Chapter 5. SOIL CLASSIFICATION

Identification of land facets within land systems was used to bridge the gap between land units and soil units, as facets are often relatively uniform insofar as soil properties are concerned. As emphasized in Chapter 4, although land facets may contain soils with differing properties, some level of generalization must be accepted in making an inventory of land resources. This chapter describes the soil classification systems used to summarize soils and their fertility constraints.

Soil Taxonomy

The soils of the land facets were first classified as far as the Great Group category of Soil Taxonomy (Soil Survey Staff, 1975), then described in terms of their physical and chemical properties. In Soil Taxonomy, soils are not grouped according to those having "similar physical and chemical properties that reflect their response to management and manipulation for use" until the soil Family category is reached, This follows the subdivision of the Great Groups into Subgroups, according to the scheme:

- Order (10 subdivisions)
- Suborder (47 subdivisions)
- Great Group (230 subdivisions)
- Subgroup (970 subdivisions in the USA)
- Family

The Order category separates soils according to their gross morphology by the presence or absence of diagnostic horizons. The Suborder separates the Orders according to criteria that distinguish the major reasons for the presence or absence of horizon differentiation, principally as related to moisture and temperature regimes. The Great Group further separates soils according to the complete assemblage of their several horizons and the most significant properties of the whole soil. However, the Subgroup category is virtually only a separation of the Great Group category, in terms of soils which:

a. Follow the central concept of the Great Group;
b. Are intergrades or transitional forms to other Orders, Suborders, or Great Groups;
c. Are extragrades-soits that have some properties not representative of the Subgroups.

In other words, the separation according to Subgroup is a convenience that does not add much to our knowledge about the characteristics of the soils. For this reason, it was decided to classify soils only as far as the Great Group level, then describe them in terms of their physical and chemical characteristics in such a way as to facilitate the computer grouping and comparison of properties.

The Land Systems Map and its Legend (Volume 2) details the soil classification of the land facets within the land systems to the Great Group level. Table 2-4 (Chapter 2) summarizes the Great Group classes identified. A summary of the land facet soil classification to the Great Group level, together with equivalents according to the FAO legend, is also recorded in Part I of Volume 3, the *Computer Summary and SoilProfile Descriptions.* Maps 6, 7, and 8 (see Map Plates) are small-scale maps based on computer printouts illustrating the extent of the soil Orders, Suborders, and Great Groups.

FAO-Unesco Soil Legend

For the convenience of readers accustomed to using the FAO Unesco soil legend, this soil classification system (FAOUnesco, 1974) was also used and has been recorded for the land facets within the land systems on the soil classification legend accompanying the Land Systems Map. This has also been coded to facilitate map making. Table 2-5 (Chapter 2) summarizes the major soil classes identified by this system. Soil climate parameters are not inherent in application of the FAO legend. Maps 9 and 10 are small-scale maps of the region using the FAO legend.

Brazilian Soil Classification System

Appendix I contains an approximate cross-indexing of the Brazilian soil classification system (Camargo et al., 1975) with Soil Taxonomy and the FAO-Unesco soil legend.

Note on Soil Classification Terminology

Soil classification terminology is regarded by many agronomists as so much gobbledygook, reserved for the special precinct of communication between soil surveyors. Yet, as illustrated by Eswaran (I 977), a lot of information concerning soil fertility is available from soil names, particularly in the case of soils classified according to Soil Taxonomy (Soil Survey Staff, 1975). Table 5-1 lists the main soil names used, and what might be deduced from these names, following

Table 5-1. Summary of direct or inferred limiting conditions for Soil Taxonomy taxa identified in the study.

	Limiting conditions[b]															
Soil class[a]	Root res. layer	Text.	Hyd. cond.	Red. cond.	Mois. str.	Low CEC	High Al	Acid sulp.	Anion fix.	Nitr. min.	Vert. prop.	Low min. cont.	Carb. gyps.	Sal. Alk.	Soil temp.	Type char.
A																
AAQ				×												
AAQNA				×										×		
AAQTR				×												
AUD																
AUDHA																
AUDRH									×							
AUDTR																
AUS					×											
AUSHA					×											
AUSNA			×		×									×		
AUSPA					×								×			
AUSRH																
AXE					×											
AXEHA					×											
D					×											
DOR					×											
DORCH					×											
E																
EAQ				×												
EAQFL				×												
EAQHA				×												
EAQHY				×												×
EAQPS		×		×												
EAQTR																
EFL																
EFLTR																
EFLUS					×											
EFLXE					×											
EOR																
EORTR																
EORUS					×											
EPS		×														
EPSQU		×			×							×				
EPSTR		×			×											
H																
HHE																
HHETR																
I																
IAN									×	×						
IANDY							×		×	×						
IANHY									×	×		×				
IAQ				×												
IAQHA				×												
IAQHU				×												

IAQPL	×			×												
IAQSU				×			×	×								
IAQTR				×												
ITR																
ITRDY							×									
ITREU																
ITRUS					×											
M																
MAQ				×												
MAQHA				×												
MUD																
MUDAR																
MUS					×											
MUSHA					×											
O						×	×		×			×				
OAQ	×			×		×	×		×			×				
OAQPL	×			×		×	×		×			×				
OOR						×	×		×			×				
OORAC						×	×		×			×				×
OOREU						×			×			×				
OORHA						×	×		×			×				
OORUM						×	×		×			×				
OUS					×	×	×		×			×				
OUSAC					×	×	×		×			×				×
OUSEU					×	×			×			×				
OUSHA					×	×	×		×			×				
U							×									
UAQ				×			×									
UAQAL			×	×			×									
UAQPA				×			×					×				
UAQPL	×		×	×			×					×				
UAQTR				×			×									
UUD							×									
UUDHA							×									
UUDPA							×					×				
UUDPL	×		×				×									
UUDRH							×		×							
UUDTR							×									
UUS					×		×									
UUSHA					×		×									
UUSPA					×		×					×				
UUSRH					×		×		×							
V			×								×					
VUD			×								×					
VUDCH			×								×					

a. See Table 2-4.
b. In order, refer to: root restriction layer, texture, hydraulic conductivity, reducing conditions, moisture stress, low cation-exchange capacity, high aluminum content, acid sulphate, anion fixation, nitrogen mineralization, vertic properties, low mineral content, carbonates and gypsum, salinity and alkalinity, soil temperature, type of charge.

SOURCE: Eswaran, 1977.

Table 5-2. Fertility Capability Classification (FCC).

FCC code	Name/condition	Characteristics
	Type[a]	
S	Sandy topsoils	Loamy sands and sands (USDA)
L	Loamy topsoils	<35% clay but not loamy sand or sand
C	Clayey topsoils	>35% clay
O	Organic soils	<30% O.M. to a depth of 50 cm or more
	Substrata Type[b]	
S	Sandy subsoil	Texture as in Type above
L	Loamy subsoil	Texture as in Type above
C	Clayey subsoil	Texture as in Type above
R	Rock or other hard root restricting layer	
	Condition Modifiers[c]	
*g	Gley	Mottles ≤2 chroma within 60 cm of surface and below all A horizons or saturated with H_2O for > 60 days in most years
*d	Dry	Ustic or xeric environments; dry, >60 consequtive days per year within 20-60 cm depth
e	Low CEC	< 4 meq/100 g soil by Σ bases + unbuffered Al < 7 meq/100 g soil by Σ cations at pH 7 <10 meq/100 g soil by Σ cations + Al + H at pH 8.2
*a	Al toxic	<60% Al saturation of CEC by (Σ bases and unbuffered Al) within 50 cm <67% Al saturation of CEC by (Σ cations at pH 7) within 50 cm <86% Al saturation of CEC by (Σ cations at pH 8.2) within 50 cm; or pH<5.0 in 1:1 H_2O except in organic soils
*h	Acid	10-60% Al saturation of CEC by (Σ bases and unbuffered Al) within 50 cm; or pH in 1:1 H_2O between 5.0 and 6.0
i	Fe-P fixation	% free Fe_2O_3/% clay>0.15 or hues redder than 5YR and granular structure
x	X-ray amorphous	pH > 10 in 1N NaF or positive to field NaF test or other indirect evidences of allophane dominance in clay fraction
v	Vertisol	Very sticky plastic clay > 35% clay and > 50% of 2:1 expanding clays; COLE>0.09; Severe topsoil shrinking and swelling
*k	K deficient	< 10% weatherable minerals in silt and sand fraction within 50 cm; or exch. K < 0.20 meq/100 g soil or K < 2% of Σ of bases, if Σ of bases < 10 meq/100 g soil
*b	Basic reaction	Free $CaCO_3$ within 50 cm (fizzing with HCl) or pH > 7.3
*s	Salinity	4 mmhos/cm of saturated extract at 25°C within 1 meter
*n	Natric	> 15% Na saturation of CEC within 50 cm
*c	Cat clay	pH in 1:1 H_2O is < 3.5 after drying, jarosite mottles with hues 2.5Y or yellower and chromas 6 or more within 60 cm

a. Texture is average of plowed layer or 20-cm depth (8"), whichever is shallower.
b. Used if textural change or hard root restricting layer is encountered within 50 cm (20").
c. In plowed layer or 20 cm (8"), whichever is shallower unless otherwise specified by an *.

SOURCE: Adapted from Buol et al. (1975).

Eswaran's approach. In Appendix 1, which summarizes equivalent names using Soil Taxonomy, the FAO Legend (FAO-Unesco, 1974), and the Brazilian classification systems, it is evident that the soil names of other classification system s can also be used to obtain an overview of potential soil nutrient problems.

Soil Fertility Capability Classification

The FCC (Fertility Capability Classification) system proposed by Buol et al. (1975), and incorporated in a slightly modified form as an integral part of the present study, synthesizes key fertility information usually available from soil survey reports. It is considered a technical classification system (Cline, 1949) specifically designed to help soil fertility specialists. Effectively, it systematizes much of what may be gleaned from soil survey reports, particularly those following Soil Taxonomy methodology. It provides a convenient checklist of the major potential problems affecting soil fertility, both physically and chemically speaking. By so doing, it obviates the need for soil fertility specialists to have an in-depth knowledge of soil classification and soil survey methodology.

The FCC system consists of three categorical levels: the Type, Substrata Type, and Condition Modifier. In brief, the Type is the average texture of the topsoil (0-20 cm), the Substrata Type is the average texture of the subsoil (21-50 cm), and the Condition Modifiers refer to chemical or physical conditions. Table 5-2 defines the Fertility Capability Classification (FCC) as proposed by Boul et al. (1975). The Conditioner Modifier constraints, and the minor changes in their definition used in the Land Systems Map, are as follows:

- a: Al toxic. In *The LandSystems Map and its Legend,* "a" is defined as greater than 70% saturation of the ECEC, in contrast with Buol et al.'s 60% level. Plants sensitive to Al toxicity will be affected.
- b: base reaction free carbonate. Rock phosphate and other nonwater-soluble phosphate should be avoided. Potential deficiency of some micronutrients, mainly Mn, Fe, and Zn.
- c: cat clays, potential acid sulphate soils. Drainage not recommended without special practices such as brine flushing (H. Evans, pers. comm.). Might be managed with plants tolerant to flooding and high water tables.
- d: a dry condition. An annual dry season of at least 60 consecutive days. Limitations to soil moisture. Plant-ing dates for annual crops should plan for flush of N at onset of rains.
- e: low CEC. Low ability to retain nutrients for plants , mainly Ca, K, and Mg.
- g: a gley condition in the subsoil as an indication of water saturation within 60 cm of the soil surface.
- h: acid. High soil acidity. Possible need for liming and some trace elements. In *The Land Systems Map and its Legend,* this has been defined as those soils with a pH less than 5.3.
- i: phosphorus fixation. Potentially high P-fixation capacity. Requires high levels of P fertilizer. Sources and methods of P fertilizer application should be carefully considered.
- k: K-deficient. Low ability to supply K. In *The Land Systems Map and its Legend,* the level of exchange-able K for this modifier has been reduced to 0.15.
- n: natric. High levels of sodium. Requires special soil-management practices for alkaline soils.
- s: salinity. Presence of soluble salts. Requires special soil management practices.
- v: vertisol. Clayey-textured topsoil. Tillage is difficult when soil is too moist (or, conversely, too dry), but soils can be highly productive.
- x: x-ray amorphous. Often high P-fixation capacity.

Many of these conditions naturally occur together in the central lowlands of tropical America (Map I 1).

The FCC indexes the common information a soil fertility specialist examines when studying soil analytical data for potential limitations. It provides a convenient checklist of potential constraints and is a very handy supplement to the computerized soil chemical data.

Soil Analytical Data

Soil survey reports contain a wealth of soil profile analyses; most national soil laboratories furnish guidelines for interpreting these analyses. A lot of information can be obtained from such data, but they must be interpreted in the light of crop requirements.

In the land-systems study, an innovation was introduced to provide a guide to soil-nutrient levels: levels were detailed in terms of crop requirements. For example, P levels are described as low (inadequate for most crops except those tolerant to low levels), medium (inadequate for crops requiring high levels of the nutrient), and high (adequate for most crops). This approach should provide a clearer idea of soil nutrient levels, particularly for the fertility specialist faced with choosing basic field trial treatments and developing fertilizer recommendations for new genetic materials, especially those purported to have partial tolerance to toxic elements, such as Al and Mn, or to produce satisfactorily with low levels of soil nutrients such as P.

Summary of Soils of the Region

Soil Geography

The distribution, by area, of soils of the region is shown in Table 5-3 at the Order, Suborder, and Great Group levels. (This table is considered tentative and subject to change as more detailed surveys become available.) All 10 soil Orders are represented in the region; however, because of their limited extent, Histosols and Vertisols are not shown in Maps 6, 7, and 8.The majority of the soils are classified as Oxisols and Ultisols, which together account for 66% of the region. Following in extensiveness are the Entisols with about 19%, most of which are of alluvial origin found along the river network. The remaining orders cover relatively small areas, but they are locally important: Alfisols cover 6.7%; Inceptisols, 6.3%; and Spodosols, Mollisols, Aridisols, Vertisols, and Histosols, with less than I % all together. Table 5-3 also shows that 48% of the region is included in five Great Groups: Haplorthox (I 8%), Tropudults (I 0%), Acrorthox (8%), Fluvaquents (6%), and Quartzipsamments (6%)
.

Table 5-3. Aereal extent of the Great Group soil classes in the central lowlands of tropical South America. (Tentative classification.)

Order	Suborder	Great Group	Area (million ha)	Percentage of total area
Oxisols	Orthox	Haplorthox	150.0	18.3
		Acrorthox	62.0	7.6
		Umbriorthox	4.0	0.5
		Eutrorthox	0.8	< 0.1
	Ustox	Haplustox	53.0	6.5
		Acrustox	32.0	3.9
		Eutrustox	24.0	3.0
	Aquox	Plinthaquox	1.0	0.1
		Total Oxisols	326.8	40.0
Ultisols	Udults	Tropudults	82.0	10.1
		Plinthudults	30.0	3.6
		Paleudults	29.0	3.5
		Rhodudults	4.0	0.5
	Aquults	Tropaquults	37.0	4.4
		Plinthaquults	15.0	1.8
		Paleuquults	0.3	< 0.1
		Albaquults	0.1	< 0.1
	Ustults	Haplustults	8.5	1.0
		Rhodustults	4.9	0.6
		Paleustults	1.6	0.2
		Total Ultisols	212.4	25.9
Entisols	Aquents	Fluvaquents	50.6	6.2
		Tropaquents	8.8	1.1
		Psammaquents	3.9	0.5
		Hydraquents	1.1	0.1
	Psamments	Quartzipsamments	52.0	6.4
		Ustipsamments	6.1	0.7
		Tropopsamments	2.2	0.3
	Fluvents	Tropofluvents	16.0	2.9
		Ustifluvents	0.7	< 0.1
		Xerofluvents	0.7	< 0.1
	Orthents	Troporthents	9.4	1.1
		Udorthents	3.3	0.4
		Ustorthents	1.1	0.1
		Total Entisols	155.9	20.0
Alfisols	Aqualfs	Tropaqualfs	19.1	2.3
		Natraqualfs	< 0.1	< 0.1
	Udalfs	Tropudalfs	19.4	2.4
		Rhodudalfs	0.5	< 0.1
		Haplustalfs	6.6	0.8
	Ustalfs	Tropustalfs	6.2	0.8
		Rhodustalfs	2.7	0.3
		Paleustalfs	1.2	0.1
	Xeralfs	Haploxeralfs	0.5	< 0.1
		Total Alfisols	56.3	7.0
Inceptisols	Aquepts	Tropaquepts	19.1	2.3
		Sulfaquepts	3.0	0.4
		Humaquepts	1.0	0.1
		Haplaquepts	< 0.1	< 0.1
		Plinthaquepts	< 0.1	< 0.1
	Tropopepts	Eutropepts	12.5	1.5
		Dystropepts	7.7	0.9
		Ustropepts	6.6	0.8
	Andepts	Dystrandepts	1.1	0.1
		Hydrandepts	0.2	< 0.1
		Total Inceptisols	51.4	6.4
Spodosols	Aquods	Tropaquods	11.0	1.4
Mollisols	Aquolls	Haplaquolls	1.3	0.2
	Udolls	Argiudolls	< 0.1	< 0.1
		Total Mollisols	1.3	0.2
Aridisols	Orthids	Camborthids	1.2	0.1
Vertisols	Uderts	Chromuderts	0.5	0.1
Histosols	Hemists	Tropohemists	0.2	< 0.1
		TOTAL	817	101.5[a]

a. Numbers are rounded to the nearest decimal; amounts less than 0.1 were counted as 0.1.

Oxisols. Haplorthox are well-drained Oxisols with very low native fertility but fairly good soil structure. They are also known as Xanthic Ferralsols (FAO) and Latossolos (Brazilian system). Many of them have very high clay contens. Acrorthox are similar except for a lower clay cation-exchange capacity. Table 5-4 shows chemical data from two Oxisol profiles, one from the Cerrados of central Brazil and the other from Amazonia. They are deep, uniform, well-drained soils dominated by low-activity clays. Their structure is good, but they are very acid and low in bases and P. The Oxisols of the savannas may be high P fixers; those found in the forested regions are generally not high P fixers. Oxisols are common throughout the Amazon and the well-drained savanna regions (see Photo Plates).

Ultisols. Ultisols are fairly extensive in both welldrained and poorly drained positions. Tropudults, Paleudults, and Plinthudults are fairly well-drained, acid, infertile soils but with less desirable physical properties than the Oxisols because of a significant clay increase with depth. They are also known as Orthic Acrisols (FAO) and Podsolico Vermelho Amarelo (Red Yellow Podzolics) in the Brazilian classification system. The difference between these Great Groups-the depth to the "clay bulge" in the subsoil-is of little agronomic relevance. In Table 5-4, examples are given for a well-drained Paleudult and a poorly drained Plinthaquult found on the well- and poorly drained positions of the tropical rain forest subregion A. The well-drained member is acid, infertile, and susceptible to compaction because of its low clay content. The poorly drained member shows high exchangeable Al contents in the subsoil, corresponding to a clayey mottled layer, a mixture of kaolinite and montmorillonite, which appears at first glance to be plinthite; however, analysis shows it is not (Sdnchez and Buol, 1974). It is suspected that many of the soils classified as Plinthudults by various authors are either Paleudults or Hapludults. Some of these soils are devoted to shifting cultivation in the upper Amazon, but most are still under native vegetation because of their low productivity.

Alluvial soils. Soils along the flood plains of the rivers, although less extensive, are very important because this is where food crops can be expected to yield well without the need for soil amendments. They show little or no profile development and are classified as Entisols (Great Group, Fluvaquents), Inceptisols, and Mollisols. These soils are known in other classification systems as Alluvials, Hydromorphics, Low Humic Gleys, and Dystric or Eutric Gleysols. Periodic flooding is the main limiting factor.

An example of an Entisol is given in Table 5-4. However, from region to region there are often major differences in native fertility due to the source of sediments, a highly variable characteristic of *vdrzeas and barriales* soils. Consequently, it cannot be generalized that alluvial soils are always of high native fertility.

Sandy Soils. Extensive areas of sandy soils, mainly Quartzipsamments, are found in the Espigão Mêstre and Parecis tablelands of eastern and western Brazil, respectively. The former region is desert in appearance; the latter is covered by grasslands affected by a strong dry season. There are considerable areas of other light-textured soils in the region, such as the Psamments in the vicinity of Três Lagoas, mainly eastward of the Paraná river.

Spodosols. A soil Order that attracts attention is the Spodosols, also known as Podzols, Ground Water Podzols, and Giant Tropical Podzols, including their deeper variants as Psamments. These soils are derived from coarse sandy materials and are found in clearly definable spots in parts of the Amazon away from the flood plains. Native forest vegetation is often different from that found on Oxisols and Ultisols. It is called *campinaranas* in Brazil. The Projeto Radambrasil recently identified large areas of Spodosols along the headwaters of the Rio Negro, which largely account for the color of this river; water passing through Spodosols characteristically carries suspended organic matter. Table 5-4 shows one example near the Ducke Forest near Manaus. Because of this extreme infertility and susceptibility to erosion, it would be better to leave the Spodosols in their natural state. Unfortunately, they have received more scientific attention than they deserve in terms of their areal extent (1.4% of the region). Therefore, the research on tropical Spodosols in the international literature (Klinge, 1971, 1975; Stark, 1978; Sombroek, 1966, 1979) should be kept in perspective; further, under no circumstances should results be extrapolated to the dominant Oxisols and Ultisols.

Well-drained fertile soils. Unfortunately only about 5.2% of the region has well-drained soils high in native fertility. These are classified mainly as Tropudalfs and Paleustalfs (Terra Roxa Estruturada), Eutropepts (Eutric Cambisols), Tropofluvents (well-drained Alluvials), Argiudolls (Chernozems), Eutrustox and Eutrorthox (Terra Roxa Legitima), and Chromuderts (Vertisols). Nevertheless, they represent a total of 42 million ha, and, where they occur, permanent agriculture has a better chance of success.

The Terra Roxa soils combine high native fertility with excellent physical properties; Table 5-4 shows an example of a Terra Roxa Estt'iturada near Altamira, Brazil. Many of the successful cacao plantations are located on such soils. Examples are found near Altamira, Porto Velho, and Rio Branco in Brazil, and in the "orient" (eastern region) of Ecuador associated with relatively recent volcanic deposits. Their relatively limited extent can be seen in Map 8, showing the Great Group soil classes.

Laterite or plinthite hazard. The area of soils with plinthite in the subsoil (Plinthaquox, Plinthaquults, Plinthudults) is limited. They total about 46 million ha, or 5.6% of the region. This point deserves emphasis, given the broad generalization that many tropical soils, if brought into production, will be irreversibly transformed into hardened plinthite or laterite. These three Great Groups are the only soils where this phenomenon can occur. However, as the soft plinthite is in the subsoil, the topsoil has to be first removed by erosion and the remaining soil dried out before irreversible hardening to laterite can take place. Since these soils occur mainly on flat and often poorly drained landscapes, erosion is not likely to be extensive.

It should be noted that many poorly drained subsoils of other soil Great Groups have mottled colors resembling phinthite, but are, in fact, mixtures of 1:1 and 2:1 clay minerals (Tyler et al., 1978). The subject of hardened plinthite is discussed in Chapter 6.

Table 5-4. Soil profile analyses of some typical soils found throughout the central lowlands of tropical South America.

Horizon depth (cm)	Clay (%)	Sand (%)	pH in H_2O	Organic C (%)	Exchangeable cations[a] (meq/100 g) Al	Ca	Mg	K	ECEC (meq/100 g)	Al Sat. (%)	P (ppm)
OXISOLS											
Typic Acrustox (Latosol Vermelho Amarelo). FCC: cdhakei. Experimental Station Brasilia, Brazil[b]											
0- 12	45	28	5.1	1.87	1.8	0.2		0.08	8.6	86	1
12- 30	44	26	5.0	1.40	1.4	0.2		0.05	6.6	82	1
30- 50	48	25	5.2	1.04	0.6	0.2		0.03	5.2	67	-
50- 85	48	24	4.9	0.77	0	0.2		0.02	3.4	0	-
85-125	50	22	5.3	0.50	0	0.2		0.01	1.9	0	-
125-160	50	22	5.3	0.44	0	0.3		0.02	1.4	0	-
160-200	48	22	5.9	0.49	0	0.2		0.01	1.2	0	-
200-220+	40	31	5.7	0.26	0	0.3		0.02	1.0	0	-
Haplic Acrorthox (Latosol Amarelo muito pesado). FCC: chaek. UEPAE-EMBRAPA, Experimental Station Manaus, Brazil[c]											
0- 8	76	15	4.6	2.9	1.1	1.70	0.30	0.19	3.29	33	-
8- 22	80	12	4.4	0.9	1.1	0.20		0.09	1.39	79	-
22- 50	84	8	4.3	0.7	1.2	0.20		0.07	1.47	82	-
50-125	88	7	4.6	0.3	1.0	0.20		0.04	1.24	81	-
125-265	89	5	4.9	0.2	0.2	0.20		0.11	0.51	39	-
Allic Haplorthox (Latosol Vermelho Amarelo Alico). FCC: ch. 66.8 km from Rio Branco toward Plácido de Castro, Edo. Acre, Brazil[d]											
0- 5	39	21	5.1	4.00	1.00	8.22	3.74	0.68	25.70	7	14
5- 20	43	22	5.0	1.21	1.60	1.10	1.02	0.17	10.24	41	4
20- 70	53	23	4.0	0.81	2.80	0.08	0.12	0.07	6.07	90	1
70-140	62	15	4.9	0.39	2.20	0.03	0.48	0.03	5.35	79	<1
140-170	63	13	5.4	0.27	1.40	0.05	0.20	0.03	3.78	81	<1
ULTISOLS											
Typic Paleudult. (Serie Yurimagua). FCC: Ihaek. Experimental Station Yurimaguas, Peru[e]											
0- 7	15	67	4.0	1.5	0.8	1.60	0.10	0.12	2.62	31	-
7- 48	23	57	3.5	0.5	3.2	1.60	0.10	0.08	4.98	64	-
48- 67	25	57	3.5	0.5	4.4	0.80	0.10	0.08	5.38	82	-
67-157+	29	57	3.5	0.4	5.3	0.60	0.10	0.08	6.08	87	-
Plinthaquult, Oxic, Allic. (Laterita hidromórfica Alica). FCC: Ihakg. Lat. 8°46'S, Long. 61°59'W. Municipio Porto Velho, Brazil[f]											
0- 40	28	42	3.8	2.90	5.20	0.15	0.04	0.07	17.62	94	2
40-100	30	52	4.0	2.21	5.20	0.16	0.03	0.07	14.97	95	3
100-130	6	90	4.5	0.16	2.20	0.11	0.01	0.03	3.47	93	1
130-160	20	64	4.5	0.19	5.60	0.11	0.01	0.04	6.47	96	1
160-200	21	60	4.6	0.18	6.60	0.13	0.01	0.05	7.49	97	1
ENTISOLS											
Quartipsamment, Ustoxic. (Areias Quartzosas). FCC: shke. 6.9 km from road S.J. Piauí - S. Méndez, Edo. Piauí, Brazil[g]											
0- 10	7	77	4.4	0.71	0.50	0.60	0.30	0.08	5.02	33	2
10- 19	6	94	4.4	0.34	0.60	0.15	0.05	0.05	2.90	59	3
19- 36	4	91	4.6	0.16	0.40	0.15	0.05	0.03	2.05	62	2
36- 31	5	95	4.8	0.18	0.40	0.15	0.05	0.03	1.72	62	2
81-115	11	89	4.9	0.12	0.50	0.10	0.10	0.03	1.56	67	2

Eutric Tropofluvent. (Solo Aluvial Eutrófico). FCC: l. Lat. 1°52'S, Long. 67°41'W, Municipio Japurá, Edo. Amazonas, Brazil[h]											
0- 10	17	50	5.5	2.23	5	5.7	1.8	0.59	13.0	5	17
10- 80	12	72	5.1	0.66	32	1.7	0.7	0.11	5.7	32	14
80- 90	12	65	5.6	0.35	25	2.1	1.0	0.11	6.2	25	16
90-180	10	74	5.3	0.33	24	1.7	0.7	0.09	5.0	24	19
ALFISOLS											
Tropudalf típico. (Terra Roxa Estruturada Eutrófica). FCC: c. Km 8 road to Panelas, Altamira, Edo. Pará, Brazil[i]											
0- 8	40	44	7.0	2.51	0.01	25.24	2.28	0.28	29.16	3.4	8
8- 26	49	28	7.3	0.84	0.11	5.96	0.70	0.27	8.91	1.4	2
26- 60	50	24	6.9	0.53	0.01	3.22	0.65	0.10	5.55	0.23	2
60-100	56	23	6.4	0.26	0.11	2.47	0.43	0.09	5.34	0.32	3
100-130+	55	24	5.5	0.22	0.11	1.29	0.75	0.06	4.86	4.4	3
INCEPTISOLS											
Udoxic Dystropept. FCC: cha. Transverse road - Florencia, Municipio Florencia, Caldas, Colombia[j]											
0- 16	37	46.3	4.7	2.02	3.2	0.95	0.80	0.23	5.66	61	3.5
16- 85	52	29.8	4.7	0.51	6.7	0.22	0.43	0.03	7.74	90	0.9
85-173	49	29.6	4.9	0.22	6.3	0.10	0.47	0.08	7.19	90	0
173-208	28	40.9	4.9	0.15	6.1	0.10	0.41	0.13	7.68	90	0
208-228	20	56.2	4.9	0.08	5.3	0.20	0.56	0.11	7.71	85	0
228-247	28	33.1	4.9	0.09	8.1	0.16	0.63	0.17	9.60	89	0
247-350	21	38.5	4.9	0.07	6.1	0.16	0.53	0.21	7.55	87	0
SPODOSOLS											
Arenic Tropaquod. (Podzol Alico). FCC: sgaek. km 4.5 of BR-174 SUFRAMA, Manaus, Brazil[k]											
0- 3	2	89	3.8	6.3	5.4	0.30		0.16	5.86	92	
3- 25	2	95	4.4	0.5	0.7	0.10		0.04	0.84	83	
25- 50	2	94	5.0	0.1	0.1	0.10		0.02	0.12	83	
50- 90	1	98	5.1	0.0	-	0.10		0.01	0.11	-	
90-105	5	93	3.7	1.1	3.0	0.10		0.04	3.14	96	
105-125	9	91	4.7	2.2	2.9	0.10		0.03	3.03	96	
125-165	16	76	5.6	0.8	0.4	0.10		0.03	0.53	75	

a. Combined levels of exchangeable Ca and Mg are expressed in a single column.
b. Profile 3 of Min. of Agr. Tech. Bull. No. 8 (1979).
c. Profile SBCS-4 of Camargo and Rodrígues (1979).
d. Profile 89 of PROJ. RADAMBRASIL, Vol. 12, 1976c.
e. Profile Y-6 of Sánchez and Buol (1974).
f. Profile 24 of PROJ. RADAMBRASIL, Vol. 16, 1978a.
g. Profile 1 of PROJ. RADAMBRASIL, Vol. 1, 1973.
h. Profile 39 of PROJ. RADAMBRASIL, Vol. 14, 1977b.
i. Profile 8 of PROJ. RADAMBRASIL, Vol. 5, 1974b.
j. Profile of BENAVIDES, 1973.
k. Profile SBCS 2 of Camargo and Rodrígues (1979).

The citations for these references are found in the Bibliography of Main Soil Studies. Citations for (d) and (i) are in the References.

Table 5-5. Aereal extent (million ha) of Great Group soil classes of the central lowlands of tropical South America by climatic subregion (a to e)[a,b]

Order and Great Group	Total area	a = Tropical rain forest: Flat, poorly drained	a: Well-drained (% slope) <8	a: 8-30	a: >30	b = Semi-evergreen seasonal forest: Flat, poorly drained	b: Well-drained (% slope) <8	b: 8-30	b: >30	c = Isohyperthermic savanna: Flat, poorly drained	c: Well-drained (% slope) <8	c: 8-30	c: >30
OXISOLS													
Haplorthox	150.0	–	38.5	20.4	7.2	–	49.2	22.2	5.0	–	5.6	0.3	0.1
Acrorthox	62.0	–	2.2	5.4	1.1	–	35.3	13.8	4.1				
Umbriorthox	4.0					–	3.5	0.8	–				
Eutrorthox	0.8					–	0.8	<0.1	–				
Haplustox	53.0						<0.1	<0.1	<0.1		17.9	7.9	6.1
Acrustox	32.0										14.2	3.2	0.5
Eutrustox	24.0										7.1	1.4	0.1
Plinthaquox	1.0					0.9	–	–	–				
TOTAL	326.8		40.7	25.8	8.3	0.9	88.8	36.8	9.1		44.8	12.8	6.8
% of total area	100.0%		12.4%	7.9%	2.5%	0.3%	27.2%	11.3%	2.8%		13.7%	3.9%	2.1%
ULTISOLS													
Tropudults	82.0	–	8.5	3.3	0.3	–	47.1	16.9	4.1				
Plinthudults	30.0	9.6	19.3	0.3	–	–	0.3	–	–	0.6	0.9		
Paleudults	29.0	–	7.6	2.5	< 0.1	–	14.3	3.4	0.2				
Rhodudults	4.0						1.3	2.7	0.4				
Tropaquults	37.0	5.8	–	–	–	8.1				11.8			
Plinthaquults	15.0	9.8	–	–	–	0.6				4.8			
Paleaquults	0.3					0.3							
Albaquults	0.1									0.1			
Haplustults	8.5						<0.1	0.1	0.1		0.1	0.2	0.1
Rhodustults	4.9						1.9	–	<0.1		2.0	0.5	
Paleustults	1.6										0.8		
TOTAL	212.4	25.2	35.4	6.1	0.3	9.0	64.9	23.1	4.8	17.3	3.8	0.7	0.1
% of total area	100.0%	11.9%	16.7%	2.8%	0.1%	4.2%	30.6%	10.9%	2.2%	8.1%	1.8%	0.3%	<0.1%
ENTISOLS													
Fluvaquents	50.6	25.1				18.8	–			1.8			
Tropaquents	8.8	1.8				11.1	–			5.3			
Psammaquents	3.9	2.2				0.2	–			0.4			
Hydraquents	1.1												
Quartzipsamments	52.0					0.3	4.1	0.4	–	0.1	11.8	1.2	<0.1
Ustipsamments	6.1					–	0.7	0.3	0.1	0.5	1.3	0.1	
Tropopsamments	2.2					<0.1	0.1	–	–				
Tropofluvents	16.0	–	3.5	–		1.9	3.1	–	–		2.4	< 0.1	
Ustifluvents	0.7					–	–	–	–		0.2		
Xerofluvents	0.7												
Troporthents	9.4	–	<0.1	<0.1	0.1	–	0.9	4.0	2.3		0.8	0.5	0.5
Udorthents	3.3												
Ustorthents	1.1										<0.1	< 0.1	0.1
TOTAL	155.9	29.1	3.5	<0.1	0.1	32.3	8.9	4.7	2.4	8.1	16.5	1.9	0.6
% of total area	100.0%	18.7%	2.2%	<0.1%	<0.1%	20.7%	5.7%	3.0%	1.5%	5.2%	10.6%	1.2%	0.4%
ALFISOLS													
Tropaqualfs	19.1	1.3	–	–	–	5.6	–	–	–	3.8			
Natraqualfs	<0.1					<0.1	–	–	–				
Hapludalfs	19.4	0.1	10.3	6.5	1.1		1.1	0.3					
Rhodudalfs	0.5,												
Haplustalfs	6.6	–				–			–		0.7	0.7	0.3
Tropustalfs	6.2												
Rhodustalfs	2.7					–			–		–		
Paleustalfs	1.2										1.2	–	–
Haploxeralfs	0.5												
TOTAL	56.3	1.4	10.3	6.5	1.1	5.6	1.1	0.3		3.8	1.9	0.7	0.3
% of total area	100.0%	2.5%	18.3%	11.5%	0.2%	9.9%	1.9%	0.5%		6.7%	3.4%	1.2%	0.5%
INCEPTISOLS													
Tropaquepts	19.1	3.3	–	–	–	6.3	–	–	–	3.2			
Sulfaquepts	3.0					2.4	0.6	–	–				
Humaquepts	1.0									0.7			
Haplaquepts	< 0.1					<0.1				0.1			
Plinthaquepts	< 0.1									0.1			
Eutropepts	12.5	–	3.5	2.0	1.8	–	1.2	0.1	–		0.4	–	–
Dystropepts	7.7	–	0.9	0.1	0.1	–	0.7	0.8	0.3	–	–	0.4	1.8
Ustropepts	6.6									–	0.1	0.3	0.5
Dystrandepts	1.1	0.2	0.9	<0.1	< 0.1		–	–	–	–			
Hydrandepts	0.2					0.5				0.5			
TOTAL	51.4	3.5	5.3	2.1	1.9	9.2	2.5	0.8	0.3	4.6	0.5	0.7	2.3
% of total area	100.0%	6.8%	10.3%	4.1%	3.7%	17.9%	4.9%	1.6%	0.6%	8.9%	1.0%	1.4%	4.5%
SPODOSOLS													
Tropaquods	11.0	8.5	–	–	–	2.5							
% of total area	100.0%	77.0%				23.0%							
MOLLISOLS													
Haplaquolls	1.3	0.8	–	–	–	0.5	–	–					
Arguidolls	<0.1					–	<0.1	<0.1	<0.1				
TOTAL	1.3	0.8				0.5							
% of total area	100.0%	61.5%				38.5%							
ARIDISOLS													
Camborthids	1.2												
% of total area	100.0%												
VERTISOLS													
Chromuderts	0.5		0.5										
% of total area	100.0%		100.0%										
HISTOSOLS													
Tropohemists	0.2												
% of total area	100.0%												

a. Climatic subregions f and o account for only 18.2 million ha.
b. Numbers are rounded to nearest decimal. Amounts less than 0.1 are not included in the summation.

d = Isothermic savanna				e = (Semi-)deciduous forest			
Flat, poorly drained	Well-drained (% slope) <8	8–30	>30	Flat, poorly drained	Well-drained (% slope) <8	8–30	>30
					< 0.1	1.0	0.2
-	6.6	5.7	5.0	-	1.7	1.0	0.5
-	8.6	4.4	0.5				
	6.4	1.4	0.1	-	2.4	3.9	2.5
	21.6	11.5	5.6		4.1	5.9	3.2
	6.6%	3.5%	1.7%		1.2%	1.8%	0.9%
0.2				10.5			
					7.7	0.1	0.1
-	0.8	0.1	-	-	0.2	< 0.1	-
				< 0.1	0.8	-	-
0.2	0.8	0.1		10.5	8.7	0.1	0.1
< 0.1%	0.4%	< 0.1%		4.9%	4.1%	< 0.1%	< 0.1%
				2.3	-	-	-
				0.4	-	-	-
				1.0	-	-	-
	<0.1	0.2	0.4		28.3	2.4	1.9
					2.5	0.5	< 0.1
				1.2	2.6	< 0.1	-
	<0.1						
					0.7	< 0.1	0.1
					< 0.1	< 0.1	< 0.1
					1.0	0.2	0.4
	0.1	0.2	0.4	4.9	35.1	3.1	2.4
	<0.1%	0.1%	0.2%	3.1%	22.5%	2.0%	1.5%
1.2				6.6			
-	0.5		-				
				-	1.4	2.9	0.6
-	0.1	0.1	-	-	1.0	0.3	0.1
					0.5	-	-
1.2	0.6	0.1		6.6	2.9	3.2	0.7
2.1%	1.1%	0.2%		11.7%	5.1%	5.7%	1.2%
				2.3			
				0.2	< 0.1	< 0.1	
					0.3	0.4	0.4
-	0.2	0.2	0.2	-	0.2	0.9	0.7
					5.0	0.1	0.1
0.1							
0.1	0.2	0.2	0.2	2.5	5.5	1.4	1.2
0.2%	0.4%	0.4%	0.4%	4.9%	10.7%	2.7%	2.3%
				-	1.2	-	-
					100.0%		
				0.2			
				100.0%			

Soils in Relation to Climatic Subregions and Topographical Position

Table 5-5 provides distribution estimates of the Great Group classification according to climatic subregions and topographic subdivisions. It may be seen that the higher ratio of Ultisols to Oxisols in subregion A, tropical rain forest, as compared with subregion B, semi-evergreen seasonal forest, is associated with the poorly drained areas where wet Ultisols are abundant. On the well-drained lands in subregion A, the ratio of Ultisols is significantly lower: 0.54 compared with 0.69 in subregion B. Ultisols account for a much lower percentage of the soils in subregions C, D, and E.

There is a higher proportion of Haplorthox in subregion A, Acrorthox in subregion B, Haplustox in subregion C, and Acrustox in subregion D. Oxisols only account for a small proportion of the soils of subregion E. The high proportion of Acrorthox in subregion B indicates a greater extent of soils with very low cation-exchange capacity (less than 1.5 meq/100 g clay) than in subregion A. The relatively large extent of well-drained Inceptisols in subregion A is mainly associated with sediments derived from materials of volcanic origin from the Andes.

The Alfisols found in subregions A, B, C, and D are also associated with superior soil-parent materials, often basic, indicating the strong impress soil-parent materials have in forming soils even under vigorous weathering conditions. The best soils found throughout the region generally are the recent alluvials, Entisols; however, this is by no means always the case. Further, many alluvial soils are subject to periodic flooding.

Part 3 in the *Computer Summary and Soil Profile Descriptions of the Land Systems* (Volume 3) contains a series of soil profile descriptions from typical land facets described by many different authors. As such it provides readers, especially soil scientists, with a more detailed picture of the morphology and properties of some of the soils in the region and emphasizes the great diversity in soil properties and agricultural potentials.