms)
2. morphometric attributes (measuring the geoforms)
3. morphogenic attributes (determining the origin and evolution of geoforms)
4. morphochronologic attributes (circumscribing the temporal context)

The hierarchic classification of geoforms for this approach is shown in table 6.

Table 6. Synopsis of the geoform classification system. (from Zinck and Valenzuela, 1990)

Level	Category	Generic concept	Short definition
6	Order	Geoestructure	Large continental portion characterized by a broad geologic structure (eg, Cordillera, geosinclinal basin, shield)
5	Suborder	Morphogenetic	Broad type of biophysical medium originated and controlled by a style of internal and/or external geodynamics (eg, structural, depositional, erosional, etc)
4	Group	Landscape	Large portion of land characterized by a repetition of similar relief types or an association of dissimilar relief types (eg, valley, plateau, mountain, etc)
3	Subgroup	Relief/molding	Relief as determined by a given combination of topography and geologic structure (eg, cuesta, horst, etc) Molding as determined by specific morphoclimatic conditions or morphogenetic processes (eg, glacis, terrace, delta, etc)
2	Family	Substratum	Lithology of hard rocks (eg, gneiss, limestone, etc) Facies of soft cover formations (eg, periglacial, lacustrine, alluvial, etc)
1	Subfamily	Landform	Conspicuous basic geoform type, characterized by an unique combination of geometry, dynamics and history (eg, levee, dune, solifluction lobe, backslope, etc)

5.1.3 Manipulation of the database

The use of Oracle's Interactive Application Facility (IAF) was a way used for generating screen forms for the manipulation of data in tables.

The application was created by entering into a dialogue in which questions about the application at the keyboard were answer. The questions fall into the following categories:

- General questions about application execution
- Questions about the tables referenced, and how rows (records) of the tables are to be displayed
- Field specifications questions, including field names, types, formats, value ranges, and validation of SQL commands.
- Questions about descriptive text and graphics for screen layout

To generate an application IAG saves each question and its associated response in a file. IAG later is directed to use the response file as an input source to generate the application. Part of the dialogue that was made to generate the forms is in appendix 3.

Figures 16a, 16b, and 16c show the form that was implemented for the soils database

```
------------------ CARACTERISTICAS  EXTERNAS  DEL  PERFIL -------------------
                PERFIL No.            SUELO            TAXONOMIA
           FAMILIA                         DESCRITO POR           FECHA
             LOCALIZACION                       ALTITUD           FOTO
                 PROFUNDIDAD EFECTIVA                FERTILIDAD
               LIMITANTE PROFUNDIDAD1        UNIDAD CARTOGRAFICA
                                    2        UNIDAD TAXONOMICA %
             REGIMEN DE TEMPERATURA                GEOESTRUCTURA
                 REGIMEN DE HUMEDAD        AMBIENTE GEOMORFOLOGICO
                    DRENAJE EXTERNO                        PAISAJE
                            INTERNO                          CLIMA
                            NATURAL                TIPO DE RELIEVE
                       RELIEVE CLASE                     LITOLOGIA
                          DISECCION              FORMA DEL TERRENO
            MICRORELIEVE            USO PRINCIPAL 1.     2.      3.       4.
                PENDIENTE GRADIENTE                    LIMITANTE USO
                           LONGITUD                         PRACTICAS
                     FORMA               EROSION CLASE      TIPO     GRADO
                           POSICION        EVIDENCIAS DE EROSION
                                 MATERIAL PARENTAL
                       HORIZONTE DIAGNOSTICO SUPERFICIAL
                                             SUBSUPERFICIAL

              Char Mode: Replace  Page 1                   Count: *0
```

Figure 16a. IAP screen for external soil profile characteristics

```
------------------------ DESCRIPCION DE HORIZONTES --------------------------
          PERFIL No        HORIZONTE No   SIMBOLO     LIMITE SUPERIOR
                                                             INFERIOR
                               COLOR en humedo1
                            2                          Plasticidad
                            3                              Fluidez
                     en seco                           Tixotropia
             MANCHAS cantidad                      PEDS naturaleza
                      Tamano                              Cantidad
                   Contraste                          Localizacion
                       Forma                              Claridad
                     Nitidez                 AGENTE CEMENTANTE tipo
                     Color 1                                 Grado
                     Color 2              POROS Cantidad muy finos
                     TEXTURA                                 Finos
         Modificador textura                                Medios
             ESTRUCTURA tipo                               Gruesos
                       Clase                                 Forma
                       Grado                              Subforma
          CONSISTENCIA en sec                          Orientacion
                   en humedo                           Continuidad
                 Pegajosidad                          Localizacion
                                     continua en la siguiente hoja

             Char Mode: Replace  Page 2                  Count: *0
```

```
--------------continuacion   DESCRIPCION DE HORIZONTES ----------------------

       FRAGMENTOS DE ROCA Tipo         RAICES Cantidad muy finas
                         Forma                            Finas
                       Volumen                           Medias
                    Alteracion                          Gruesas
                    Naturaleza                           Estado
         CONCENTRACIONES Tipo                      Distribucion
                      Cantidad                     Localizacion
                        Tamano                   REACTIVO Clase
                         Forma                            Grado
                  Consistencia                      Continuidad
                  Distribucion                  LIMITE Nitidez
                   Composicion                       Topografia
                       MCROORGANISMOS Actividad
                         Clase                               pH
                   MATERIA ORGANICA Composicion
                                         Estado

             Char Mode: Replace  Page 3                  Count: *0
```

Figure 16b. Screen for the profile descriptive characteristics by horizons

```
----------------- ANALISIS FISICO-QUIMICOS --------------------------------

    PERFIL No      HORIZONTE No     No LABORATORIO       LIMITE SUPERIOR
                                                         LIMITE INFERIOR

         % ARENA                CIC          % CARBON ORGANICO
          % LIMO       BASES TOTALES               % NITROGENO
       % ARCILLA              CALCIO               FOSFORO (ppm)
         TEXTURA            MAGNESIO                   ALUMINIO
              pH             POTASIO     CONDUCTIVIDAD ELECTRICA
           % CaO               SODIO         SATURACION DE SODIO
       % HUMEDAD                                    CLASE SALINA

             Char Mode: Replace  Page 4                  Count: *0
```

Figure 16c. IAP screen for chemical and physical characteristics by soil horizon

These screen applications provide access to the database to enter,update or delete database records as well as to retrieve and display database information and it also provides data and operation validation checks. Thus, the screen facility allows personnel with no data processing experience to use the soils database.

Attribute constraints were implemented by specifying a data type and/or range for that attribute, in which the validity of the entered value is checked to protect the contents of the database from error in order to maintain the integrity of the database.

5.1.3.1 Updating procedures

When the attribute database needs to be updated, it can be because of missing data in the database, incorrect data or obsolete data. If data was missing, the gaps can simply be filled up; when new data replaces incorrect data, the old data can be overwritten.

In contrary to this, when more up-to-date data becomes available, the old data remains correct for that moment in time and is not replaced. Instead, the old data are down-loaded to a database containing obsolete data this database can then be used for the monitoring of changes.

5.1.4 Integrity of the database

To ensure entity integrity of the soils database an unique index was created over the combination of all fields in the primary key. This indexing have two purposes the first is to speed the execution; faster and easily search. Second, they offer a guarantee of uniqueness; an index can ensure that data in one column, or combination of columns, are unique for every record in a table.

5.1.5 Data input

For this study 58 representative pedons of each soil mapping unit were inserted in the database for processing and analysis of 16 soil mapping units. These data were take from a Soil Survey made by IGAC Soil Survey Staff scale 1:250.000 of the Cockade area that covers an area of approximately 2.500.000 has.

5.2 SPATIAL DATABASE AND ANALYSIS

The following input data were digitized into the GIS:

a.the soils map of the area scale 1:250.000 derived from a survey made by IGAC soil survey staff (1988). This map comprised 8 associations, 4 complexes, 2 consociations, 1 undifferentiated group and 1 unassociated group. Figure 17, together with table 7, displays the whole set of 16 map units. The morphologic, physical and chemical data of the representative

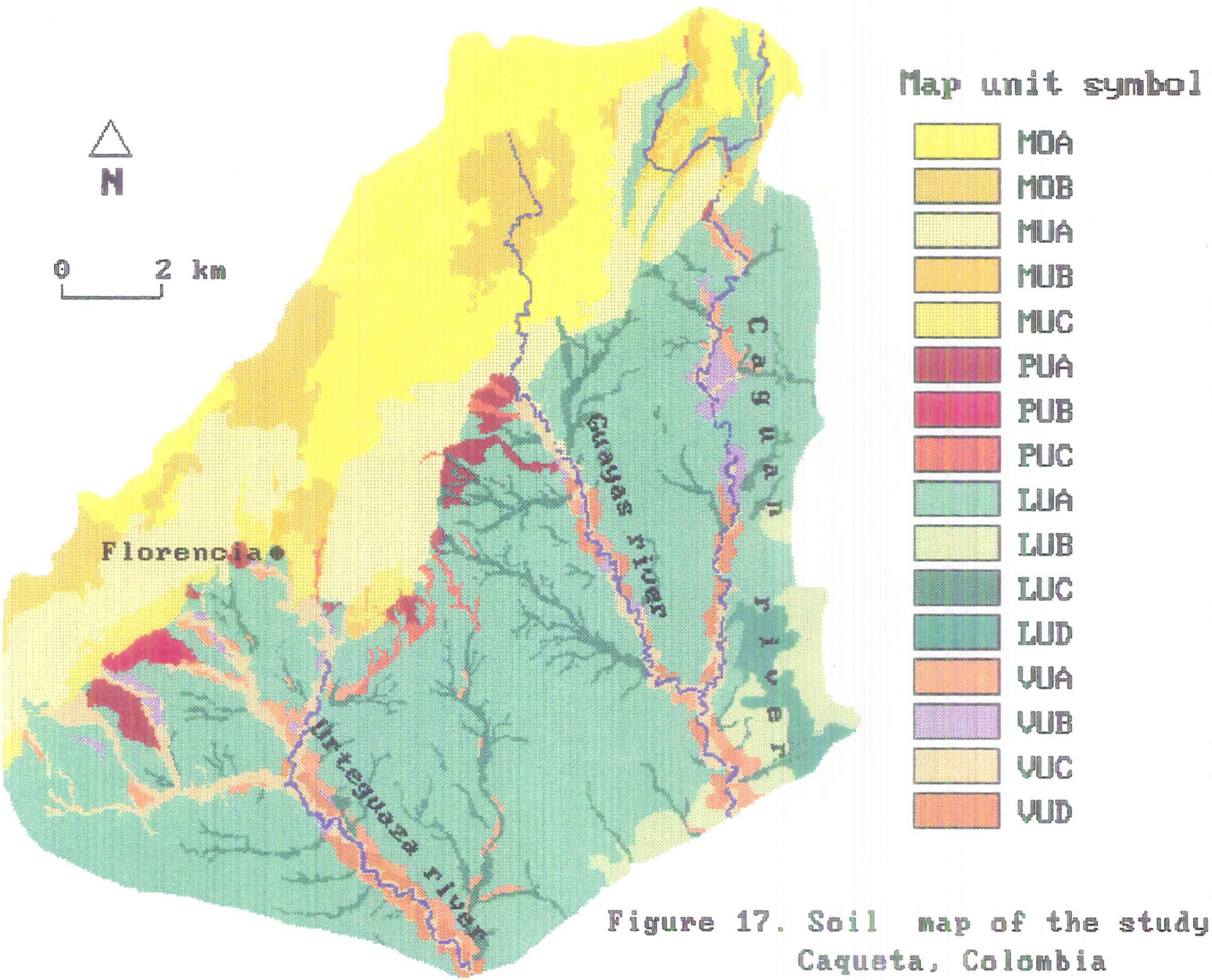


Figure 17. Soil map of the study area
Caqueta, Colombia

Table 7. Legend of soil map units, Caqueta (Colombia)

LANDSCAPE	CLIMATE	RELIEF	SUBSTRATUM	TAXONOMIC UNITS Main and associated soils	Profile No.	%	MAP UNITS Name	Symbol
MOUNTAIN	Medium and cold Pluvial	Ridge and chevron	Granites and gneisses with different rate of weathering	Typic Troporthents	6	50	Undifferentiated group JORDAN	MOA
				Typic Humitropepts	57	30		
	Medium pluvial	Ridge and chevron	Granites and gneisses with inclusions of Sandstone	Oxic Dystropepts	7	45	Association VENTANAS	MOB
				Typic Troporthents	59	30		
	Warm very Humid	Ridge and chevron	Granites and gneisses with inclusions of sandstone and claystone	Inceptic Hapludox	5	30	Association GUACAMAYAS	MUA
				Oxic Dystropepts	74	30		
				Typic Dystropepts	73	25		
		Creston	Layers of sandstone with interbedded claystones, conglomerates and inclusions of bitumen materials	Typic Kandiudox	76	45	Association CABANAS	MUB
				Lithic Dystropepts	78	20		
				Typic Quartzipsa-mments	145	20		
		Hogback	Layers of sandstone , claystone and conglo-merates strongly tilted	Oxic Dystropepts	141	40	Association BELEN DE LOS ANDAQUIES	MUC
				Lithic Dystropepts	78	30		
				Lithic Troporthents	18	20		
PIEDMONT	Warm very Humid	Glacis and Fan	Colluvial and Alluvial sediments	oxic Dystropepts	46	50	Association ESMERALDA	PUA
				Inceptic Hapludox	75	40		
				Typic Paleudults	70	30	Association PALOCAL	PUB
				Aquic Dystropepts	71	30		
				Typic Dystropepts	83	20		
		Vale	Heterometric colluvial-alluvial sediments	Fluventic Dystropepts	38	40	Complex GRANADA	PUC
				Typic Tropofluvents	8	30		
				Aeric Tropaquepts	20	20		

continuation table 7

LANDSCAPE	CLIMATE	RELIEF	SUBSTRATUM	TAXONOMIC UNITS Main and associated soils	Profile No.	%	MAP UNITS Name	Symbol
HILLAND	Warm very Humid	Hill	Upper tertiary variegated claystones	Typic Paleudults	79	55	Consociation SANTIAGO DE LA SELVA	LUA
				Typic Hapludults	61	30		
			Deposits of quartzitic sandstone and variegated claystones	Typic Quartzip-samments	90		Unassociated group CRISTALES	LUB
				Typic Hapludults	96			
				Plinthic Paleudults	151			
		Vale	Colluvial-alluvial sediments	Plintaquepts	68	50	Complex BOMBAYACO	LUC
				Aquic Tropofluvents	103	40		
		Mesa	Kaolinitic clayey materials with fragments of Iron-oxides and gravels	Typic Dystropepts	159	45	Association MESAS	LUD
				Oxic Dystropepts	138	40		
VALLEY	Warm very Humid	Terraces	Fine grained alluvial sediments	Typic Kandiudults	25	40	Consociation RAYO	VUA
				Typic Paleudults	109	40		
			Fine to moderately fine grained alluvial sediments over coarse grained materials	Fluventic Eutropepts	13	50	Association PROVIDENCIA	VUB
				Aquic Dystropepts	29	40		
		Floodplain	Coarse and medium grained alluvial sediments	Fluventic Eutropepts	30	40	Complex CHAIRA	VUC
				Typic tropofluvents	12	30		
				Aquic Dystropepts	31	25		
			Fine grained alluvial sediments	Typic Tropaquents	48	50	Complex CANANGUCHAL	VUD
				Aeric tropic Fluvaquents	93	30		

pedons of each map unit and additional supporting profiles were inserted into the soils database for the analysis of the degradation processes that are occurring in the area.

b. The cover map of the area derived from an image of a thematic mapper computer compatible type of 2nd january 1988 and aerial photographs scale 1:30.000 and 1:40.000 (IGAC, 1989). The main units are shown in figure 18.

The soils map was combined with the cover map to obtain the basic units for the soil degradation map. The obtained map shows the location of each cover units for each soil map unit. From the last map was decided to take the basic units to insert in ALES for evaluation of the land degradation (see appendix 4). The general procedure for the spatial analysis is shown in figure 19.

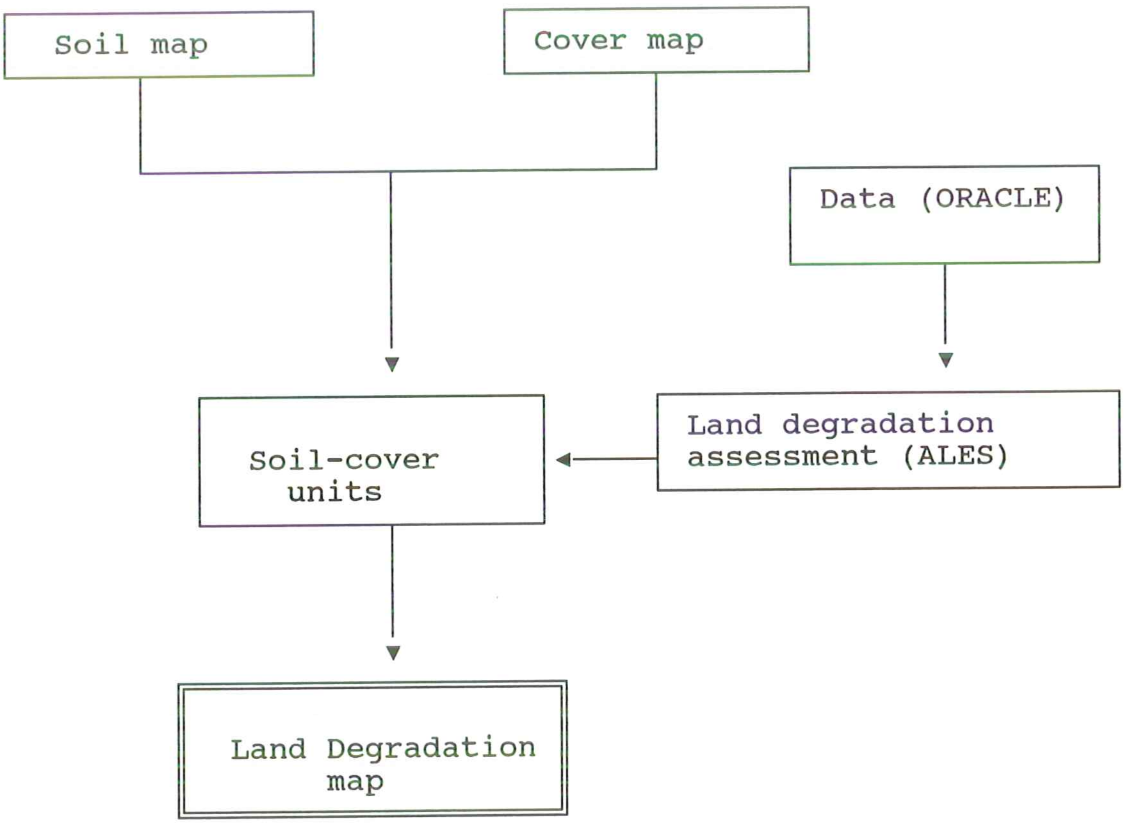


Figure 19. General procedure for the spatial analysis

Figure 20 shows the land degradation map obtained from the above procedure. The effect of the vegetation in the current degradation of the area is very significative and the soils more affected are the soils of the hilland area, specially the Consociation Santiago de la Selva under grassland. This can be explain due to the fragility of this soils after deforestation; deforestation breaks down the soil structure due to oxidation of the organic layer and the finer particles are more easily washed

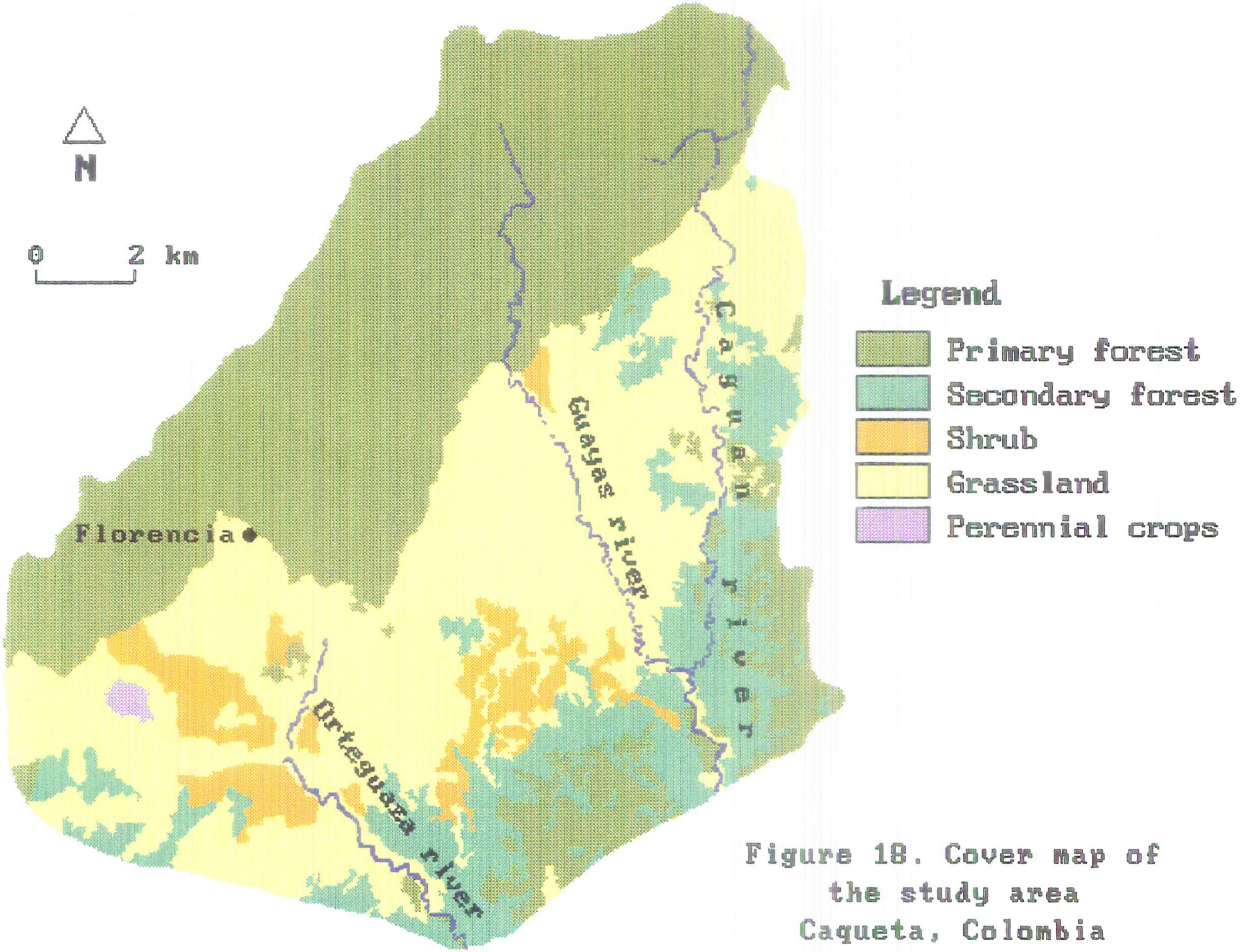


Figure 18. Cover map of the study area Caqueta, Colombia

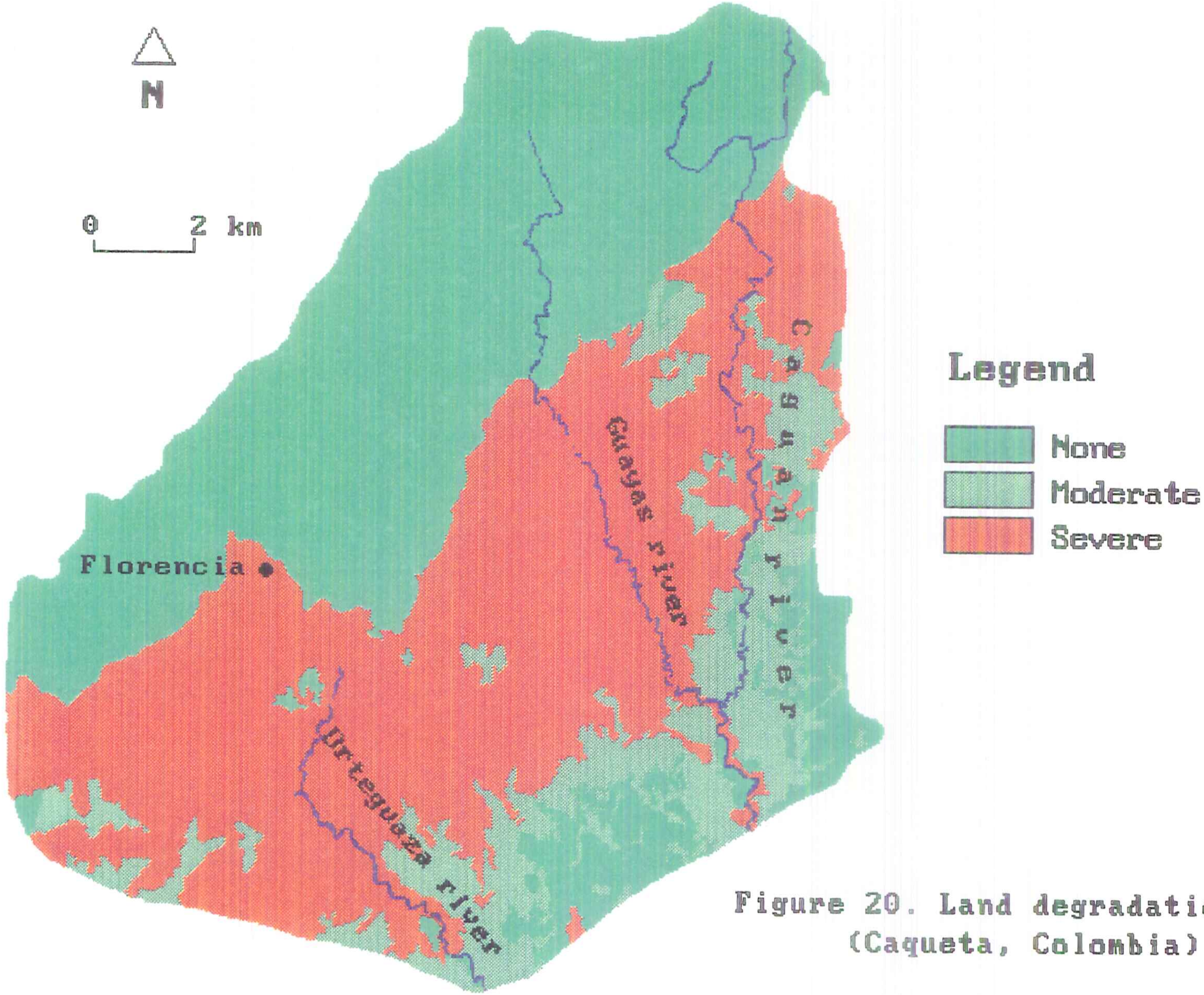


Figure 20. Land degradation map
(Caqueta, Colombia)

downwards. The high precipitation in the area contribute to increase the processes of physical degradation such as water erosion (sheet and rill erosion occur on this soils).

Another important factor of soil degradation, related to the absence of organic layer, is the reduction of the biotic activity as shown by Chamorro and Garcia (1990).

Table 18 shows that 15% of the area is moderate degraded, 40% is no degraded and 45% is severe degraded.

Table 18. Percentage of each land degradation degree respect to the total area.

Land degradation degree	Area has	%
None	1'000.000	40
Moderate	400.000	15
Severe	1'100.000	45

Areas under extreme degradation did not occur as an output of the model. However, extreme degraded soils in the area could occur. This can be explained due to the lack of the required information about the effect of each cover type on soil properties.

6. CONCLUSIONS AND RECOMMENDATIONS

The soil database is an important component of a GIS for natural resources. The capability of the GIS to handle and update spatial and attribute data in a short time is an important characteristic that can be used to generate attribute and interpretative maps as well as in monitoring changes of the environment, to be used for a broad range of applications.

The screen application of the soil database provides capabilities to enter, update or delete database records as well as to retrieve and display database information, and it also provides data and operation validation checks. Thus, the screen facility allows personnel with no data processing experience to use the soil database.

The quantitative critical limits of soil properties in relation to degradation are different for various soils and crops, and are no well defined yet. Is necessary to make research to fin out these critical limits in order to improve the degradation model proposed in this study.

In Colombia the government has encouraged colonization to the Caqueta area as a solution of the socio-economic problems due to the rural-urban migration and the related population pressures in the upland farming areas and the unemployment. Because of the rapid decline in land productivity after deforestation many small-scale cattle rancher in the region, have gone bankrupt after only 5-10 years of operation. These cattle ranchers look for new land to deforest and so, deforested areas will be more extensive.

In order to solve this problems the following recommendations are suggested:

The Caqueta area should be protected against deforestation because it is a fragile ecosystem and its productivity potential is strongly related with the removal of the vegetation. Areas which are not degraded (40% of the study area) should be kept under present cover (primary forest).

For moderately degraded areas (15% of the study area, under secondary forest) sustainable forest management can be developed by doing research about the economic forest species and management techniques.

Another tangible approach is agroforestry; the practice of growing food-producing trees and shrubs in crop fields, on deforested lands (40% of the study area, under shrubs and grassland), can increase the productivity of the already cleared lands. During the first year of an agroforestry system, an annual crop can be planted, like corn or rice. Then in the second or third year, short-lived perennials like papayas can be grown. After a few more years, long lived trees such as cacao can be put in.

Finally protection of the Tropical Rain Forest has a world-wide effect and what affects the people living in the Caqueta area also will affect the people living in Holland, because according to some scientist(Savonnen, 1990) global warming can rise the Sea level which would dramatically affect this low lying country. Then, protection of Tropical Rain Forest is a world-wide concern, and needs a world-wide action.

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Appendix 1. Some codes of the attributes used in the soil database

USO DE LAS TIERRAS

TIPO E INTENSIDAD			
CODIGO	DENOMINACION	CODIGO	DENOMINACION
DE	Desconocido	PM2	Pastos manejados de corte para ganadería intensiva
NO	No usado	PM3	Pastos manejados de pastoreo para ganaderia semiintensiva
CT1	Cultivos transitorios de Subsistencia, semitecnificados	PM4	Pastos manejados de pastoreo para ganadería intensiva
CT2	Cultivos transitorios de Subsistencia no tecnificados	PN1	Pastos no manejados (naturales o introducidos), de pastoreo para ganadeía extensiva
CT3	Cultivos transitorios comerciales, semitecnificados	PN2	Pastos no manejados (naturales o introducidos), de pastoreo para ganadería extensiva
CT4	Cultivos transitorios comerciales, tecnificados	PR1	Pastos con rastrojos, de pastoreo para ganadería extensiva
CS1	Cultivos semiperennes de subsistencia, semitecnificados	BO1	Bosque primario comercial homogéneo
CS2	Cultivos semiperennes de subsistencia, no tecnificados	BO2	Bosque primario comercial heterogéneo
CS3	Cultivos semiperennes comerciales semitecnificados	BO3	Bosque primario no comercial
CS4	Cultivos semiperennes comerciales tecnificados	BI1	Bosque intervenido comercial homogéneo
CP1	Cultivos perennes de subsistencia, semitecnificados	BI2	Bosque intervenido comercial heterogéneo
CP2	Cultivos perennes de subsistencia, no tecnificados	BI3	Bosque intervenido, no comercial
CP3	Cultivos perennes comerciales, semitecnificados	BP1	Bosque plantado productor
CP4	Cultivos perennes comerciales, tecnificados	BP2	Bosque plantado productor-protector
CM1	Cultivos mixtos de subsistencia, semitecnificados	BP3	Bosque plantado protector
CM2	Cultivos mixtos de subsistencia, no tecnificados	VS	Sabanas naturales
CM3	Cultivos mixtos comerciales, semitecnificados	VX	Vegetación xerofita
CM4	Cultivos mixtos comerciales, tecnificados	VP	Gramíneas y arbustos de páramo (3000-4000 m.s.n.m.)
PM1	Pastos manejados de corte para ganadería semiintensiva	NP	Pantanos
		NC	Ciénagas
		NR	Rastrojos
		NE	Tierras malas (bad lands)
		NS	Superpáramos (4000-4800 m.s.n.m)
		NN	Areas nivales
		ZU	Areas urbanas

R A I C E S

CANTIDAD			TAMAÑO			ESTADO	
CODIGO	DENOMINACION	NUMERO*	CODIGO	DENOMINACION	DIAMETRO mm	CODIGO	DENOMINACION
1	No hay	0	1	Muy finas	< 1	V	Vivas
2	Pocas	< 1	2	Finas	1 - 2	M	Muertas
3	Frecuentes	1 - 5	3	Medias	2 - 5		
4	Muchas (abundantes)	> 5	4	Gruesas**	> 5		

Raíces (continuación)

DISTRIBUCION		LOCALIZACION	
CODIGO	DENOMINACION	CODIGO	DENOMINACION
N	Normal	1	En las grietas
A	Anormal	2	Horizonte sobre capas limitantes
		3	Entre los peds (imped)
		4	Fuera de los peds (exped)
		5	Recubriendo rocas o gravilla

* la cantidad de poros o de raíces se define en términos de número, por tamaño y por unidad de área (1 cm² para poros o raíces muy finos y finos, y 1 dm² para poros o raíces medios y gruesos).

** Los poros o raíces con diámetro superior a 10 mm se pueden describir separadamente anotando el número y la sección transversal que está ocupada por estos, en observaciones.

P O R O S

CANTIDAD			TAMAÑO			FORMA	
CODIGO	DENOMINACION	NUMERO*	CODIGO	DENOMINACION	DIAMETRO mm	CODIGO	DENOMINACION
2	Pocos	< 1	1	Muy finos	< 0.5	V	Vesiculares
3	Frecuentes	1 - 5	2	Finos	0.5 - 2	T	Tubulares
4	Muchos	> 5	4	Medios	2 - 5	I	Irregulares
			6	Gruesos**	> 5		

Poros (continuación)

SUBFORMA		ORIENTACION		CONTINUIDAD		LOCALIZACION	
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION
S	Simples	V	Verticales	1	Contínuos	I	Imped
D	Dendríticos	H	Horizontales	2	Discontinuos	E	Exped
A	Abiertos	O	Oblicuos				
C	Cerrados	C	Caóticos				

* La cantidad de poros o de raíces se define en términos de número, por tamaño y por unidad de área (1 cm^2 para poros o raíces muy finos y finos y 1 dm^2 para poros o raíces medios y gruesos)

** Los poros o raíces con diámetro superior a 10 mm se pueden describir separadamente anotando el número y la sección transversal que está ocupada por estos en observaciones.

M A C R O O R G A N I S M O S

ACTIVIDAD		CLASE			
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION
1	No hay	B	Babosas	H	Hormigas
2	Poca	C	Caracoles	L	Lombrices
3	Frecuente	S	Ciempies	T	Termites
4	Mucha	E	Escarabajos	O	Otros
		G	Gusanos		

MATERIALES ORGANICOS

COMPOSICION				ESTADO DE DESCOMPOSICION	
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION
0	No indicada	7	Materiales humilúvicos	O	Sin identificar
1	Fibra no alterada	8	Materiales sulfídicos	S	Sáprico
2	Fibra alterada	9	Musgo	H	Hémico
3	Hierba	10	Tierra coprógena	F	Fíbrico
4	Leños	11	Tierra diatomácea	L	Límnico
5	Marga	12	Otros		
6	Materiales ferrihúmicos				

REACCIONES

REACTIVO		GRADO		CONTINUIDAD	
CODIGO	NOMBRE	CODIGO	DENOMINACION	CODIGO	DENOMINACION
A	HCl	0	No hay	C	continua
F	NaF	1	Ligera	D	Discontinua
P	H2O2	3	Fuerte		
		4	Violenta		

C L I M A   E D A F I C O

ESTADO DE HUMEDAD		REGIMEN DE TEMPERATURA		
CODIGO	DENOMINACION	CODIGO	CLASE	
N	Desconocido	01	Desconocido	
S	Seco	02	No usado	
H	Húmedo	04	Frígido	< 8 °C
M	Saturado	06	Mésico	8 - 15
		08	Térmico	15 - 22
		10	Hipotérmico	> 22
		12	Isofrígido	< 8
		14	Isomésico	8 - 15
		16	Isotérmico	15 - 22
		18	Isohipertérmico	> 22

Clima edáfico (continuación)

REGIMEN DE HUMEDAD DEL SUELO		
CODIGO	CLASE	CARACTERISTICAS
NN	No identificado	
AQ	Acuico	a. Todo el suelo saturado durante el año b. Horizontes inferiores saturados todo el año
PU	Perúdico	El agua se mueve a través sel suelo, en todos los meses, cuando no se encuentre congelada
UD	Udico	Suelo no seco en ninguna parte por más de 90 días acumulativos
US	Ustico	Suelo húmedo en un período de tiempo tal que las condiciones son propicias para el creci- miento de las plantas
AR	Arídico	Estos términos se usan para el misma régimen de húmedad pero en diferentes categorias a. Seco en todas sus partes más de la mitad del tiempo (acumulativo) cuando la tempe- ratura del suelo a una profundidad de 50 cm. es mayor de 5°C b. La humedad en alguna o en todas sus partes no ocurre en períodos tan largos como 90 días consecutivos cuando la temperatura del suelo a una profundidad de 50 cm. es mayor de 8°C
TO	Tórrido	Los mismos términos que para el arídico, pero se presenta unicamente en regiones templadas donde los suelos aparecen cálidos y secos en la estación de verano
XE	Xérico	Típico de los climas mediterráneos con invier- nos fríos y húmedos y veranos cálidos y secos

M A N C H A S

CONDICION DE HUMEDAD		CANTIDAD		TAMAÑO			NITIDEZ		
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION	DIAMETRO (mm)	CODIGO	DENOMINACION	TRANSICION (mm)
N	No indicada	2	Poca < 2%	0	No indicado	——	N	No indicada	
S	En seco	3	Frecuente > 2 - 20%	2	Pequeño	> 15	A	Abrupta	Sin limite
H	En húmedo	4	Mucha > 20%	3	Mediano	5 - 15	C	Diferenciable	< 2
M	En mojado			4	Grande	> 15	D	Difusa	> 2

Manchas (continuación)

FORMA		C O N T R A S T E		
CODIGO	DENOMINACION	CODIGO	DENOMINACION	DIFERENCIA CON LA MATRIZ
R	Rayas	T	Tenues	Igual matiz, pero se diferencia en 1 unidad de intensidad o 2 de pureza. Similar pureza e intensidad pero diferencia en 2.5 unidades de matiz (1 página).
B	Bandas	C	Claros	Igual matiz, pero diferencia en 2 o 4 unidades de intensidad o 3 a 4 unidades de pureza. No más de 1 unidad de intensidad o 2 unidades de pureza cuando difieren por 2.5 unidades de matiz.
L	Lenguas			
T	Tubos	P	Prominentes	Por lo menos 5 unidades (2 páginas) de matiz si la intensidad o pureza son las mismas. Igual matiz, pero diferencia al menos de 4 unidades de pureza o intensidad. 2.5 unidades de matiz y al menos 1 unidad de intensidad o 2 de pureza.
M	Manchas			
N	No indicada	N	No indicada	

FRAGMENTOS DE ROCA EN EL SUELO

TIPO				FORMA	
CODIGO	DENOMINACION	FORMAS IRREGULARES Diametro en cm.	FORMAS PLANAS Longitud en cm.	CODIGO	DENOMINACION
G	Gravilla	0.2 - 2		A	Angular
C	Cascajo	> 2 - 7.6		I	Irregular
J	Guijarro	> 7.6 - 25		P	Plana
L	Laja		>0.2 - 38	R	Subredondeada
P	Piedra	> 25 - 60	> 38 - 60		
R	Pedregón	> 60	> 60		

Fragmentos de roca (continuación)

VOLUMEN			ALTERACION		NATURALEZA	
CODIGO	DENOMINACION	PORCENTAJE	CODIGO	DENOMINACION	CODIGO	DENOMINACION
1	Poco o no hay	< 15	S	Sin alteración	I	Ignea
2	Frecuente	> 15 - 35	M	Mediana alteración	M	Metamórfica
3	Mucho	> 35 - 60	F	Fuerte alteración	S	Sedimentaria
4	Extrema/abundante	> 60				

ESTRUCTURA

TIPO				FORMA	
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION
BA	Bloques angulares	1	Muy fina	D	Debil
BS	Bloques subangulares	2	Fina	M	Moderada
GR	Gránulos	3	Muy fina y fina	F	Fuerte
PR	Prisma	4	Media		
PA	Prismas que rompen en bloques angulares	5	Fina y media		
PS	Prismas que rompen en bloques subangulares	6	Gruesa		
CO	Columnas	7	Media y gruesa		
CA	Columnas que rompen en bloques angulares	8	Muy gruesa		
CS	Columnas que rompen en bloques subangulares				
LA	Láminas				
SM	Sin estructura (masivo)				
SG	Sin estructura (grano suelto)				

G E O M O R F O L O G I A

GEOESTRUCTURA		AMBIENTE MORFOGENTICO		PAISAJE	
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION
C	Cordillera	E	Erosional	A	Altiplanicie
G	Geosinclinal (Basín sedimento)	S	Estructural	L	Lomerío
P	Plataforma (Escudo)	D	Deposicional	M	Montaña
		C	Disolucional	N	Peneplanicie (En escudos)
		R	Residual	P	Piedemonte
		M	Mixto (Extructural-erosional)	R	Planicie
		X	Mixto (Deposicional-erosional)	V	Valle

Geomorfología (continuación)

T I P O D E R E L I E V E					
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION
AB	Abanico	CN	Cono volcánico	LL	Llanura
AA	Abanico aluvial	CR	Crestón	LD	Llanura de desborde
AC	Abanico coluvial	CU	Cuesta	LO	Loma
AE	Abanico de explayamiento	CP	Cúpula	ME	Mesa
AT	Abanico torrencial	DE	Depresión	MO	Morrena
AG	Abanico - glacís	DI	Dique	PO	Polje
AN	Anticlinal	ER	Erg	SI	Sinclinal
BL	Bad - land	ES	Escarpe	SC	Sinclinal colgante
BA	Barra	FI	Fila	SE	Sinclinal excavado
CH	Campo de hums	FS	Flanco de sinclinal	SA	Superficie de aplanamiento
CM	Campo morrénico	FL	Flatirón	TA	Talud
CA	Cañón	GL	Glacís	TE	Terraza
CI	Circo	GE	Glacís erosional	TG	Terraza glacís
CL	Clusa	GC	Glacís coluvial	TO	Torre
CO	Colina	GX	Glacís de explayamiento	VA	Vallecito
CB	Comba	HO	Hogback	VE	Vega
				VI	Viga

FORMA DEL TERRENO					
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION
001	Acantilado	065	Cubeta de decantación	140	Lengua de solifluxión
003	Albardón de diflufuente	067	Cubeta de deflacción	142	Lodazal litoral
006	Albardón de orilla	068	Cubeta de desborde	144	Lupia de solifluxión
009	Alvéolo	069	Cubeta de sobre excavación	150	Marisma
012	Arco morrénico	080	Depresión periférica	152	Meandro colmatado
015	Avens	083	Depresión de sofución	154	Morrena de fondo
020	Barra marina	086	Derrubio de gelifracción	156	Morrena frontal
023	Brazo deltáico	089	Deslizamiento	158	Morrena lateral
026	Banco de lechos	091	Dientes de sierra	162	Napa de cenizas
028	Barkanes	093	dolina	164	Napa de explayamiento
030	Caldera eólica	095	Dorso de ballena	166	Napa de limos de desborde
033	Campo de escorias	097	Duna longitudinal	168	Neck
036	Cárcava	098	Duna transversal	172	Plataforma de abrasión
038	Casquete glaciar	101	Eje de explayamiento	174	Playa
039	Címa	103	Escarpe glaciar	181	Reg
040	Cicatriz de despegue	105	Escarpe interno	183	Resalto
042	Cobertura eólica generalizada	107	Estero fluvial	185	Rocas aborregadas
045	Cobertura eólica localizada	108	Estero marino	192	Sebkha
047	Colada de barro	109	Explayamiento de ruptura	194	Sima (Embudos Kársticos)
049	Colada de gelifluxión	112	Falda	202	Talud de terraza
051	Colada de lava	114	Flecha marina	204	Talud estriado
053	Cono de avalancha	118	Golpe de cuchara	206	Talud no estriado
055	Cono proglaciar	120	Hombrera	208	Talud con matriz fina
057	Cordón litoral	124	Hombro	210	Talud con matriz gruesa
059	Corredor de avalancha	132	Inselberg	212	Tómbolo
061	Cráter	134	Ladera	218	Umbral
063	Cresta de gelifracción	136	Lapiáz		

C O N S I S T E N C I A

EN SECO		EN HUMEDO		EN MOJADO							
				PEGAJOSIDAD		PLASTICIDAD		FLUIDEZ		TIXOTROPIA	
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION
S	Suelta	S	Suelta								
P	Polvosa	B	Muy friable	1	No pegajosa	1	No plástica	2	Ligera	D	Débil
L	Ligera/dura	F	Friable	2	Ligera/pegajosa	2	Ligera/plástica	3	Moderada	F	Fuerte
D	Dura	D	Firme	3	Pegajosa	3	Plástica	4	Muy fluida		
U	Muy dura	U	Muy firme	4	Muy pegajosa	4	Muy plástica				
E	Extrema/dura	E	Extrema/firme								

A S P E C T O S D E L O S P E D S

NATURALEZA				CANTIDAD		
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION	AREA CUBIERTA %
01	Peliculas de arcilla	08	Recubrimientos de materia orgánica	1	Muy poca	< 5
02	Puentes de arcilla	09	Recubrimietnos de sales	2	Poca	5 - 25
03	Recubrimientos de arena	10	Recubrimientos de cárbon	3	Frecuente	25 - 50
04	Recubrimientos de limos	11	Superficies de presión	4	Mucha	> 50
05	Recubrimientos de Fe02	12	Superficies de deslizamiento			
06	Recubrimientos de aluminio	13	No identificada			
07	Recubrimientos de manganeso					

Aspectos de los peds (continuación)

LOCALIZACION				CLARIDAD	
CODIGO	DENOMINACION	CODIGO	DENOMINACION	CODIGO	DENOMINACION
01	Caras horizontales	06	Ped y sobre rocas	T	Tenue
02	Caras verticales	07	Sobre arenas y gravillas	C	Clara (definida)
03	Ambas caras	08	Puentes entre granos de arenas	P	Prominente
04	Canales y poros	09	Nódulos		
05	Todo el horizonte	10	Concreciones		

T E X T U R A

GRUPO TEXTURAL	CLASE TEXTURAL		CODIGO	GRUPO TEXTURAL	CLASE TEXTURAL		CODIGO
Suelos arenosos:				Texturas medias	Franco arenosa muy fina	FAmf	120
Texturas gruesas	Arenosa gruesa	Ag	010		Franca	F	130
	Arenosa	A	020		Franco limosa	Fl	140
	Arenosa fina	Af	030		Limosa	L	150
	Arenosa muy fina	Amf	040				
	Arenosa franca gruesa	Afg	050	Texturas moderadamente finas	Franco arcillosa	FAr	160
	arenosa franca	Af	060		Franco arcillo arenosa	FArA	170
	arenosa franca fina	AFf	070		Franco arcillo limosa	FArL	180
	Arenosa franca muy fina	AFmf	080				
Suelos francos:				Suelos arcillosos:			
Texturas moderadamente gruesas	Franco arenosa gruesa	FAg	090	Texturas finas	Arcillo arenosa	ArA	190
	Franco arenosa	FA	100		Arcillo limosa	ArL	200
	Franco arenosa fina	FAf	110		Arcillosa	Ar	210
				Texturas muy finas	Arcillosa fina	Arf	212

Textura (continuación)

MODIFICADORES DE LA TEXTURA			
CODIGO	DENOMINACION	CODIGO	DENOMINACION
GR	Gravillosa	LA	Lajosa
UG	Muy gravillosa	UL	Muy lajosa
EG	Extremadamente gravillosa	EL	Extremadamente lajosa
CA	Cascajosa	PE	Pedregosa
UC	Muy cascajosa	UP	Muy pedregosa
EC	Extremadamente cascajosa	EP	Extremadamente pedregosa
JU	Guijarrosa	VF	Piroclástica fina
UJ	Muy guijarrosa	VG	Piroclástica gruesa
EJ	Extremadamente guijarrosa		

PROFUNDIDAD EFECTIVA

CLASE			LIMITANTES			
CODIGO	DENOMINACION	PROFUNDIDAD cm	CODIGO	DENOMINACION	CODIGO	DENOMINACION
1	Extremadamente superficial	< 10	00	Sin limitaciones	09	Material compactado
2	Muy superficial	10 - 25	01	Cambio textural abrupto	10	Material esqueletal
3	Superficial	25 - 50	02	Capa cálcica	11	Material fragmental
4	Moderada\profunda	50 - 100	03	Capa salina (> 16 mmhos/cm)	12	Permeabilidad excesiva
5	Profunda	100 - 150	04	Coraza de hierro	13	Permeabilidad nula
6	Muy profunda	> 150	05	Contacto lítico	14	Saturación de sodio (> 15% Na)
			06	Contacto paralítico	15	Toxicidad mineral
			07	Hidromorfismo	16	Toxicidad por aluminio (> 50% Al)
			08	Horizonte nátrico	17	Otros

Appendix 2. Structure of tables in ORACLE

```
UFI> describe external
  # size csize type                 name
  1    6     1  1 character         PERFNO
  2   22     1  1 character         SUELO
  3   30     1  1 character         TAXCLAS
  4   30     1  1 character         TAXCLAS2
  5   64     1  1 character         FAMILIA
  6   22     1  1 character         DESCRITO
  7    8     1  1 character         FECHA
  8   56     1  1 character         LOCALIZACION
  9   22    40  2 numeric           ALTITUD
 10   12     1  1 character         FOTO
 11   22    40  2 numeric           PROFEFEC
 12   22    40  2 numeric           LIMPROF
 13   22    40  2 numeric           LIMPROF2
 14   22    40  2 numeric           REGTEMP
 15    2     1  1 character         REGHUM
 16   22    40  2 numeric           DRENEXT
 17   22    40  2 numeric           DRENINT
 18   22    40  2 numeric           DRENNAT
 19    2     1  1 character         CREL
 20   20     1  1 character         DREL
 21   20     1  1 character         MICROR
 22   20     1  1 character         PENGR
 23   20     1  1 character         PLON
 24   20     1  1 character         PENFOR
 25   20     1  1 character         PENPOS
 26   71     1  1 character         MATPAREN
 27    2     1  1 character         HORDIAGSUPER
 28    2     1  1 character         HDAGSUBSUP
 29    8     1  1 character         FERTILIDAD

UFI> describe soilcomp
  # size csize type                 name
  1    6     1  1 character         PERFNO
  2    3     1  1 character         PAIS
  3    3     1  1 character         DEPARTAMENTO
  4   20     1  1 character         MUNICIPIO
  5   22    40  2 numeric           PORCUT
  6   21     1  1 character         UNIDAD_CARTOGRAFICA
  7   22     1  1 character         NOMBRE
  8    3     1  1 character         SIMBOLO
  9   20     1  1 character         FASES
 10   20     1  1 character         EXTENSION

UFI> describe uso
  # size csize type                 name
  1    6     1  1 character         PERFNO
  2   22     1  1 character         SUELO
  3    4     1  1 character         USOPRIN
  4    4     1  1 character         USOSEC
  5    3     1  1 character         USOTER
  6    3     1  1 character         USOCUAT
  7   20     1  1 character         LIMITANTES
  8   20     1  1 character         PRACMANEJO

UFI> describe erosion
  # size csize type                 name
  1    6     1  1 character         PERFNO
  2   22     1  1 character         SUELO
  3    1     1  1 character         CLASEROSION
  4    2     1  1 character         TIPOEROS
  5   22    40  2 numeric           GRADOEROSION
  6   20     1  1 character         EVIDENCIAS

UFI> describe geomor
  # size csize type                 name
  1   33     1  1 character         UNIDCART
  2    6     1  1 character         PERFNO
  3   20     1  1 character         GEOESTRU
  4   20     1  1 character         AMBMORF
  5    1     1  1 character         PAISAJE
```

```
  6    1      1  1 character          CLIMA
  7    4      1  1 character          TIPORELIEVE
  8  119      1  1 character          LITOLOGIA
  9   20      1  1 character          FORMATERRENO

UFI> describe fisqin
  # size csize type                   name
  1    6      1  1 character          PERNO
  2   22     40  2 numeric            HR
  3   22     40  2 numeric            NOLABORAT
  4   22     40  2 numeric            LIMSUP
  5   22     40  2 numeric            LIMINF
  6   22     40  2 numeric            A
  7   22     40  2 numeric            L
  8   22     40  2 numeric            AR
  9    4      1  1 character          TEXT
 10   22     40  2 numeric            PH
 11   20      1  1 character          CAO
 12   22     40  2 numeric            HUM
 13   22     40  2 numeric            CCC
 14   22     40  2 numeric            BT
 15   22     40  2 numeric            CA
 16   22     40  2 numeric            MG
 17   22     40  2 numeric            K
 18   22     40  2 numeric            NA
 19   22     40  2 numeric            C
 20   20      1  1 character          N
 21   22     40  2 numeric            P
 22   22     40  2 numeric            AL
 23   20      1  1 character          CE
 24   20      1  1 character          SNA
 25   20      1  1 character          CSA

UFI> describe perfil
  # size csize type                   name
  1    6      1  1 character          PRNO
  2   22     40  2 numeric            HR
  3    4      1  1 character          NOMEN
  4   22     40  2 numeric            LS
  5   22     40  2 numeric            LI
  6   11      1  1 character          COLORHUM
  7    8      1  1 character          COLHUMS
  8    8      1  1 character          COLHUMT
  9   20      1  1 character          COLORSECO
 10   22     40  2 numeric            CM
 11   22     40  2 numeric            TM
 12    1      1  1 character          COM
 13    1      1  1 character          FRM
 14   20      1  1 character          NTM
 15    8      1  1 character          COLMOT1
 16    8      1  1 character          COLMOT2
 17    8      1  1 character          TEXTUR
 18    9      1  1 character          MODTEXT
 19    5      1  1 character          TIPOESTR
 20   22     40  2 numeric            CLASESTR
 21    1      1  1 character          GRADOESTR
 22    3      1  1 character          CUTESP
 23   20      1  1 character          CUTCAN
 24   20      1  1 character          CONSECO
 25    3      1  1 character          CONSHUMEDO
 26   22     40  2 numeric            PEGAJOS
 27   22     40  2 numeric            PLASTICID
 28   20      1  1 character          FLUIDEZ
 29   20      1  1 character          TIXOTROP
 30   20      1  1 character          PEDNAT
 31   20      1  1 character          PEDCANT
 32   20      1  1 character          PEDLOC
 33   20      1  1 character          PEDCLAR
 34   20      1  1 character          AGCEMENT
 35   20      1  1 character          GRADCEMENT
 36   22     40  2 numeric            POROSMFINOS
 37   22     40  2 numeric            PORFINOS
 38   22     40  2 numeric            PORMEDIOS
 39   22     40  2 numeric            PORGRUESOS
```

```
40    20     1  1 character          POROSFORMA
41    20     1  1 character          PORSUBFOR
42    20     1  1 character          PORORIENTACION
43    20     1  1 character          POROSCONTINUIDAD
44    20     1  1 character          PORLOC
45    20     1  1 character          FRAGRTIPO
46    20     1  1 character          FRGRFORM
47    20     1  1 character          FRAGRVOL
48    20     1  1 character          FRAGRALT
49    20     1  1 character          FRAGRNAT
50    20     1  1 character          CONCLASE
51    20     1  1 character          CONCAN
52    20     1  1 character          CONTAM
53    20     1  1 character          CONFORMA
54    20     1  1 character          CONCONSIST
55    20     1  1 character          CONDIST
56    20     1  1 character          CONCOMP
57    22    40  2 numeric            ACTMACRO
58    20     1  1 character          CLASMACRO
59    20     1  1 character          DENOMACRO
60     1     1  1 character          MATORGDENO
61     1     1  1 character          MAORGESTD
62    20     1  1 character          RAIMFINAS
63    22    40  2 numeric            RAIFINAS
64    22    40  2 numeric            RAIMEDIAS
65    22    40  2 numeric            RAIGRUESAS
66     1     1  1 character          RAIEST
67    20     1  1 character          RADIS
68    20     1  1 character          RALOC
69     1     1  1 character          REACTIVO
70    22    40  2 numeric            GRADO
71    20     1  1 character          CONTINUIDAD
72     1     1  1 character          LNIT
73     1     1  1 character          LTOP
74    22    40  2 numeric            PH

UFI> describe cafis
   # size csize type                 name
   1   22    40  2 numeric           HORNO
   2    5     1  1 character         PERFILNO
   3   22    40  2 numeric           LABNO
   4   22    40  2 numeric           LIMSUP
   5   22    40  2 numeric           LINF
   6   22    40  2 numeric           DR
   7   22    40  2 numeric           DAP
   8   22    40  2 numeric           MICROPOR
   9   22    40  2 numeric           MACROPOR
  10   22    40  2 numeric           POROSTOTAL
  11   22    40  2 numeric           PUNTOSAT
  12   22    40  2 numeric           TENA
  13   22    40  2 numeric           TENB
  14   22    40  2 numeric           TENC
  15   22    40  2 numeric           TEND
  16   22    40  2 numeric           TENE
  17   22    40  2 numeric           TENF
  18   22    40  2 numeric           HUMAPROV
  19   20     1  1 character         HUMEQUIV
  20   20     1  1 character         CONDHIDR
  21   20     1  1 character         LIMLIQUIDO
  22   20     1  1 character         LIMPLASTICO
  23   20     1  1 character         INDPLAST
  24   20     1  1 character         COLE

UFI> describe disgra
   # size csize type                 name
   1   22    40  2 numeric           HORNO
   2    5     1  1 character         PERFNO
   3   22    40  2 numeric           LABNO
   4   22    40  2 numeric           LIMSUP
   5   22    40  2 numeric           LIMINF
   6   22    40  2 numeric           A
   7   22    40  2 numeric           B
   8   22    40  2 numeric           AF
   9   22    40  2 numeric           D
```

```
 10   22    40  2 numeric         E
 11   22    40  2 numeric         F
 12   22    40  2 numeric         G
 13   22    40  2 numeric         H
 14    4     1  1 character       TEXT

UFI> describe codlet
  # size csize type               name
  1    3     1  1 character       CODIGO
  2   15     1  1 character       RHUM
  3   30     1  1 character       GEOEST
  4   30     1  1 character       AMBGEO
  5   25     1  1 character       PAISAJE
  6   40     1  1 character       CLIMA
  7   26     1  1 character       TRELIEVE
  8   27     1  1 character       MICROR
  9    5     1  1 character       GRADPEND
 10   18     1  1 character       FORMAPEND
 11   15     1  1 character       HDSUPERF
 12   84     1  1 character       USO
 13   25     1  1 character       EROSC
 14   28     1  1 character       EROST
 15   11     1  1 character       CONTMANCHAS
 16   11     1  1 character       FORMANCHAS
 17   13     1  1 character       NITDM
 18   25     1  1 character       MODTEXT
 19   43     1  1 character       TIPOESTR
 20    8     1  1 character       GRADEST
 21   19     1  1 character       CONSECO
 22   20     1  1 character       CONSHUM
 23    6     1  1 character       TIXOTROPIA
 24   20     1  1 character       PEDNAT
 25   16     1  1 character       PEDCLAR
 26   28     1  1 character       AGCEMENT
 27   11     1  1 character       POROSFORMA
 28   11     1  1 character       POROSUBF
 29   12     1  1 character       POROSOR
 30    5     1  1 character       POROSLOC
 31    8     1  1 character       FRAGROCA
 32   13     1  1 character       FORMFRGROCA
 33   17     1  1 character       ALTFRAGROCA
 34   12     1  1 character       NATURFRAGROCA
 35   12     1  1 character       CONCENT
 36   10     1  1 character       FORMACONCT
 37    6     1  1 character       CONSISTCONT
 38    9     1  1 character       DISTBCONCTR
 39    9     1  1 character       COMPOSIC
 40   11     1  1 character       CLASE
 41   15     1  1 character       ESTDESCMATORG
 42    7     1  1 character       ESTDRAIC
 43    7     1  1 character       DISTRAIC
 44    4     1  1 character       REACTIVO
 45   11     1  1 character       CONTIN
 46    7     1  1 character       LIMITEN
 47   12     1  1 character       TOP

UFI> describe codnum
  # size csize type               name
  1   22    40  2 numeric         CODIGO
  2   26     1  1 character       PROFEFECTI
  3   32     1  1 character       LIMPROF
  4   15     1  1 character       RTEMP
  5   10     1  1 character       DEXTERNO
  6   11     1  1 character       DINT
  7   31     1  1 character       DNAT
  8   50     1  1 character       CLIMAKOP
  9   23     1  1 character       DISEC
 10    6     1  1 character       MICROR
 11   21     1  1 character       LONGITUD
 12   28     1  1 character       PENDPOSIC
 13   29     1  1 character       FTERRENO
 14   35     1  1 character       LIMUSO
 15   36     1  1 character       PRACT
 16   10     1  1 character       EROSG
```

```
17   60    1  1 character              EVID
18   10    1  1 character              SUSCEPEROS
19    9    1  1 character              CANTM
20   11    1  1 character              TAM
21   23    1  1 character              TEXTURA
22   15    1  1 character              CLASESTR
23   20    1  1 character              PEGAJOS
24   20    1  1 character              PLASTIC
25   10    1  1 character              FLUIDEZ
26   34    1  1 character              PEDNAT
27    9    1  1 character              PEDCANT
28   30    1  1 character              PEDLOC
29    8    1  1 character              GRADCEEN
30   10    1  1 character              POROSMF
31   10    1  1 character              POROSF
32   10    1  1 character              POROSM
33   10    1  1 character              POROSG
34   12    1  1 character              POROSCONT
35   24    1  1 character              VOL
36   10    1  1 character              CANTIDAD
37   21    1  1 character              TAMANO
38    9    1  1 character              MAORGACT
39   23    1  1 character              MOCOMP
40   19    1  1 character              RAICESMF
41   19    1  1 character              FINAS
42   19    1  1 character              MEDIAS
43   19    1  1 character              GRUESAS
44   32    1  1 character              LOCALIZ
45    8    1  1 character              GRADO

UFI> describe codcolor
  # size csize type                    name
  1   10    1  1 character             CODIGO
  2   25    1  1 character             COLOR

UFI> describe codtax1
  # size csize type                    name
  1    5    1  1 character             CODIGO
  2   16    1  1 character             TAXCLAS

UFI> describe codtax2
  # size csize type                    name
  1    4    1  1 character             CODIGO
  2   26    1  1 character             TAXCLAS

UFI> spool off
```

Appendix 3. Part of IAG dialogue for creation of screens.

```
;Application Title :
CARACTERISTICAS EXTERNAS DEL PERFIL
;ORACLE workspace size :
12
;Block name / Description :
EXTERNAL
;Table name :
external
;Check for uniqueness before inserting Y/N :
Y
;Display/Buffer how many records :
1/10
;Field name :
PERFNO
;Type of field :
CHAR
;Length of field / Display length / Query length :
6
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
Y
;Field to copy primary key from :

;Default value :

;Page :
1
;Line :
2
;Column :
12
;Prompt :
PERFIL No.
;Display prompt above field Y/N :
n
;Allow field to be entered Y/N :
y
;SQL>

;Is field fixed length Y/N :
n
;Auto jump to next field Y/N :
y
;Convert field to upper case Y/N :
y
;Help message :

;Lowest value :

;Highest value :

;Field name :
SUELO
;Type of field :
CHAR
;Length of field / Display length / Query length :
22/10
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
2
;Column :
29
;Prompt :
```

```
SUELO
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
Y
;Help message :

;Lowest value :

;Highest value :

;Field name :
TAXCLAS
;Type of field :
CHAR
;Length of field / Display length / Query length :
30/14
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
2
;Column :
49
;Prompt :
TAXONOMIA
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>
select codtax2.codigo into taxclas from codtax2
where codtax2.taxclas=:taxclas

;Message if value not found :
trate nuevamente
;Must value exist Y/N :
y
;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
Y
;Help message :
ENTRE EL CODIGO DEL SUBGRUPO
;Lowest value :
@CODTAX2.CODIGO
;Field name :
TAXCLAS2
;Type of field :
CHAR
;Length of field / Display length / Query length :
```

```
30/15
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
2
;Column :
64
;Prompt :
G
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>
select codtax1.codigo into taxclas2 from codtax1
where codtax1.taxclas=:taxclas2

;Message if value not found :
verifique la clasificacion!
;Must value exist Y/N :
y
;Is field mandatory Y/N :
Y
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
Y
;Help message :
ENTRE LA CLASIFICACION TAXONOMICA A NIVEL DE GRANGRUPO
;Lowest value :
@codtax1.codigo
;Field name :
FAMILIA
;Type of field :
CHAR
;Length of field / Display length / Query length :
64/8
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
3
;Column :
12
;Prompt :
FAMILIA
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
```

```
Y
;Convert field to upper case Y/N :
N
;Help message :
ENTRE LA CLASIFICACION TAXONOMICA A NIVEL DE FAMILIA
;Lowest value :

;Highest value :

;Field name :
DESCRITO
;Type of field :
CHAR
;Length of field / Display length / Query length :
22/8
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
3
;Column :
49
;Prompt :
DESCRITO POR
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :

;Lowest value :

;Highest value :

;Field name :
FECHA
;Type of field :
CHAR
;Length of field / Display length / Query length :
8
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
3
;Column :
64
;Prompt :
FECHA
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
```

```
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
Y
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
FECHA DE DESCRIPCION DEL PERFIL
;Lowest value :

;Highest value :

;Field name :
LOCALIZACION
;Type of field :
CHAR
;Length of field / Display length / Query length :
56/8
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
4
;Column :
19
;Prompt :
LOCALIZACION
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
ENTRE LA LOCALIZACION GEOGRAFICA DEL PERFIL
;Lowest value :

;Highest value :

;Field name :
ALTITUD
;Type of field :
NUMBER
;Length of field / Display length / Query length :
22/8
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
```

```
1
;Line :
4
;Column :
49
;Prompt :
ALTITUD
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :

;Lowest value :

;Highest value :

;Field name :
FOTO
;Type of field :
CHAR
;Length of field / Display length / Query length :
12/8
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
4
;Column :
64
;Prompt :
FOTO
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :

;Lowest value :

;Highest value :

;Field name :
PROFEFEC
;Type of field :
```

```
NUMBER
;Length of field / Display length / Query length :
22/5
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
5
;Column :
24
;Prompt :
PROFUNDIDAD EFECTIVA
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
1=extrema/mente profundo; 2=muy superficial; 3=superficial; 4=modera/mente profunda; 5=profunda; 6=muy
profunda
;Lowest value :

;Highest value :

;Field name :
LIMPROF
;Type of field :
NUMBER
;Length of field / Display length / Query length :
22/4
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
6
;Column :
24
;Prompt :
LIMITANTE PROFUNDIDAD1
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>
select codnum.codigo into limprof from codnum
where codnum.limprof=:limprof

;Message if value not found :
verifique limitante de profundidad
;Must value exist Y/N :
Y
```

```
;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :

;Lowest value :

;Highest value :

;Field name :
LIMPROF2
;Type of field :
number
;Length of field / Display length / Query length :
22/4
;Is this field in the base table Y/N :
y
;Is this field part of the primary key Y/N :
n
;Default value :

;Page :
1
;Line :
7
;Column :
24
;Prompt :
2
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>
select codnum.codigo into limprof2 from codnum
where codnum.limprof=:limprof2

;Message if value not found :
verifique el limitante de la profundidad efectiva
;Must value exist Y/N :
y
;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :

;Lowest value :

;Highest value :

;Field name :
REGTEMP
;Type of field :
NUMBER
;Length of field / Display length / Query length :
22/6
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :
```

```
;Page :
1
;Line :
8
;Column :
24
;Prompt :
REGIMEN DE TEMPERATURA
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
1=desconocido; 2=no usado; 4=frigido; 6=mesico; 8=termico; 10=hipotermico; 11;isofrigido; 14=isomesico;
16=isotermico; 18=isohipert
;Lowest value :

;Highest value :

;Field name :
REGHUM
;Type of field :
CHAR
;Length of field / Display length / Query length :
2
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
9
;Column :
24
;Prompt :
REGIMEN DE HUMEDAD
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
NN=No identificado; AQ=Acuico; PU=Perudico; UD=Udico; US=Ustico; AR=Aridico; TO=Torrido; XE=xerico
;Lowest value :

;Highest value :

;Field name :
```

```
DRENEXT
;Type of field :
NUMBER
;Length of field / Display length / Query length :
22/4
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
10
;Column :
24
;Prompt :
DRENAJE EXTERNO
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
1=Encharcado; 2=Muy lento; 3=Lento; 4=Medio; 5=Rapido; 6=Muy rapido
;Lowest value :

;Highest value :

;Field name :
DRENINT
;Type of field :
NUMBER
;Length of field / Display length / Query length :
22/6
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
11
;Column :
24
;Prompt :
INTERNO
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
```

```
Y
;Convert field to upper case Y/N :
N
;Help message :
2=Muy lento; 3=Lento; 4=Medio; 5=Rapido; 6=Muy rapido; 7=sin drenaje
;Lowest value :

;Highest value :

;Field name :
DRENNAT
;Type of field :
NUMBER
;Length of field / Display length / Query length :
22/6
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
12
;Column :
24
;Prompt :
NATURAL
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
8=Pantanoso; 9=Muy pobre; 10=pobre;11=Imperfecto; 12=Moderado; 13=bien; 14=Mode/mente excesivo; 15=excesivo;
16=alterado
;Lowest value :

;Highest value :

;Field name :
CREL
;Type of field :
CHAR
;Length of field / Display length / Query length :
2
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
13
;Column :
24
;Prompt :
RELIEVE CLASE
;Display prompt above field Y/N :
N
```

```
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
ENTRE LA CLASE DE RELIEVE
;Lowest value :

;Highest value :

;Field name :
DREL
;Type of field :
CHAR
;Length of field / Display length / Query length :
20/5
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
14
;Column :
24
;Prompt :
DISECCION
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
0=No disectado; 1=Ligeramente disectado; 2=Moderadamente disectado; 3=muy disectado
;Lowest value :

;Highest value :

;Field name :
MICROR
;Type of field :
CHAR
;Length of field / Display length / Query length :
20/5
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :
```

```
;Page :
1
;Line :
15
;Column :
24
;Prompt :
MICRORELIEVE
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
E=Escarceos; G=Gilgai; H=Hormigueros; M=microdepresiones; R=Rizamientos por pata de vaca; S=Surales;
T=Termiteros; O=Otros
;Lowest value :

;Highest value :

;Field name :
PENGR
;Type of field :
CHAR
;Length of field / Display length / Query length :
20/5
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
16
;Column :
24
;Prompt :
PENDIENTE GRADIENTE
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
p=0-1 a=1-3 b=3-7 c=7-12 d=12-25 e=25-50 f=50-75 g=>75
;Lowest value :

;Highest value :

;Field name :
```

```
PLON
;Type of field :
CHAR
;Length of field / Display length / Query length :
20/5
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
17
;Column :
24
;Prompt :
LONGITUD
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
0=No registrada; 1=Corta <50mt; 2=Media 50-100 mt; 3=Larga 100-300mt; 4=Muy larga >300 mt
;Lowest value :

;Highest value :

;Field name :
PENFOR
;Type of field :
CHAR
;Length of field / Display length / Query length :
20/5
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
18
;Column :
24
;Prompt :
FORMA
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
```

```
Y
;Convert field to upper case Y/N :
N
;Help message :
N=No identificada; R=Rectilinea o plana; C=Convexa; V=Concava; O=Ondulada; X=Compleja
;Lowest value :

;Highest value :

;Field name :
PENPOS
;Type of field :
CHAR
;Length of field / Display length / Query length :
20/5
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
19
;Column :
24
;Prompt :
POSICION
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :
ENTRE LA POSICION DEL SUELO EN LA PENDIENTE
;Lowest value :

;Highest value :

;Field name :
MATPAREN
;Type of field :
CHAR
;Length of field / Display length / Query length :
71/25
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
20
;Column :
24
;Prompt :
MATERIAL PARENTAL
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
```

```
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :

;Lowest value :

;Highest value :

;Field name :
HORDIAGSUPER
;Type of field :
CHAR
;Length of field / Display length / Query length :
2
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
21
;Column :
35
;Prompt :
HORIZONTE DIAGNOSTICO SUPERFICIAL
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
Y
;Help message :
ENTRE EL NOMBRE DEL HORIZONTE DIAGNOSTICO SUPERFICIAL
;Lowest value :

;Highest value :

;Field name :
HDAGSUBSUP
;Type of field :
CHAR
;Length of field / Display length / Query length :
2
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
```

```
1
;Line :
22
;Column :
35
;Prompt :
SUBSUPERFICIAL
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
Y
;Help message :
ENTRE EL NOMBRE DEL HORIZONTE DIAGNOSTICO SUBSUPERFICIAL
;Lowest value :

;Highest value :

;Field name :
FERTILIDAD
;Type of field :
CHAR
;Length of field / Display length / Query length :
8
;Is this field in the base table Y/N :
Y
;Is this field part of the primary key Y/N :
N
;Default value :

;Page :
1
;Line :
5
;Column :
49
;Prompt :
FERTILIDAD
;Display prompt above field Y/N :
N
;Allow field to be entered Y/N :
Y
;Allow field to be updated Y/N :
Y
;SQL>

;Is field mandatory Y/N :
N
;Is field fixed length Y/N :
N
;Auto jump to next field Y/N :
Y
;Convert field to upper case Y/N :
N
;Help message :

;Lowest value :

;Highest value :

;Field name :
```

;Block name / Description :

------------------ CARACTERISTICAS EXTERNAS DEL PERFIL ------------------

%PAGE

Appendix 4. Evaluation of physical subclases from ALES

```
degca (Land degradation Cockade area, Colombia)
Physical subclasses
LUT: deg (Land degradation)
---------------------------------------------------------
1       LUAfo (Consociation Santiago.. forest)
        LUBfo (Unassociated group Cristales..  forest)
        MOAfo (Undifferentiated group Jordan.. forest)

2b      LUAof (Consociation Santiago..open forest)
        LUBof (Unassociated group cristales..open foret)
        MOAof (Undifferentiated group Jordan open fores)
        LUDof (Association mesas   .. open forest)

3b      LUAgr (Consociation Santiago.. grass land)
        LUAsh (Consociation Santiago.. shrub)
        LUCgr (Complex Bombayaco..  grassland)
        MUAgr (Association Guacamayas..  grassland)
        MUAsh (Association Guacamayas..   shrub)
        MUBgr (Association Cabanas..  -grassland)
        MUBsh (Association cabanas..    shrub)
        MUCgr (Association Belen de... grassland)
        PUAgr (Association Esmeralda  - grassland)
        PUBgr (Association Palocal..  grassland)
        PUCgr (Complex Granad a..   grassland)
        VUAgr (Consociation rayo..    grassland)
        VUCgr (Association Toro..  grassland)
        VUCsh (Association Toro..  shrub)
        VUDgr (Association providencia..   grassland)
        VUEgr (Association Orteguaza..   grassland)
        VUEsh (Asociation Orteguaza...shrub)
        VUFgr (Complex chaira  grassland)
        VUFsh (Complex chaira...shrub)

3b/p    LUBgr (Unassociated group cristales.. grassland)
        LUDgr (Association mesas..  grassland)
```