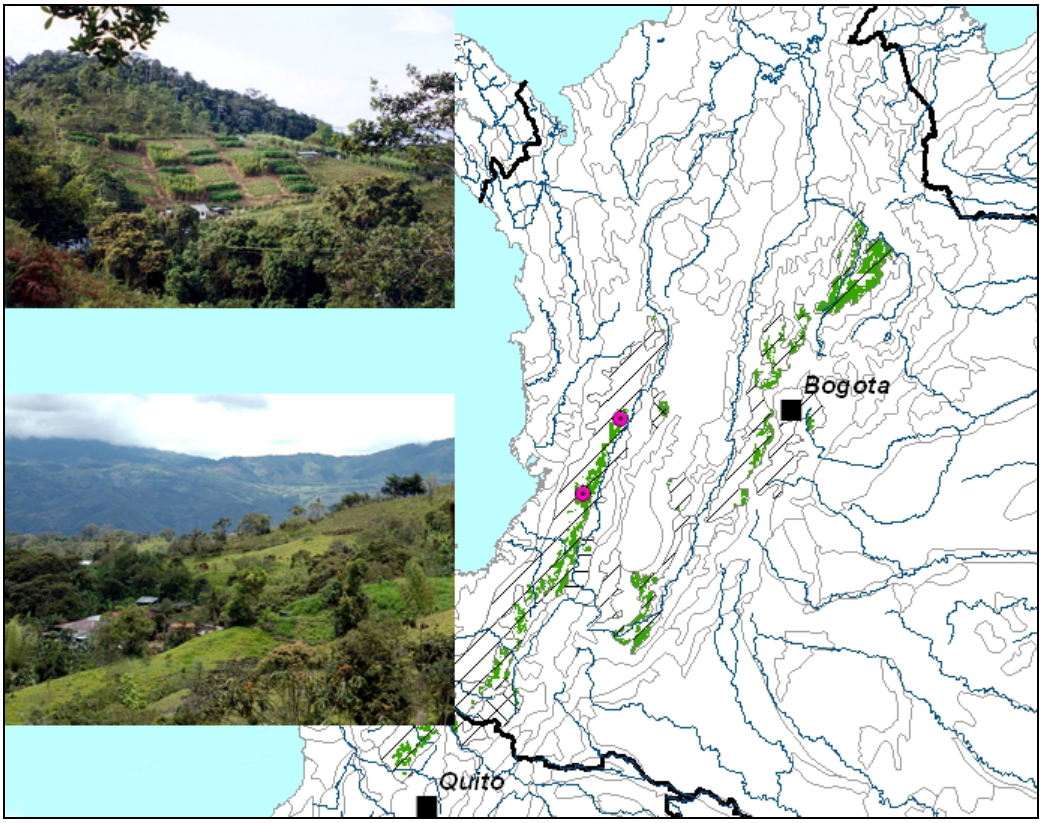
Report 2006/03

Extrapolation Study for the Carbon Sequestration Project of Pasture Systems in the American Tropical Forest Ecosystem

Vincent van Engelen
Jan Huting

(August 2006)



ISRIC World Soil Information

Disclaimer:

While every effort has been made to ensure that the data are accurate and reliable, ISRIC and CSEQ cannot assume liability for damages caused by inaccuracies in the data. ISRIC and CSEQ provide no warranty, expressed or implied, nor does an authorized distribution of the data set constitute such a warranty. ISRIC and CSEQ reserve the right to modify any information in this document and related data without notice.

Correct citation:
van Engelen VWP and Huting JRM 2006. Extrapolation Study for the Carbon Sequestration Project of Pasture Systems in the American Tropical Forest Ecosystem. Report 2006/03, (available through: http://www.isric.org), ISRIC – World Soil Information and Carbon Sequestration Project (CSEQ), Wageningen (39 p).

Inquiries:

c/o Director, ISRIC – World Soil Information
PO Box 353
6700 AJ Wageningen
The Netherlands
Telefax: +31-(0)317-471700
E-mail: soil.isric@wur.nl
Web: www.isric.org

c/o Scientific Director,
Carbon Sequestration Project
CIAT Science Park
Apartado Aéreo 67-13, Cali
Colombia
Telefax: +57-2-4450073
E-mail: M.Amezquita@cgiar.org

Front cover: Part of map showing extent of Ecosystem 1

Contents

List of Figures

List of Tables

SUMMARY

This document presents the results of an extrapolation study for the Carbon Sequestration Project (CSEQ) – a research Network for the Evaluation of Carbon Sequestration Capacity of Pasture, Agropastoral and Silvopastoral Systems in the American Tropical Forest Ecosystem.

Research ecosystems of CSEQ are:

- Andean Hillsides, Colombia
- Humid Tropical Forest, Amazonia, Colombia
- Humid Tropical Forest, Atlantic Coast, Costa Rica
- Sub-humid Tropical Forest, Pacific Coast, Costa Rica

Similarity was based on climatic parameters, topography (elevation and slope) and soil conditions. The Length of Growing Period (LGP) is used to characterize the climate conditions of the research sites. A Digital Elevation Model (DEM) with a resolution of 90 m was used to define elevation and slope conditions, while soil characterization originated from the Soil and Terrain Database of Latin America and the Caribbean (SOTERLAC). Available (sub)continental data allowed only for a low resolution of the maps produced (scale 1:5M).

Results are presented as maps and in tabular format.

Some 7,000 km^2 and 3,000 km^2 of areas similar to the Andean Hillsides ecosystem occur in Colombia, Peru and Ecuador.

The Humid Tropical Forest ecosystem, represented by the Amazonia sites in Colombia with flat topography, extends to 288,000 km^2 of similar areas with *Haplic Acrisols* and 80,000 km^2 of *Haplic Ferralsols* covering large parts of the Amazon basin in Colombia, Brazil and Peru. The same ecosystem with rolling topography occupies less than 10,000 km^2.

Similar areas as the research sites in the Humid Tropical Forest in Costa Rica cover 750 km^2 in the country itself and in neighbouring Nicaragua and Guatemala.

The Sub-humid Tropical Forest ecosystem of Costa Rica has equivalent areas in the country itself and in Panama and Nicaragua, totalling 1,300 km^2.

Keywords: carbon sequestration, pasture systems, tropical forest, SOTER database, Length of Growing Period, Digital Elevation Model.

1. INTRODUCTION

Terms of Agreement between the Carbon Sequestration Project (CSEQ) – a research Network for the Evaluation of Carbon Sequestration Capacity of Pasture, Agropastoral and Silvopastoral Systems in the American Tropical Forest Ecosystem – and ISRIC – World Soil Information were signed on April 28th 2005, to establish collaboration in support of producing an extrapolation study for the four ecosystems of CSEQ. The project period was from 01-11-2005 until 28-2-2006.

The ecosystems considered in CSEQ's research sites are:

1. *Tropical Andean hillsides* in Colombia,
2. *Humid tropical forest, Amazonia* in Colombia,
3. *Humid tropical forest* at the Atlantic coast of Costa Rica,
4. *Sub-humid tropical forest* at the Pacific coast of Costa Rica

The location of the CSEQ research sites is shown in Figure 1.

Similar environmental conditions as found in the four ecosystems were to be identified in:

(a) Colombia and the neighbouring countries of Ecuador, Peru and Bolivia for ecosystem 1
(b) Colombia and the neighbouring Amazonian countries of Peru, Brazil, Bolivia and Ecuador for ecosystem 2
(c) Costa Rica and the neighbouring countries of Panama, Nicaragua, Honduras, El Salvador and Guatemala for ecosystems 3 and 4.

The deliverables were specified as:

Three digital maps with the paper copies at scale 1:5 M (one per ecosystem) and accompanying databases. These show, for each of the ecosystems, areas having similar conditions (length of growing period, altitude, slope and soil conditions) as found in the corresponding research sites of CSEQ.

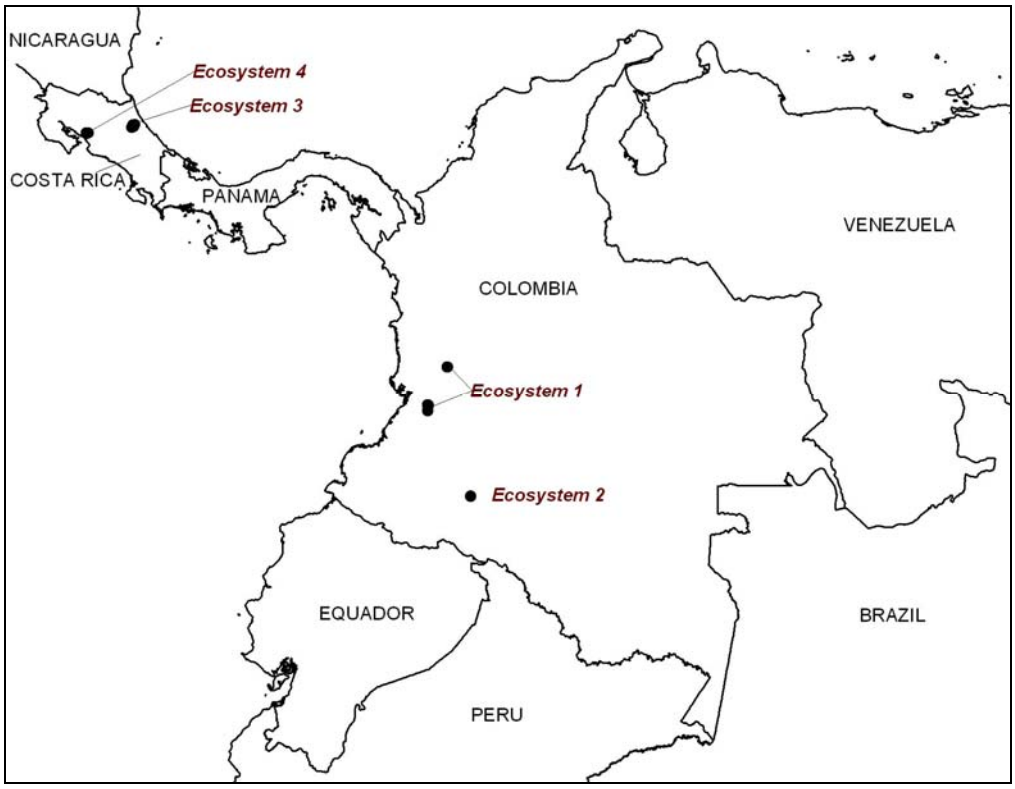


Figure 1. Location of CSEQ research sites.

The maps were derived from of an analysis of the Soil and Terrain Database for Latin America and the Caribbean - SOTERLAC (Dijkshoorn *et al.* 2005; FAO *et al.* 1998), the SRTM90 digital elevation model (USGS 2003) and the Global Agro-Ecological Zones Map - AEZ (FAO-IIASA 2000) for the region. The extrapolation for the *Humid tropical forest* ecosystem was based on the analysis of AEZ and SOTER only, but a subdivision on slopes (breakpoint 5%) was made to distinguish foothills from the flat areas.

The materials and methods are described in Chapter 2; the results in Chapter 3, and conclusions and options for future improvements in Chapter 4.

2. MATERIALS AND METHODS

2.1 Characterization of the ecosystems

Agro-ecological conditions of the research sites were defined in broad terms by CSEQ: 'Tropical Andean Hillsides', or '(Sub)humid Tropical Forest'. To allow a geographical extrapolation to similar environments the four ecosystems were characterized in terms of their broad agro-ecological conditions using the Global Agro-Ecological Zones project - GAEZ (FAO-IIASA 2000). The GAEZ map shows 15 Length of Growing Period (LGP) classes of 30 days intervals (see Appendix 1; Figures 2 and 3). LGP was calculated by GAEZ with the following assumptions and definitions:

- water balance for a standard reference crop;
- soil with 100 mm of Available Water Content (AWC);
- average climatology data from the Climatic Research Unit of the University of East Anglia (CRU) for the years 1961-90 (0.5 degrees) interpolated to 5 arcminutes.

The ecosystems of the research sites were further characterized by elevation and slope, both available from GPS data collected by CSEQ at the sites of ecosystems 1 and 2. Missing elevation data and slope gradient of ecosystems 3 and 4 were derived from the global SRTM 90m Digital Elevation Model - DEM (USGS 2003). Slight discrepancies were observed between elevation data derived from the SRTM and the GPS readings.

Soil characterizations of the research sites are based on the work of CSEQ (Carbon Sequestration Project 2005a, b). Classification is according to the US Soil Taxonomy (Soil Survey Staff 1998). Selected analytical data are available for some of the profiles (soils of the Andean Hillsides and the Amazonia ecosystem), focusing on organic matter related data. Morphological descriptions, however, are lacking. Descriptions and analytical data from the Costa Rica sites were not available. As the spatial soil information – SOTERLAC – follows versus the Revised Legend of the Soil Map of the World (FAO *et al.* 1988), the soil names had to be reclassified to the Revised Legend. The lack of standard profile descriptions and the

limited analytical data only permitted a rough reclassification – more detailed profile characteristics would be needed for more detailed assessments.

Spatial soil data were derived from the Soil and Terrain Database of Latin America and the Caribbean at scale 1:5 M (Dijkshoorn *et al.* 2005). Mapping units contain information on the terrain units and their soil components. Each mapping unit (SOTER unit) consists of up to three soil components of which the proportional percentage (relative area) is given.

Table 1 gives the ranges of ecosystem attributes.

Table 1. Selected ecological conditions of the four CSEQ ecosystems.

Ecosystem	Site	Soils	LGP	Altitude (m)	Slope (%)
1) Tropical Andean Hillsides, Colombia	Dagua	Typic Dystropepts	2	1300-1400	15-45
	Dovio	Typic Dystrandepts	2	1700-2000	35-65
2) Humid Tropical Forest, Amazonia, Colombia	La Guajira	Typic Kandiudults, Paleudults	1	200-300	2-5
	Pequín	Typic Paleudults	1	200-300	10-15
	Santo Domingo	Oxic Dystropepts	1	200-300	2-5
	Balcanes	Typic Paleudults, Hapludults	1	200-300	10-15
3) Humid tropical forest, Atlantic Coast, Costa Rica	Pocora	Inceptisols	1	200-300	0-5
4) Sub-humid tropical forest, Pacific Coast, Costa Rica	Esparza	Inceptisols/ Entisols	4	200-300	15-30

LGP = Length of Growing Period
Sources: Carbon Sequestration Project (2003, 2005a, b); FAO-IIASA (2000); USGS (2003)

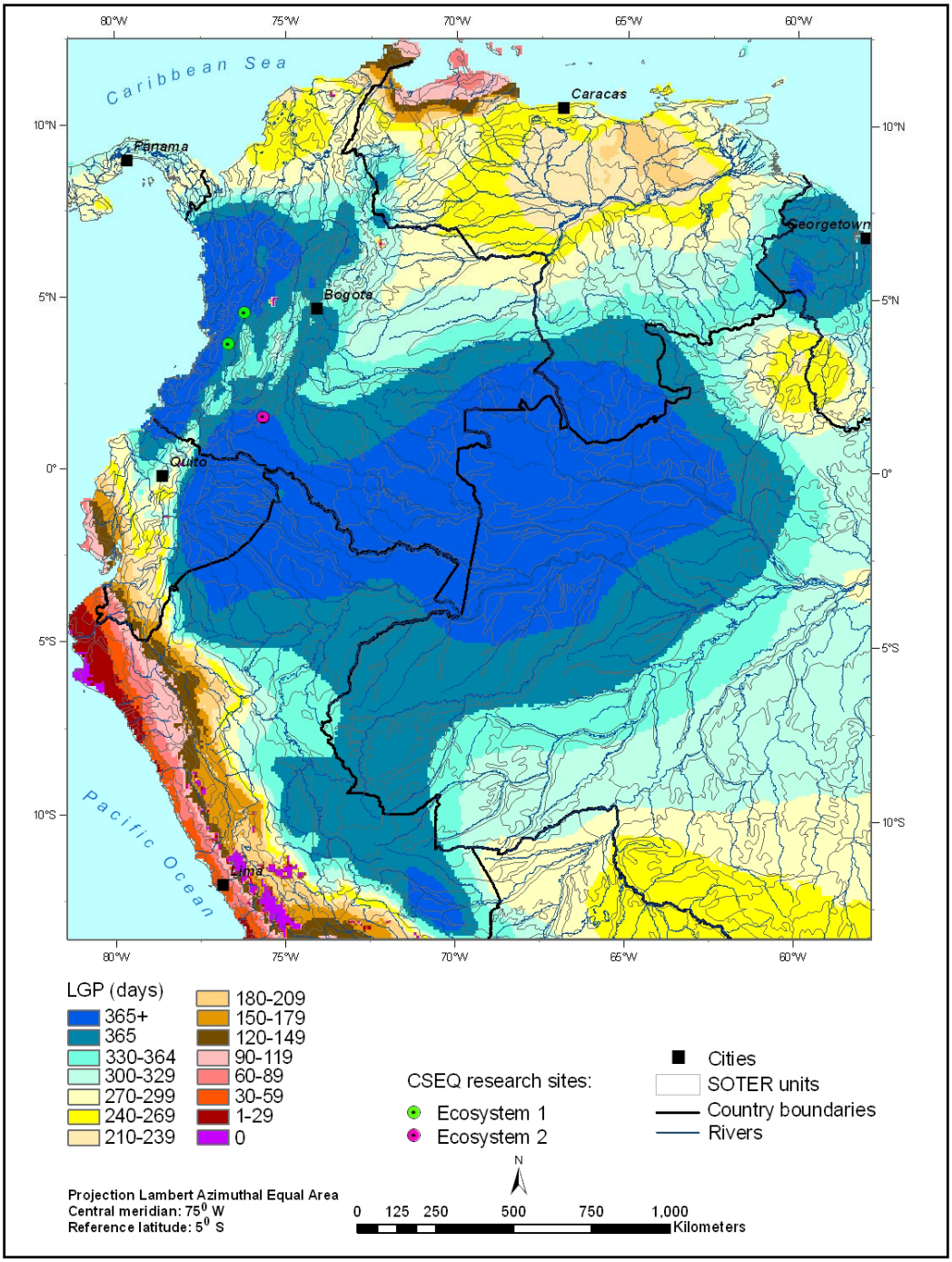


Figure 2. Length of Growing Period (LGP) in NE South America (FAO-IIASA 2000)

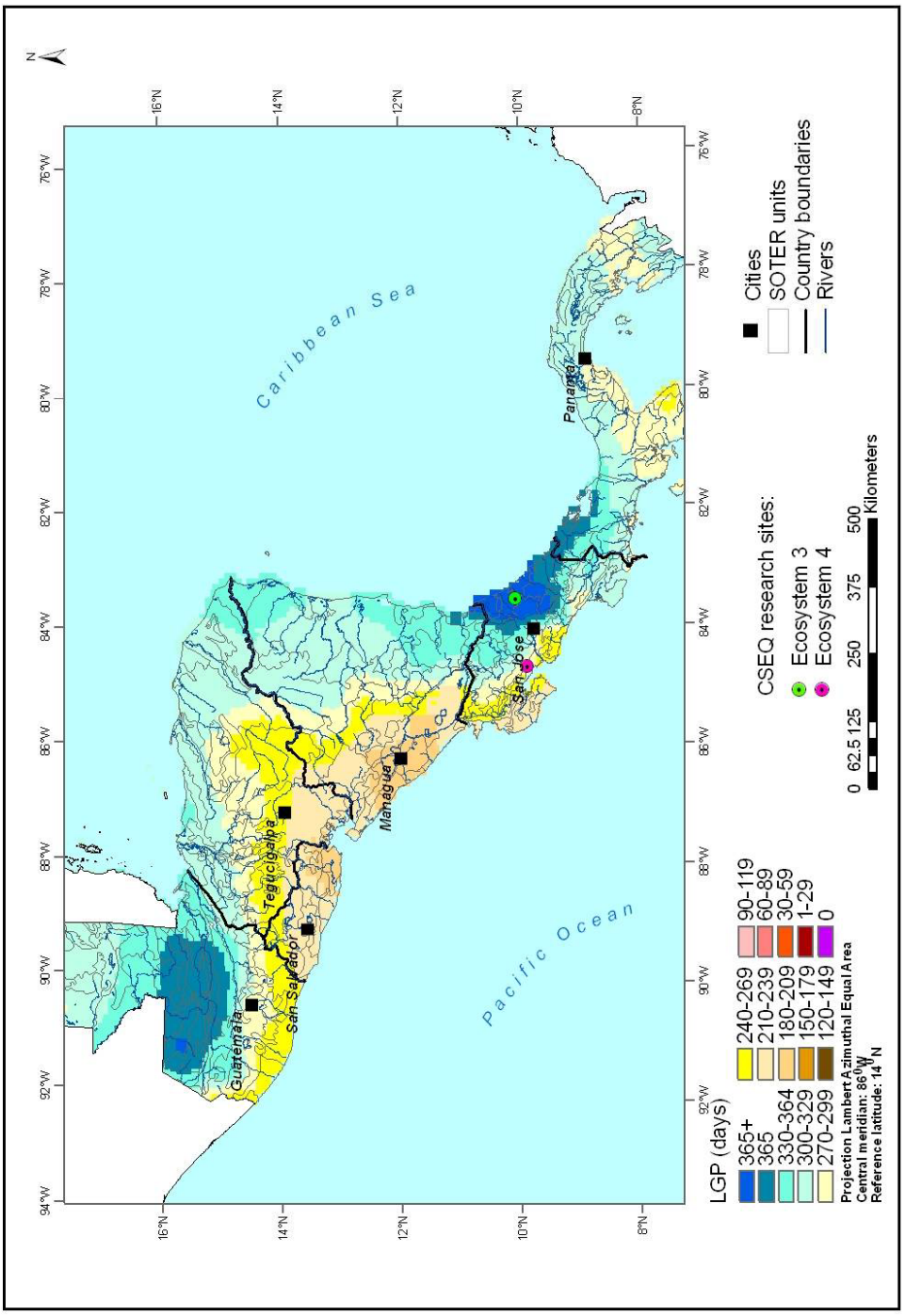


Figure 3. Length of Growing Period (LGP) in Central America (FAO-IIASA 2000)

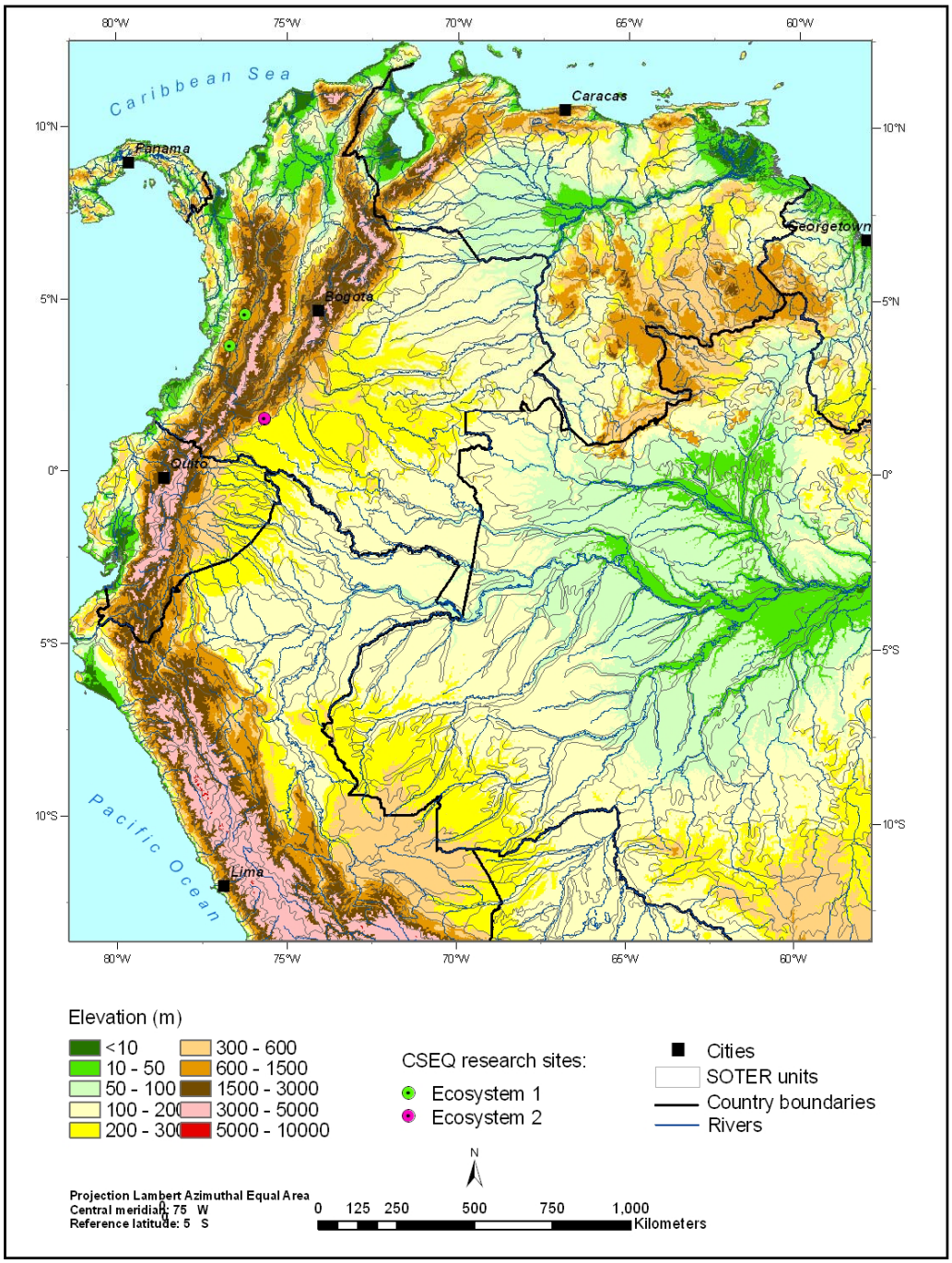


Figure 4. Elevation in m from SRTM 90 DEM (USGS 2003)

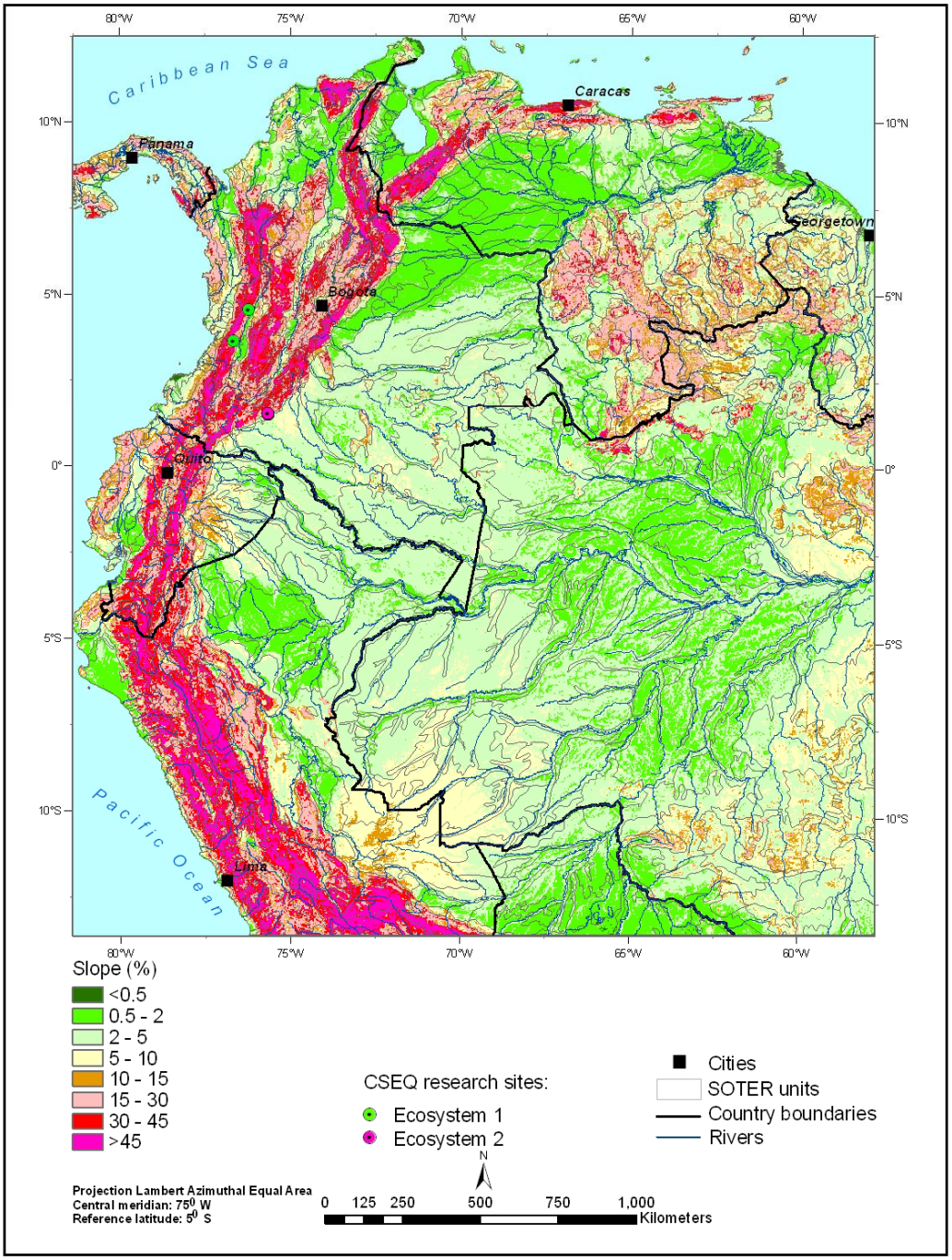


Figure 5. Slope classes derived from SRTM 90 DEM (USGS 2003)

2.2 Extrapolation method

Selection of areas with characteristics similar to those observed in the four ecosystems consisted of:

(1) A selection of the LGP class corresponding to the CSEQ ecosystem site (Figures 2 and 3);
(2) An overlay of the map resulting from (1) with the elevation range representing the ecosystem: this map is derived from the SRTM DEM (Figure 4);
(3) An overlay of map (2) with the slope class map derived from the SRTM DEM (Figure 5) using the slope ranges observed within the ecosystem;
(4) An overlay of map (3) and the SOTER unit map with the condition: soil classification of the soil component of the SOTER unit = soil classification in the selected research site. Figures 6 and 7 show areas having soils similar to those of ecosystem 2.

The maps used in steps 1, 2 and 3 are in raster format. Cells sizes vary between 90 m for the SRTM DEM to 5 arcminutes (about 9 km x 9 km at the equator) for the LGP map. The LGP map was resampled to the pixel size of the SRTM to make the resulting overlay less blocky, while maintaining the resolution of the LGP map. Selection of areas having the appropriate LGP, slope and elevation values was done by a GIS query for each ecosystem. The resulting raster map was vectorized and subsequently combined with the map showing SOTER units having soils similar to those of the considered ecosystem.

The extrapolation criteria for each ecosystem are described below, and summarized in Table 2.

Ecosystem 1, Andean Hillsides, Colombia

The two sites – Dagua and Dovio – both fall within the LGP class 1: 365 days.

GPS-measured altitudes range between 1439 and 1899 m for the Dagua sites and between 1791 and 1859 m for the Dovio sites.

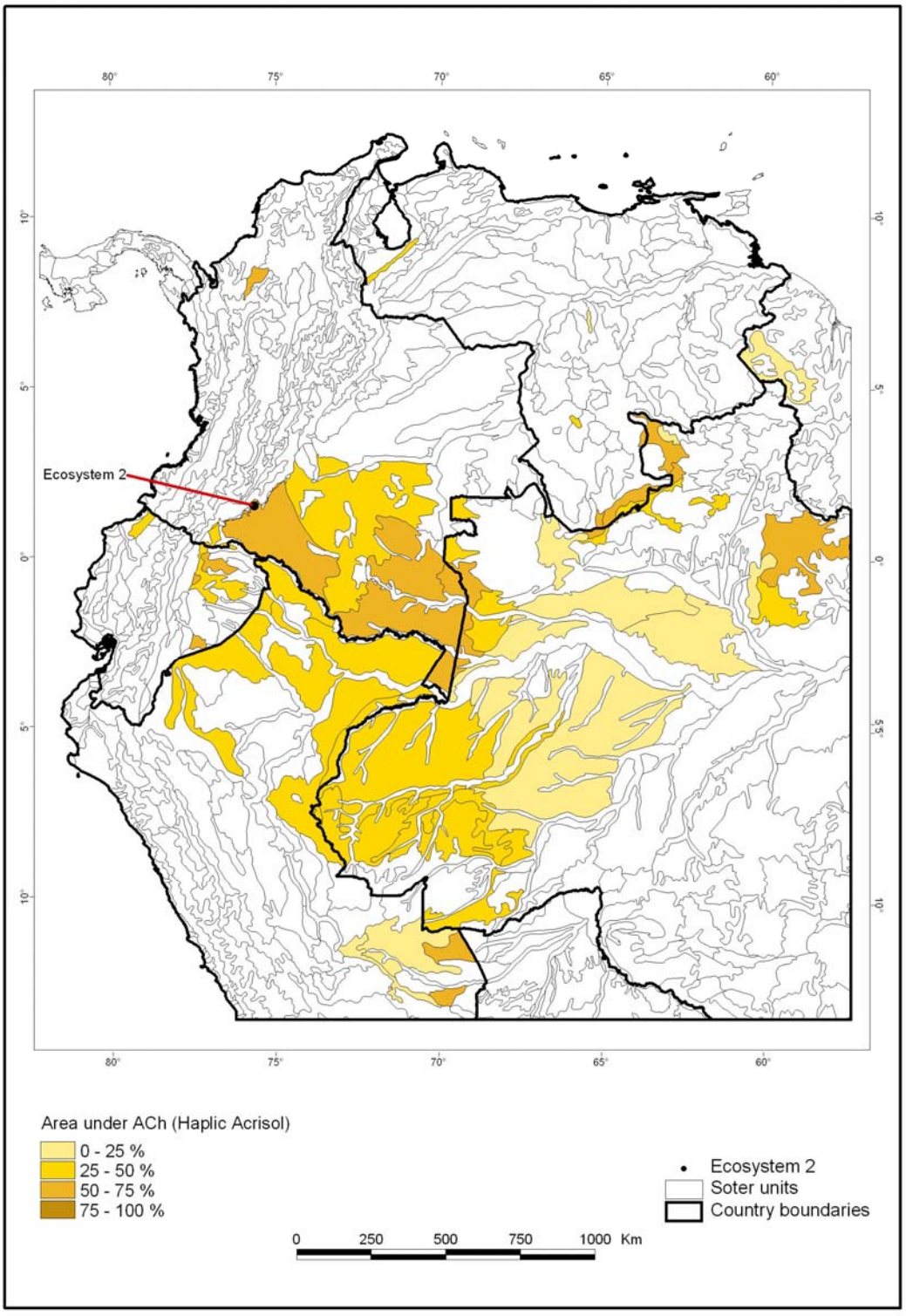


Figure 6. Extent and proportion of *Haplic Acrisols* (Dijkshoorn *et al.* 2005)

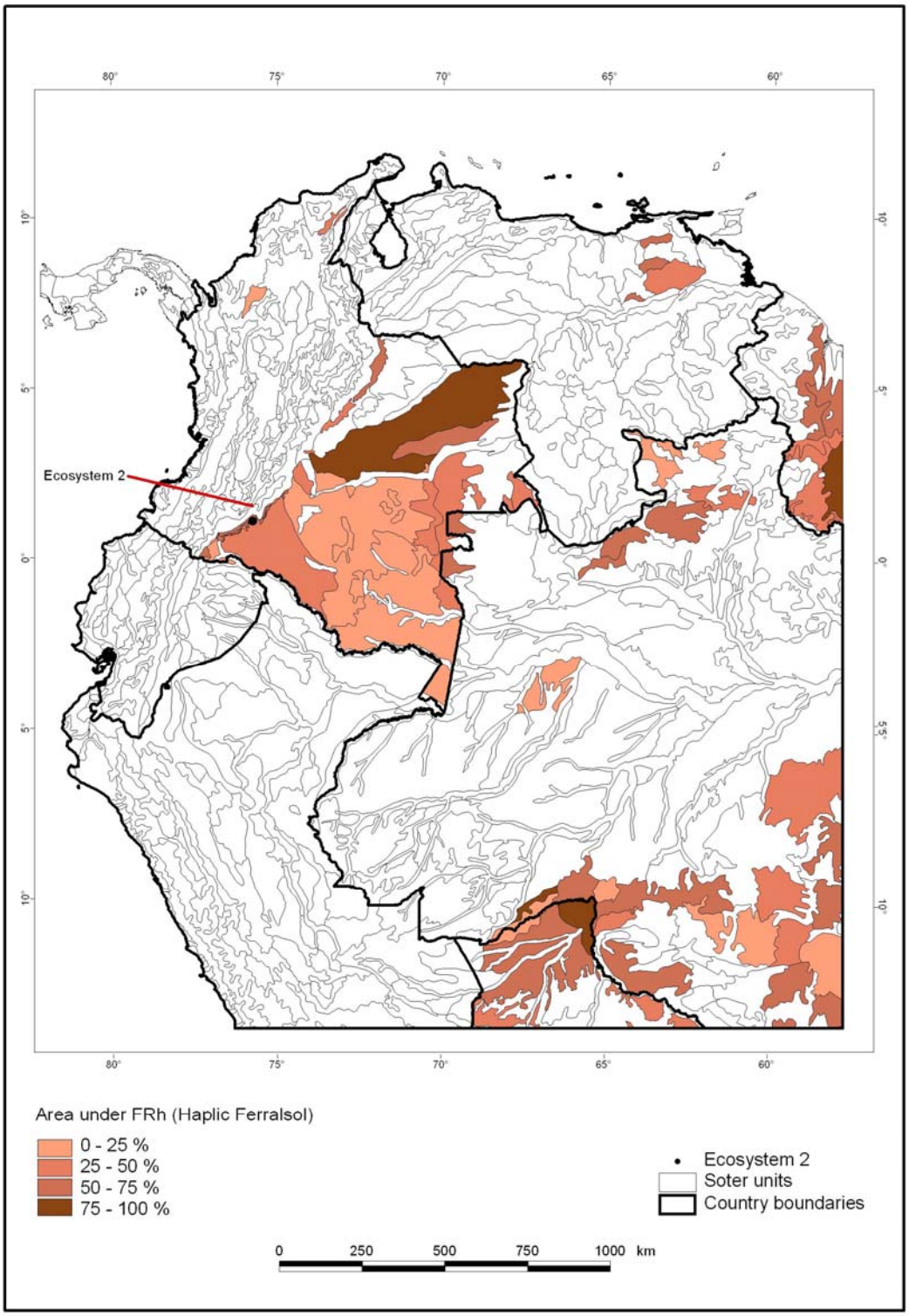


Figure 7. Extent and proportion of *Haplic Ferralsols* (Dijkshoorn *et al.* 2005)

Elevation indicated by the SRTM DEM falls between 1413 to 2137 m. A range of 1400 – 2000 m was taken for the extrapolation.

Slopes at the sites are described as 'moderate and steep' for Dagua and Dovio respectively (Amézquita *pers. comm.*), while the DEM quantifies them as 6-16% for Dagua, with a 30-45% outlier in one site, and 3-30% in Dovio. Slopes greater than 10% were used for the extrapolation.

Soils of Dovio are classified as *Typic Dystropepts* (Soil Survey Staff 1987) corresponding to *Dystric Cambisols* of the Revised Legend (FAO *et al.* 1988). The soils of the Dagua sites are *Typic Dystrandepts* and were correlated to *Umbric Andosols.* According to SOTERLAC, the research sites fall in a SOTER unit with two soil components: 70% *Umbric Andosols* and 30% *Dystric Cambisols*.

Figure 8. Ecosystem 1-research sites

Ecosystem 2, Humid Tropical Forest, Amazonia, Colombia

All sites in this ecosystem fall within LGP zone 1': 365 days with year-round excess moisture conditions. Also LGP zone 1: 365 days was used for the extrapolation.

Altitudes for the four sites in the ecosystem range from 232 to 244 m according to the DEM. Conversely, the altitude of 800 m given by CSEQ (Carbon Sequestration Project 2003) therefore could not be used. Instead, an altitude of less than 300 m was used in the extrapolation.

Slopes of the sites range from 2–15 % as determined by the DEM, while. Amézquita (*pers. comm.*) described the slopes as flat to mild. Percentages from 0 to 5 for the flat areas (flat to gently undulating topography) and 10 to 15 for the mild slopes (rolling topography) have been used for the extrapolation.

Soils range from *Typic Kandiudults, Paleudults* and *Hapludults* to *Oxic Dystropepts*. Tentatively, they were correlated with *Haplic Acrisols* and *Ferralsols.* According to SOTERLAC, the research site occurs in a unit with 70% *Haplic Acrisols* and 30% *Haplic Ferralsols*.

Figure 9. Ecosystem 2 with flat topography

Figure 10. Ecosystem 2 with rolling topography

Ecosystem 3, Humid Tropical Forest, Atlantic Coast, Costa Rica

All sites in this ecosystem fall within LGP zone 1: 365 days. Zone 1 was used for the extrapolation.

Altitudes for the sites in the ecosystem range from 25 to 190 m in the DEM. An altitude of less than 200 m was used in the extrapolation.

Slopes of the sites range from 0–5 % as determined by the DEM. These percentages have been used for the extrapolation.

Soils of the sites are classified by CSEQ as *Inceptisols*. Tentatively, they have been correlated with *Dystric Cambisols.* The spatial information of SOTERLAC indicates for the site a unit with 50% *Dystric Cambisols*, 25% *Eutric Gleysols* and 25% *Dystric Fluvisols* of which only the first soil type has been used in the extrapolation.

Figure 11. Ecosystem 3

Ecosystem 4, Sub-humid Tropical Forest, Pacific Coast, Costa Rica

All sites in this ecosystem fall within LGP zone 4: 270 -299 days. This zone was used for the extrapolation.

Altitudes for the sites in the ecosystem range from 25 to 300 m in the DEM. An altitude of less than 300 m was used in the extrapolation.

Slopes of the sites range from 15–30% as determined by the DEM. These percentages have been used for the extrapolation.

Soils of the sites are classified as *Inceptisols* and *Entisols* by CSEQ corresponding with Cambisols of the Revised Legend. The SOTER unit that covers the research area comprises *Cambisols*: *Umbric* (50%), *Dystric* (25%) and *Eutric* (25%).

Table 2. Criteria for extrapolation of research sites characteristics.

Ecosystem	**Site**	**Soil name** [a]	**Area** [b]	**LGP** [c]	**Altitude (m)**	**Slope (%)**
1) Tropical Andean Hillsides, Colombia	Dagua	Umbric Andosols	75	1	1200-2000	>10
	Dovio	Dystric Cambisols	25	1	1200-2000	>10
2) Humid Tropical Forest, Amazonia, Colombia	all	Haplic Acrisols/ Ferralsols	70 30	1' and 1	< 300	0-5 and 10-15
3) Humid tropical forest, Atlantic Coast, Costa Rica	Pocora	Dystric Cambisols	50	1	< 300	0-5
4) Sub-humid tropical forest, Pacific Coast, Costa Rica	Esparza	Cambisols: Umbric Dystric Eutric	 50 25 25	4	< 300	15-30

[a] Soil classification from the SOTERLAC database (Dijkshoorn *et al.* 2005)
[b] Relative area of the soil with the SOTER unit.
[c] LGP 1'= 365+ days, LGP 1 = 365 days, LGP 4 = 270-299 days

3. RESULTS

Ecosystem 1 - Andean Hillsides, Colombia

An areas of about 7,000 km^2 has *Umbric Andosols* and 3,000 km^2 *Dystric Cambisols* with identical LGP and slope/elevation conditions as those observed in ecosystem 1 (Figures 12 and 13, Table 3).

Table 3. Areas (x1000 km^2) for the soil types of ecosystem 1, by country

Country	*Umbric Andosols*	*Dystric Cambisols*
Colombia	6	2
Ecuador	<1	<1
Peru	-	<1
Total	7	3

Ecosystem 2 - Humid Tropical Forest, Amazonia, Colombia

This ecosystem is extensive in the upper Amazon basin in the gently undulating to flat lowlands. Soils in these areas are mainly *Haplic Acrisols* and *Haplic Ferralsols.*

Some 288,000 km^2 are *Haplic Acrisols* and 80,000 km^2 *Haplic Ferralsols* with similar LGP and slope/elevation conditions as ecosystem 2 when slopes are flat. The rolling topography ('mild' slopes) is less extensive and the total surface for the *Haplic Acrisols* amounts to 6,700 km^2 and for the *Haplic Ferralsols* to 2,500 km^2. (Figures 14 and 15, and Table 4 for the flat topography, Figures 16 and 17, and Table 5 for the rolling topography).

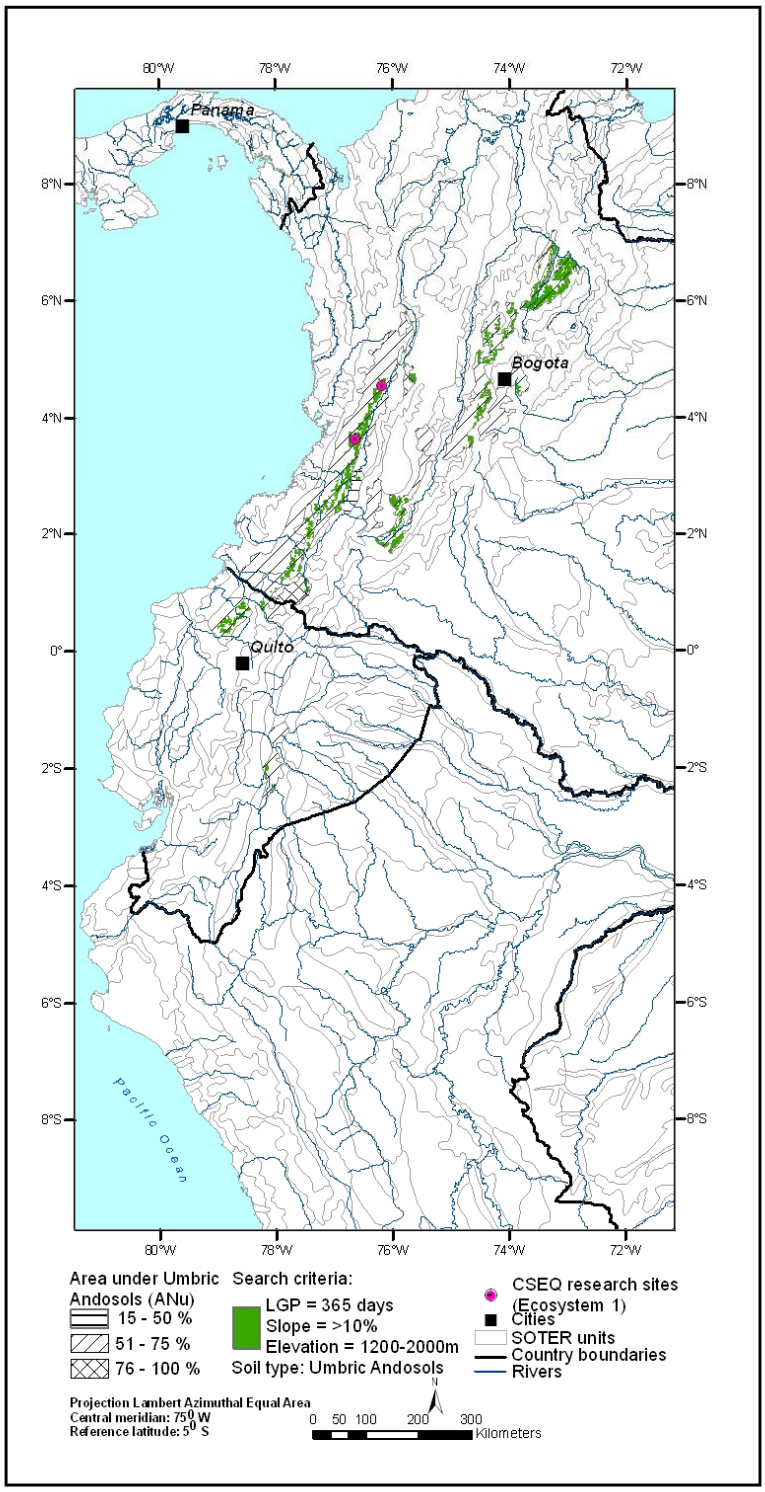


Figure 12. Areas of ecosystem 1 with *Umbric Andosols*

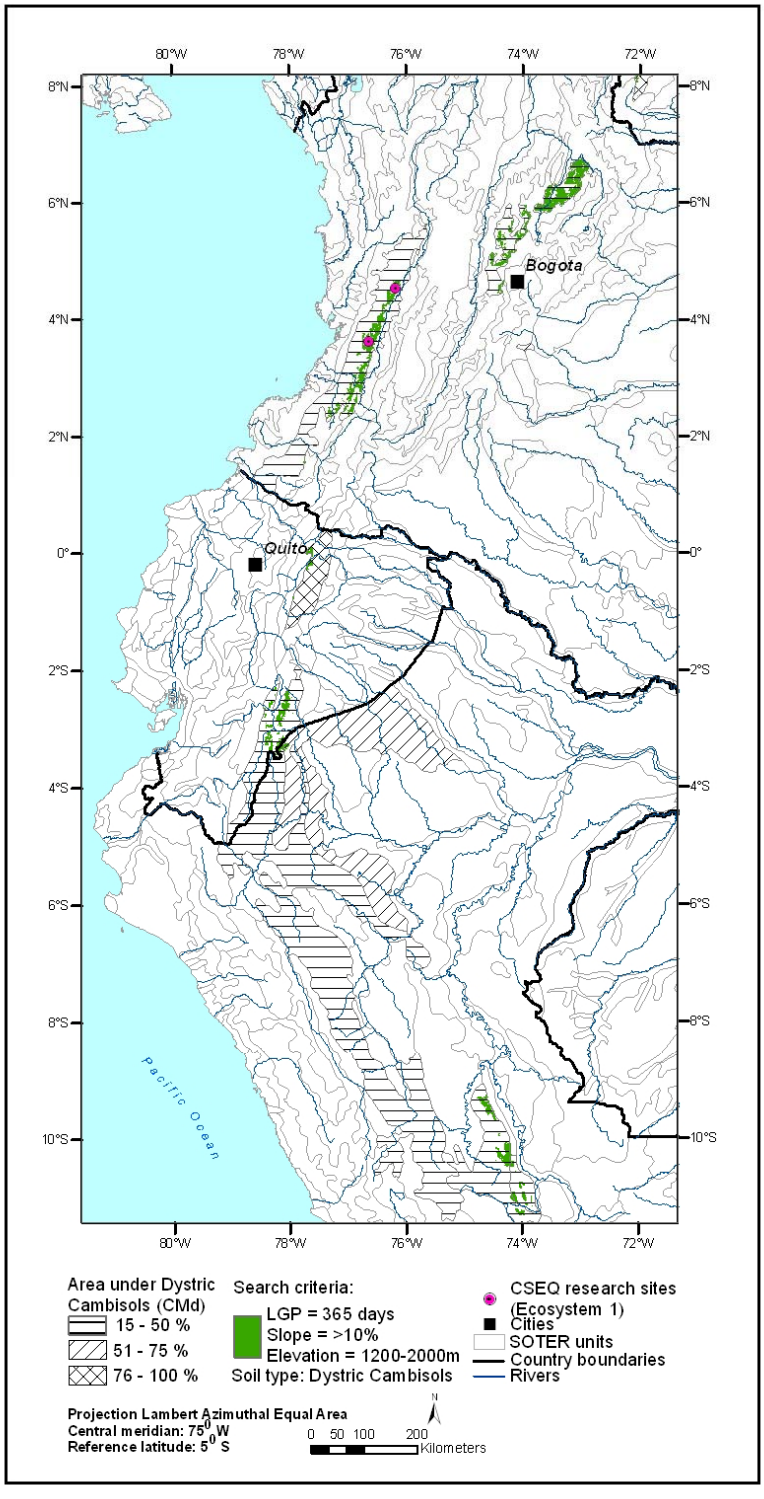


Figure 13. Areas of ecosystem 1 with *Dystric Cambisols*

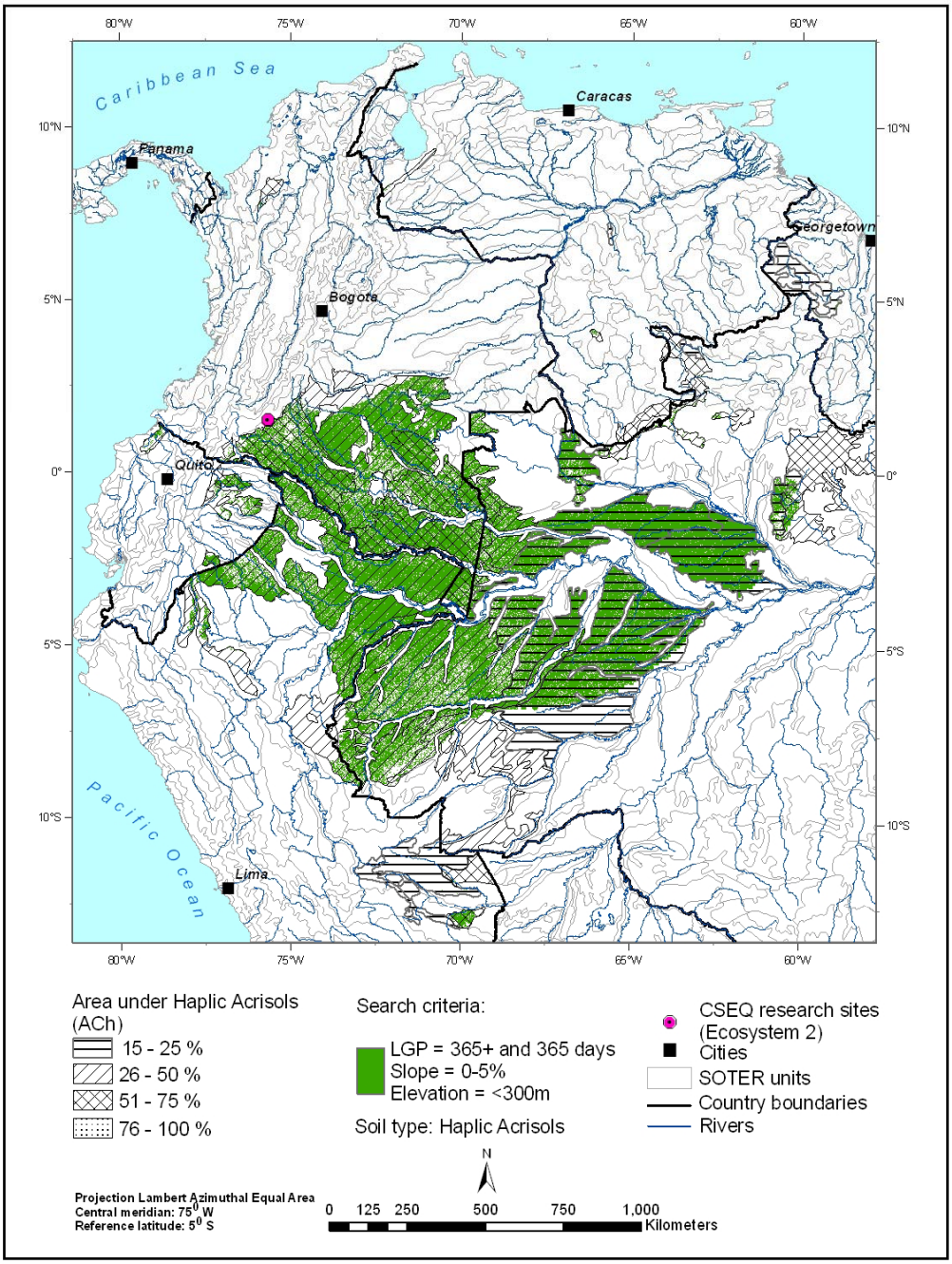


Figure 14. Areas of ecosystem 2 with *Haplic Acrisols* with flat topography

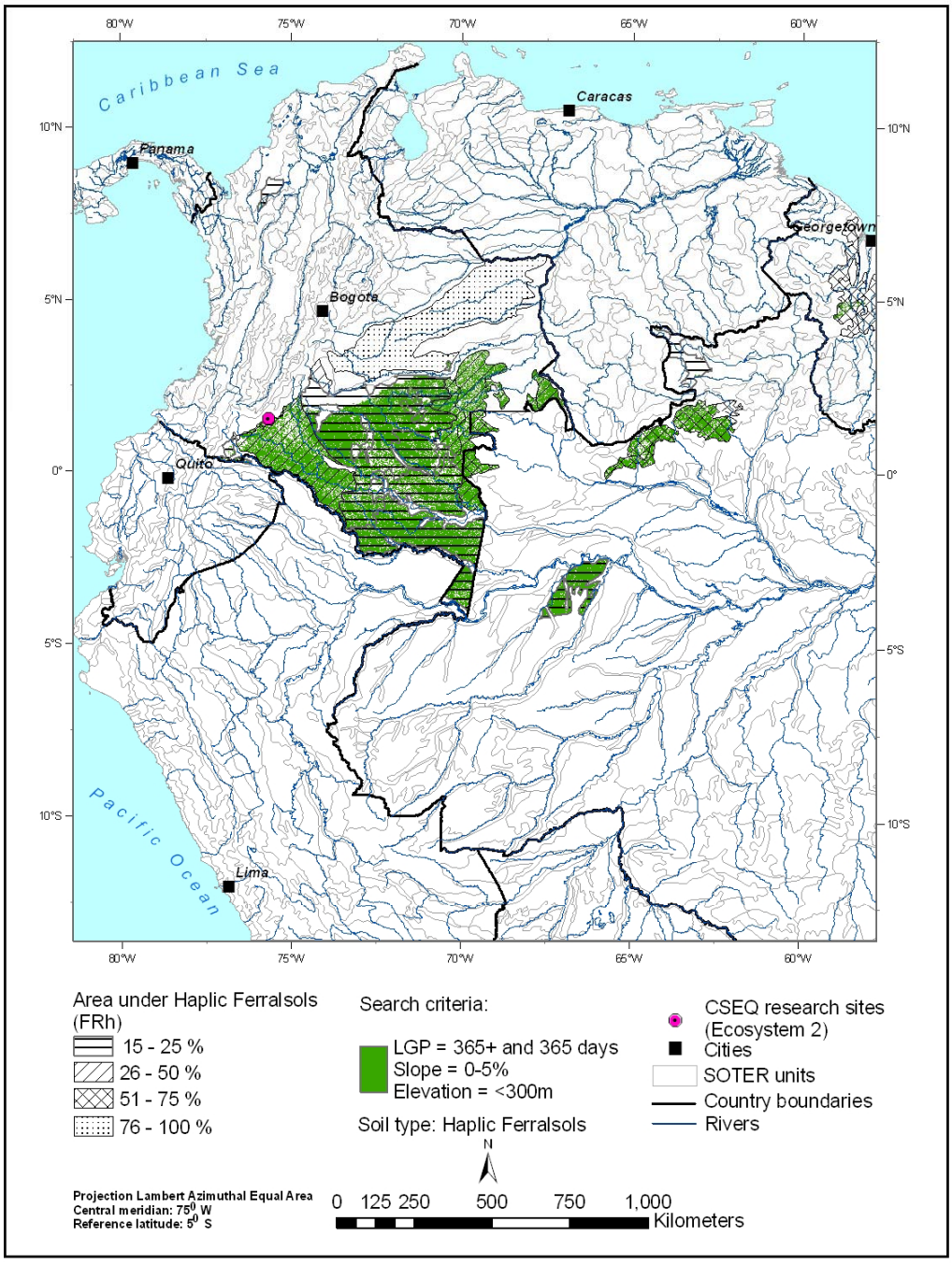


Figure 15. Areas of ecosystem 2 with *Haplic Ferralsols* with flat topography

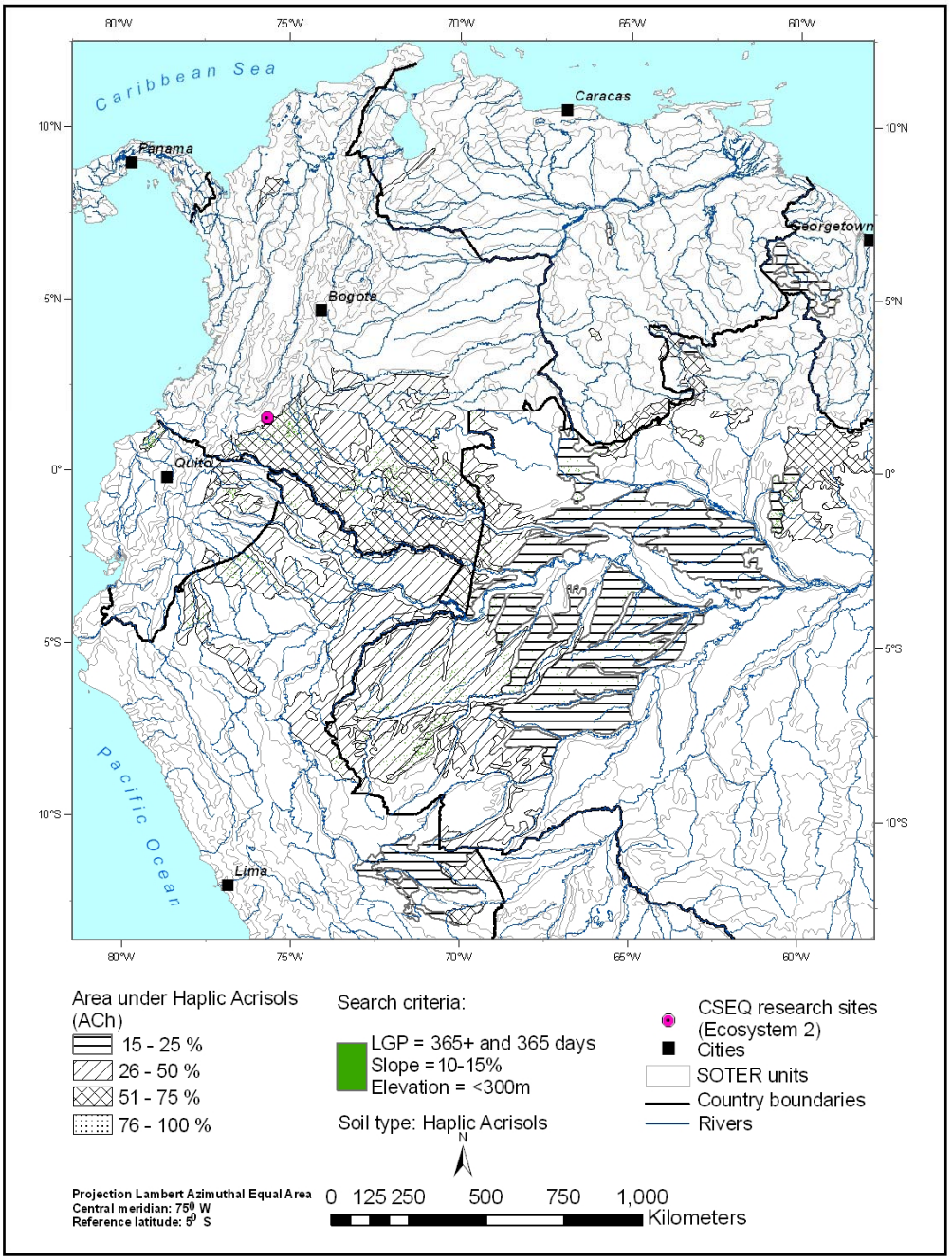


Figure 16. Areas of ecosystem 2 with *Haplic Acrisols* with rolling topography

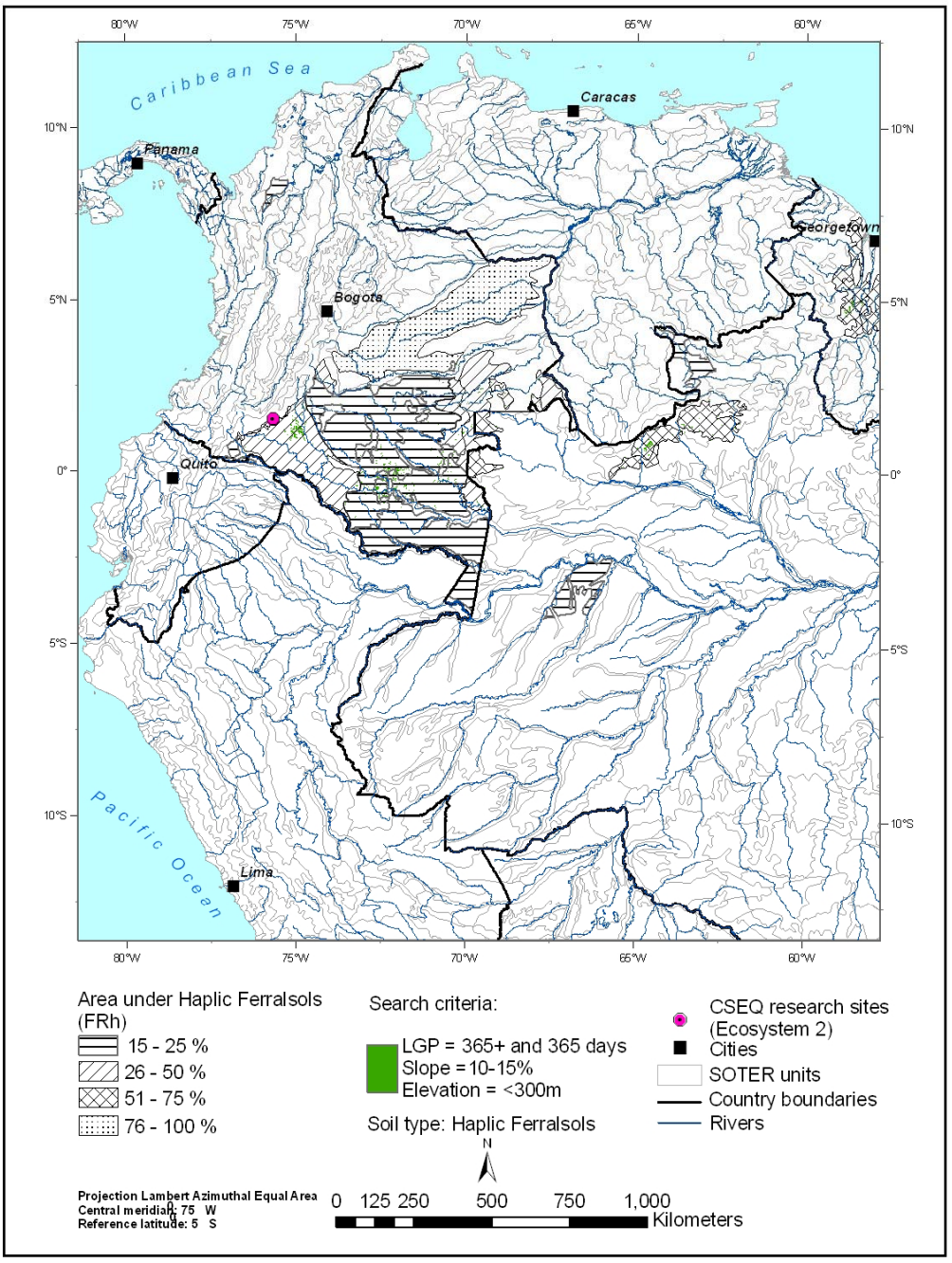


Figure 17. Areas of ecosystem 2 with *Haplic Ferralsols* with rolling topography

Table 4. Areas (x1000 km^2) for the soil types of ecosystem 2 on flat topography, by country

Country	*Haplic Acrisols*	*Haplic Ferralsols*
Brazil	111	19
Colombia	112	60
Ecuador	4	-
Guyana	-	1
Peru	60	-
Venezuela	<1	-
Total	288	80

Table 5. Areas (x1000 km^2) for the soil types of ecosystem 2 on rolling topography, by country

Country	*Haplic Acrisols*	*Haplic Ferralsols*
Brazil	3	<1
Colombia	3	2
Ecuador	<1	-
Guyana	<1	<1
Peru	1	-
Venezuela	<1	-
Total	7	2

Ecosystem 3 - Humid Tropical Forest, Atlantic Coast, Costa Rica

An area of less than 750 km^2 has *Dystric Cambisols* with identical LGP and slope/elevation conditions as ecosystem 3 (Figure 18 and Table 6).

Table 6. Areas (x1000 km^2) under Humid Tropical Forest (ecosystem 3), by country

Country	*Ecosystem 3*
Costa Rica	0.7
Guatemala	<0.1
Panama	<0.1
Total	0.7

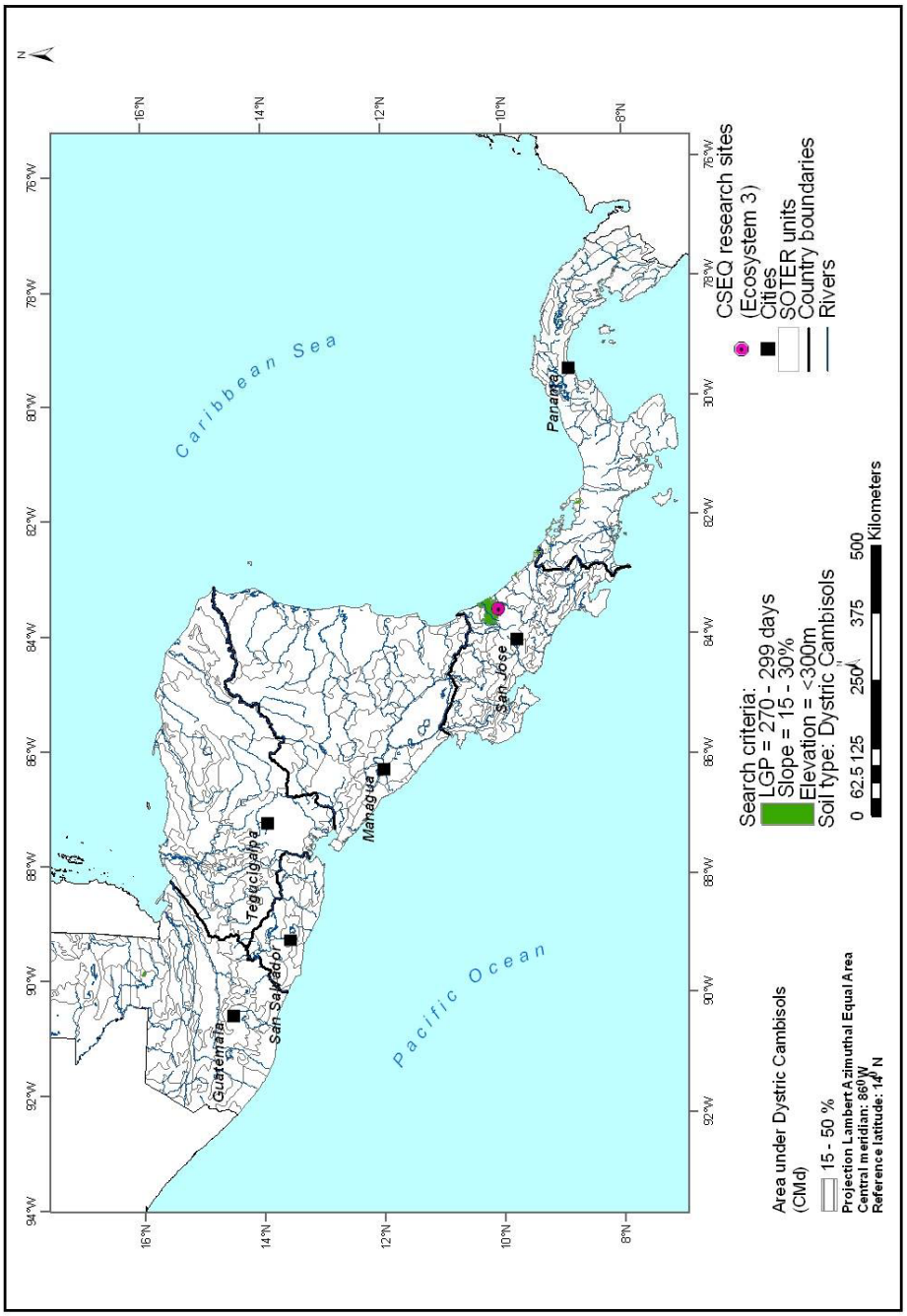


Figure 18. Areas of ecosystem 3 with *Dystric Cambisols*

Ecosystem 4 - Sub-humid Tropical Forest, Pacific Coast, Costa Rica

An area of about 1,300 km^2 has *umbric, dystric* or *eutric Cambisols* with identical LGP and slope/elevation conditions as ecosystem 4 (see Figure 19 and Table 7).

Table 7. Areas (x1000 km^2) of the soil types of ecosystem 4, by country

Country	***Umbric Cambisols***	***Dystric Cambisols***	***Eutric Cambisols***
Costa Rica	<0.1	<0.1	<0.1
Nicaragua	-	<0.1	-
Panama	<0.1	0.7	0.4
Total	<0.1	0.8	0.4

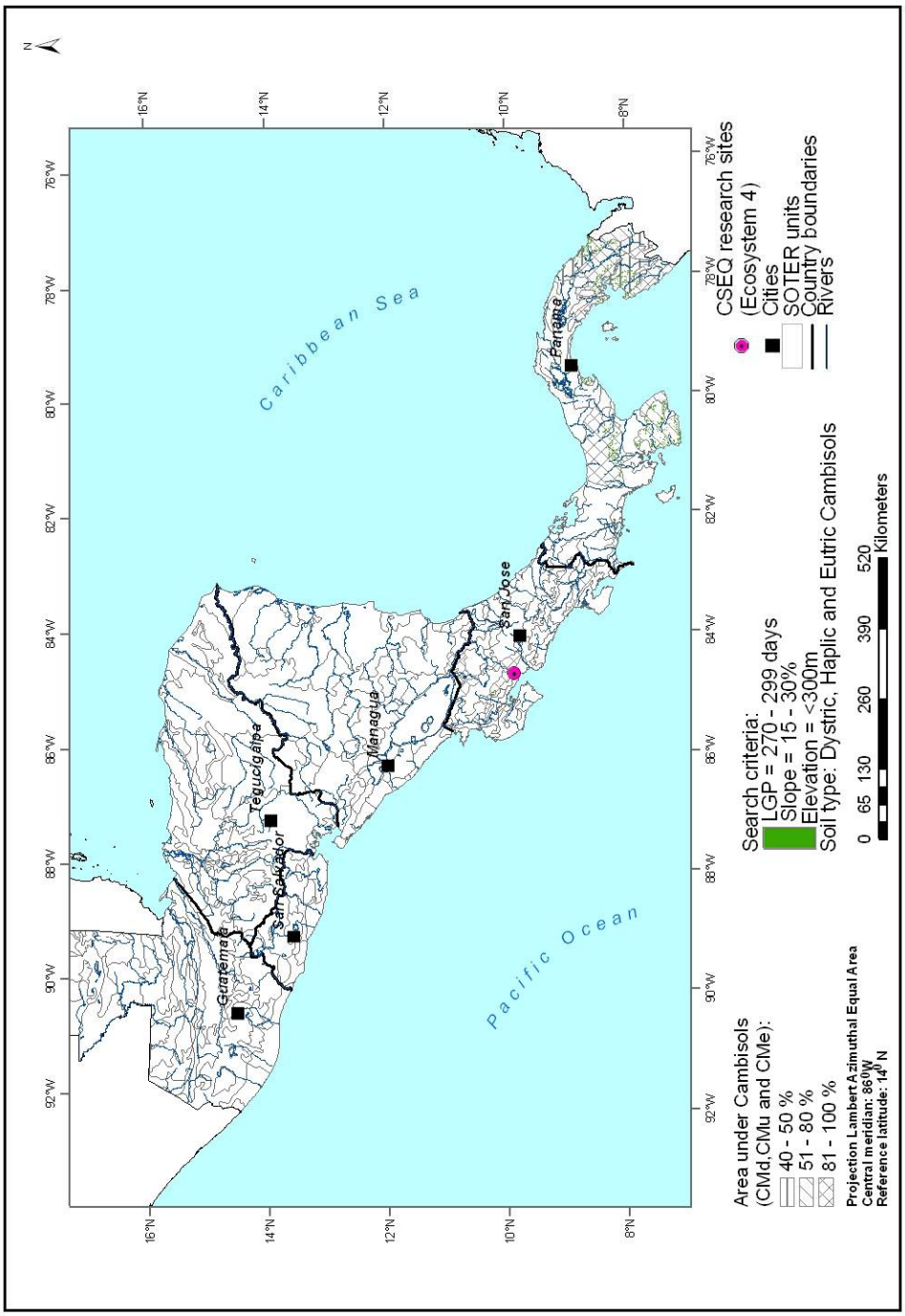


Figure 19. Areas of ecosystem 4 with *Cambisols*

4. CONCLUSIONS

Areas with similar ecological conditions as reported for four CSEQ research sites by the Carbon Sequestration Project (2003) were mapped and characterized.

There are a number of uncertainties in this assessment:

- Soil identification by CSEQ is according to the Soil Taxonomy (Soil Survey Staff 1987). Available data however, do not allow for a good correlation with the Revised Legend (FAO-Unesco 1988).
- The topography characterization of the research sites of ecosystems 2, 3 and 4 by CSEQ is descriptive. Quantification of these terms is approximate as no standardized class names were used. Therefore, the extrapolation was based on slope and elevation determined by the SRTM-DEM.
- Mapping units of the 1:5 M SOTERLAC database (Dijkshoorn *et al.* 2005) typically consist of more than one soil component. This is inherent to the low resolution of the map. Some units can have three components (for example CR 183 in Costa Rica – occurring in ecosystem 4, which includes 50% *Dystric Cambisols*, 25% *Eutric Gleysols* and 25% *Dystric Fluvisols*). Although the relative composition of the map unit is known, the exact location of the component soils cannot be delineated at the considered scale. For quantification purposes, it was therefore assumed that the various soil components are evenly distributed within a unit.

A better assessment would require new soil characterization of the research sites, using internationally accepted methods for description(FAO 2006a, b). This would allow for a better translation of the soil classification names into the ones used in SOTER, and subsequent spatial extrapolation.

Assessment at national scale should be based on more detailed spatial data. The latter are available for Costa Rica, Colombia and Peru, albeit not in SOTER format.

REFERENCES

Carbon Sequestration Project 2003. Two-year Project Achievements, Dec.1, 2001 - Nov. 30, 2003. In: Amézquita MC, and Ruiz, F., (editor), *Fourth International Coordination Meeting*. Internal Document #9. CSEQ, CIAT, Cali, Colombia, pp 194

Carbon Sequestration Project 2005a. *Six-months Report No 7*. 16, CSEQ, Cali

Carbon Sequestration Project 2005b. *Six-months Report No 8*. 14, CSEQ, Cali

Dijkshoorn JA, Huting JRM and Tempel P 2005. *Update of the 1:5 million Soil and Terrain Database for Latin America and the Caribbean (SOTERLAC; version 2.0).* . ISRIC Report 2005/01, ISRIC - World Soil Information, Wageningen

FAO-IIASA 2000. Global Agro-Ecological Zones, FAO-IIASA (http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm)

FAO-Unesco 1988. *Soil map of the world - Revised legend*. 60, FAO, Rome

FAO 2006a. *Guidelines for soil description*. FAO, Rome, 97 p

FAO 2006b. *World reference base for soil resources 2006*, IUSS, ISRIC, FAO, Rome

FAO, Unesco and ISRIC 1988. *Revised Legend, Soil Map of the World*. World Soil Resources Reports 60, FAO, Rome

FAO, ISRIC, UNEP and CIP 1998. *Soil and Terrain Database for Latin America and the Caribbean - SOTERLAC (version1.0).* Land and Water Digital Media Series 5, Food and Agriculture Organization (FAO) of the United Nations, the International Soil Reference and Information Centre (ISRIC), the United Nations Environment Programme (UNEP) and the International Potato Centre (CIP), Rome

Soil Survey Staff 1987. *Keys to Soil Taxonomy*. SMSS Technical Monograph no. 6, 6. Goverment Printing Office, Washington

Soil Survey Staff 1998. *Soil Taxonomy, A Basic System of Soil Classification for Making and Interpreting Soil Surveys*. Agricultural Handbook, 438. U.S. Government Printer, Washington DC

USGS 2003. Shuttle Radar Topographic Mission Digital Elevation Model (http://srtm.usgs.gov/)

APPENDICES

Appendix 1: Length of Growing Period classes

Length of Growing Period (LGP) classes in days (FAO-IIASA 2000)

LGP class	No. of days	Remarks
1'	365+	year-round excess moisture conditions
1	365	
2	330-364	
3	300-329	
4	270-299	
5	240-269	
6	210-239	
7	180-209	
8	150-179	
9	120-149	
10	90-119	
11	60-89	
12	30-59	
13	1-29	
14	0	year-round moisture deficit

Appendix 2: Extent of areas similar to the four ecosystems

Areas that fit the extrapolation criteria are described in this appendix. Data are listed by SOTER polygon that meets the extrapolation criteria of the ecosystem and, if applicable, per soil type within the ecosystem.

A - Codes used in area data tables

Column	Code		Description
1	SUID		SOTER unit ID (country code with number)
		BR	Brazil
		CO	Colombia
		CR	Costa Rica
		EC	Ecuador
		SV	El Salvador
		GT	Guatemala
		GY	Guyana
		HN	Honduras
		NI	Nicaragua
		PA	Panama
		PE	Peru
		VE	Venezuela
2	NNn_%		Proportion of specified soil type (e.g. FRh) within SUID (e.g. BR214)
		ACh	*Haplic Acrisols*
		ANu	*Umbric Andosols*
		CMd	*Dystric Cambisols*
		CMe	*Eutric Cambisols*
		CMu	*Umbric Cambisols*
		FRh	*Haplic Ferralsols*
3	NNn_SQKM		area in km^2 of specific soil type having similar LGP, slope and elevation conditions as the considered ecosystem
4	SQKM_POLY		area in km^2 of SUID
5	%_NNn		Proportion within SUID of the specific soil type having similar LGP, slope and elevation conditions as the considered ecosystem

B – List of SOTER polygons with *Umbric Andosols* in Ecosystem 1

SUID	ANu_%	ANu_SQKM	SQKM_POLY	%_ANu
CO46	50	46.644	1844.261	2.5
CO45	100	90.647	2119.586	4.3
CO26	60	258.348	1304.274	19.8
CO26	60	43.934	4717.854	0.9
CO26	60	345.672	4188.986	8.3
CO26	60	13.268	1238.945	1.1
CO26	60	561.612	3752.957	15.0
CO26	60	1.857	2152.604	0.1
CO26	60	237.848	2838.888	8.4
CO25	70	15.598	559.087	2.8
CO25	70	319.624	2664.838	12.0
CO23	70	1622.629	3985.493	40.7
CO23	70	721.043	5143.578	14.0
CO23	70	1804.455	25887.498	7.0
CO19	100	109.180	845.759	12.9
EC9	75	97.127	3254.943	3.0
EC21	70	480.561	4178.866	11.5
EC19	60	61.775	1117.851	5.5
EC16	70	0.448	174.620	0.3
All		13664.540	71970.888	19.0

Note: Extrapolation criteria: *Umbric Andosols* having LGP 1, slopes >10% and elevation 1400-2000 m

C – List of SOTER polygons with *Dystric Cambisols* in Ecosystem 1

SUID	CMd_%	SQKM_CMD	SQKM_POLY	%_CMd
CO23	30	695.036	3985.493	17.4
CO23	30	308.117	5143.578	5.9
CO23	30	772.956	25887.498	2.9
CO37	60	3.183	315.539	1.0
EC10	85	182.391	7054.442	2.5
EC11	45	485.598	12060.793	4.0
PE36	40	56.794	81098.150	0.1
PE75	30	330.983	15980.062	2.0
PE76	50	144.484	3212.845	4.5
PE8	60	35.721	43750.582	0.1
VE16	100	16.427	4363.398	0.4
All		6046.953	202852.380	3.0

Note: Extrapolation criteria: *Dystric Cambisols* having LGP 1, slopes >10% and elevation 1400-2000 m

D – List of SOTER polygons with *Haplic Acrisols* in Ecosystem 2 on flat topography

SUID	ACh_%	ACh_SQKM	SQKM_POLY	%_ACh
BR214	40	3270.524	13330.451	24.5
BR214	40	6031.555	23875.357	25.2
BR214	40	91.245	3528.621	2.5
BR214	40	5.265	16882.912	0.0
BR216	40	485.349	14804.281	3.2
BR216	40	1324.706	7632.532	17.3
BR216	40	376.757	1581.657	23.8
BR216	40	604.895	1988.488	30.4
BR216	40	780.331	2221.115	35.1
BR216	40	265.132	2204.323	12.0
BR216	40	321.136	1300.088	24.7
BR216	40	196.704	636.261	30.9
BR216	40	196.156	1942.968	10.0
BR217	40	33805.256	111437.610	30.3
BR218	15	14186.375	146531.909	9.6
BR219	50	2422.957	5194.175	46.6
BR219	50	1181.818	2735.509	43.2
BR219	50	260.840	583.389	44.7
BR219	50	747.116	1827.594	40.8
BR219	50	894.175	2171.964	41.1
BR221	15	3357.902	26210.920	12.8
BR221	15	1609.317	13325.612	12.0
BR221	15	307.112	2897.984	10.5
BR231	15	7948.051	58131.071	13.6
BR232	15	6884.714	47834.021	14.3
BR232	15	96.190	671.285	14.3
BR232	15	2570.246	19034.787	13.5
BR233	20	700.520	3852.709	18.1
BR234	70	1032.983	2068.871	49.9
BR235	35	2052.067	6888.682	29.7
BR235	35	2983.571	10532.018	28.3
BR236	60	3542.454	7984.244	44.3
BR236	60	2102.407	5035.326	41.7
BR237	40	1118.176	4244.333	26.3
BR237	40	1653.547	4975.541	33.2
BR240	15	2046.480	17404.746	11.7
BR246	70	148.271	1442.513	10.2
BR247	30	245.481	8479.677	2.8
BR248	70	39.117	2616.035	1.4
BR249	70	15.275	9659.079	0.1
BR260	30	92.661	3808.977	2.4
BR261	25	1144.670	8624.394	13.2
BR262	70	918.557	41375.108	2.2
BR264	50	1631.360	15215.293	10.7

CO51	65	3195.729	5893.184	54.2
CO63	70	29414.378	57283.353	51.3
CO8	60	29.311	3432.310	0.8
CO8	60	18524.983	41086.004	45.0
CO8	60	23636.702	44665.015	52.9
CO8	60	3776.876	7573.085	49.8
CO9	45	32970.767	106001.839	31.1
CO9	45	151.300	2273.702	6.6
CO9	45	109.689	380.778	28.8
EC24	30	344.265	3081.179	11.1
EC3	60	1467.185	4137.782	35.4
EC43	45	106.099	341.584	31.0
EC5	70	851.566	1750.141	48.6
EC8	40	1320.582	11225.396	11.7
GY12	20	7.695	18428.964	0.0
PE1	40	16649.929	46163.553	36.0
PE11	40	4609.613	13631.340	33.8
PE17	20	30.393	35186.474	0.0
PE18	60	69.148	9192.505	0.7
PE2	40	747.095	2394.315	31.2
PE2	40	2490.222	7696.495	32.3
PE21	60	1474.471	4345.698	33.9
PE4	40	5027.495	15949.768	31.5
PE4	40	1022.962	3279.490	31.1
PE5	40	8752.588	26590.767	32.9
PE6	40	11424.386	56218.041	20.3
PE70	20	0.941	9649.902	0.0
PE8	40	7821.836	43750.582	17.8
VE15	40	174.766	2905.396	6.0
VE77	40	96.209	843.603	11.4
VE78	65	16.627	6661.295	0.2
VE94	70	0.692	423.762	0.1
VE95	70	7.156	1282.110	0.5
All		288013.077	1278443.842	22.5

Note: Extrapolation criteria: *Haplic Acrisols* having LGP 1 or 1', slopes <5% and elevation <300 m

E - List of SOTER polygons with *Haplic Ferralsols* in Ecosystem 2 on flat topography

SUID	FRh_%	FRh_SQKM	SQKM_POLY	%_FRh
BR222	15	1466.001	10435.436	14.1
BR222	15	753.335	5311.940	14.2
BR222	15	80.248	563.915	14.2
BR237	60	1676.510	4244.333	39.5
BR237	60	2478.517	4975.541	49.8
BR244	60	7091.041	19066.269	37.2
BR244	60	3180.039	8687.200	36.6
BR249	15	3.271	9659.079	0.0
BR287	60	2110.066	4742.977	44.5
CO36	40	6935.077	25010.660	27.7
CO36	40	1824.791	5559.629	32.8
CO38	70	0.958	264.006	0.4
CO38	70	90.113	702.127	12.8
CO38	70	259.845	1897.413	13.7
CO41	40	7.601	3663.045	0.2
CO42	100	1043.385	100389.775	1.0
CO43	20	49.946	381.661	13.1
CO43	20	190.128	1120.026	17.0
CO43	20	154.663	877.917	17.6
CO43	20	131.722	1030.745	12.8
CO43	20	230.902	3944.103	5.9
CO43	20	360.910	3006.618	12.0
CO43	20	233.479	3306.603	7.1
CO44	40	644.660	2665.140	24.2
CO44	40	296.023	1211.186	24.4
CO51	35	1719.583	5893.184	29.2
CO63	30	12606.128	57283.353	22.0
CO64	45	4044.682	11867.462	34.1
CO8	15	7.326	3432.310	0.2
CO8	15	4630.783	41086.004	11.3
CO8	15	5907.232	44665.015	13.2
CO8	15	943.613	7573.085	12.5
CO9	25	18316.528	106001.839	17.3
CO9	25	84.037	2273.702	3.7
CO9	25	60.853	380.778	16.0
EC43	25	58.887	341.584	17.2
GY21	55	733.672	16511.194	4.4
GY5	65	82.139	12162.488	0.7
All		80488.694	532189.342	15.1

Note: Extrapolation criteria: *Haplic Ferralsols* having LGP 1 or 1', slopes <5% and elevation <300 m

F – List of SOTER polygons with *Haplic Acrisols* in Ecosystem 2 on rolling topography

SUID	ACh %	ACh_SQKM	SQKM_POLY	% ACh
BR214	40	38.106	13330.451	0.3
BR214	40	300.678	23875.357	1.3
BR214	40	5.401	3528.621	0.2
BR214	40	0.574	16882.912	0.0
BR216	40	6.587	14804.281	0.0
BR216	40	330.697	7632.532	4.3
BR216	40	41.365	1581.657	2.6
BR216	40	23.049	1988.488	1.2
BR216	40	4.526	2221.115	0.2
BR216	40	19.168	2204.323	0.9
BR216	40	32.744	1300.088	2.5
BR216	40	3.522	636.261	0.6
BR216	40		1942.968	
BR217	40	711.604	111437.610	0.6
BR218	15	112.203	146531.909	0.1
BR219	50	7.395	5194.175	0.1
BR219	50	21.056	2735.509	0.8
BR219	50	0.883	583.389	0.2
BR219	50	11.664	1827.594	0.6
BR219	50	6.144	2171.964	0.3
BR221	15	42.140	26210.920	0.2
BR221	15	15.578	13325.612	0.1
BR221	15	14.997	2897.984	0.5
BR231	15	14.654	58131.071	0.0
BR232	15	13.989	47834.021	0.0
BR232	15	0.061	671.285	0.0
BR232	15	18.117	19034.787	0.1
BR233	20	1.583	3852.709	0.0
BR234	70	17.266	2068.871	0.8
BR235	35	11.876	6888.682	0.2
BR235	35	41.479	10532.018	0.4
BR236	60	73.157	7984.244	0.9
BR236	60	56.444	5035.326	1.1
BR237	40	42.904	4244.333	1.0
BR237	40	19.557	4975.541	0.4
BR240	15	64.101	17404.746	0.4
BR246	70	52.544	1442.513	3.6
BR247	30	55.465	8479.677	0.7
BR248	70	2.551	2616.035	0.1
BR249	70	3.629	9659.079	0.0
BR260	30		3808.977	
BR261	25	147.918	8624.394	1.7
BR262	70	64.037	41375.108	0.2
BR264	50	83.021	15215.293	0.5
CO51	65	59.194	5893.184	1.0

CO63	70		57283.353	
CO8	60	17.700	3432.310	0.5
CO8	60	718.016	41086.004	1.7
CO8	60	134.228	44665.015	0.3
CO8	60	26.346	7573.085	0.3
CO9	45	713.090	106001.839	0.7
CO9	45		2273.702	
CO9	45	10.443	380.778	2.7
EC24	30	141.633	3081.179	4.6
EC3	60	29.558	4137.782	0.7
EC43	45	4.465	341.584	1.3
EC5	70	13.154	1750.141	0.8
EC8	40	148.593	11225.396	1.3
GY12	20	10.300	18428.964	0.1
PE1	40	73.590	46163.553	0.2
PE11	40	15.273	13631.340	0.1
PE17	20	2.443	35186.474	0.0
PE18	60	2.455	9192.505	0.0
PE2	40	18.394	2394.315	0.8
PE2	40	25.752	7696.495	0.3
PE21	60	21.238	4345.698	0.5
PE4	40	96.694	15949.768	0.6
PE4	40	28.182	3279.490	0.9
PE5	40	65.244	26590.767	0.2
PE6	40	66.935	56218.041	0.1
PE70	20	0.052	9649.902	0.0
PE8	40	492.266	43750.582	1.1
VE15	40	11.687	2905.396	0.4
VE77	40	16.544	843.603	2.0
VE78	65	0.432	6661.295	0.0
VE94	70	0.000	423.762	0.0
VE95	70	2.694	1282.110	0.2
All		5501.029	1278443.842	0.4

Note: Extrapolation criteria: *Haplic Acrisols* having LGP 1 or 1', slopes 10-15% and elevation <300 m

G - List of SOTER polygons with *Haplic Ferralsols* in Ecosystem 2 on rolling topography

SUID	FRh_%	FRH_SQKM	SQKM_POLY	%_ FRh
BR222	15	6.107	10435.436	0.1
BR222	15	2.199	5311.940	0.0
BR222	15	0.125	563.915	0.0
BR237	60	64.395	4244.333	1.5
BR237	60	29.325	4975.541	0.6
BR244	60	190.294	19066.269	1.0
BR244	60	228.536	8687.200	2.6
BR249	15	0.775	9659.079	0.0
BR287	60	81.634	4742.977	1.7
CO36	40	217.744	25010.660	0.9
CO36	40	19.949	5559.629	0.4
CO38	70		264.006	
CO38	70		702.127	
CO38	70	28.546	1897.413	1.5
CO41	40	0.003	3663.045	0.0
CO42	100	38.921	100389.775	0.0
CO43	20	3.932	381.661	1.0
CO43	20	2.004	1120.026	0.2
CO43	20	1.845	877.917	0.2
CO43	20	4.719	1030.745	0.5
CO43	20		3944.103	
CO43	20	21.527	3006.618	0.7
CO43	20	64.930	3306.603	2.0
CO44	40	51.633	2665.140	1.9
CO44	40	19.495	1211.186	1.6
CO51	35	31.874	5893.184	0.5
CO63	30		57283.353	
CO64	45	90.870	11867.462	0.8
CO8	15	4.415	3432.310	0.1
CO8	15	179.595	41086.004	0.4
CO8	15	33.597	44665.015	0.1
CO8	15	6.580	7573.085	0.1
CO9	25	396.301	106001.839	0.4
CO9	25		2273.702	
CO9	25	5.802	380.778	1.5
EC43	25	2.473	341.584	0.7
GY21	55	114.538	16511.194	0.7
GY5	65	2.933	12162.488	0.0
All		1947.616	532189.342	0.4

Note: Extrapolation criteria: *Haplic Ferralsols* having LGP 1 or 1', slopes 10-15% and elevation <300 m

H - List of SOTER polygons with *Dystric Cambisols* in Ecosystem 3

SUID	CMd_%	CMd_SQKM	SQKM_POLY	%_CMd
GT155	15	2.723	4340.482	0.1
CR185	50	657.760	1320.837	49.8
CR210	40	12.480	170.340	7.3
CR210	40	16.326	240.190	6.8
PA210	40	15.280	601.893	2.5
PA210	40	4.727	64.570	7.3
PA210	40	0.340	51.232	0.7
PA210	40	0.382	36.072	1.1
PA210	40	0.178	53.597	0.3
PA210	40	14.894	828.520	1.8
All		725.090	7707.733	7.8

Note: Extrapolation criteria: *Dystric Cambisols* having LGP 1, slopes 0-5% and elevation <200 m

I - List of SOTER polygons with *Umbric Cambisols* in Ecosystem 4

SUID	CMu_%	CMu_SQKM	SQKM_POLY	%_CMu
CR184	50	27.714	1869.761	1.5
PA69	100	49.418	243.967	20.3
PA82	80	20.658	863.249	2.4
All		97.790	2976.977	8.0

Note: Extrapolation criteria: *Umbric Cambisols* having LGP 4, slopes 15-30% and elevation <300 m

J - List of SOTER polygons with *Dystric Cambisols* in Ecosystem 4

SUID	CMd_%	CMd_SQKM	SQKM_POLY	%_CMd
CR182	80	2.274	533.371	0.4
CR199	100	1.952	1660.739	0.1
CR206	80	2.825	1022.953	0.3
NI199	100	0.753	561.772	0.1
PA209	50	0.571	734.542	0.1
PA72	100	4.771	277.621	1.7
PA73	100	358.903	8909.777	4.0
PA80	70	386.807	4823.628	8.0
All		758.856	18524.403	1.9

Note: Extrapolation criteria: *Dystric Cambisols* having LGP 4, slopes 15-30% and elevation <300 m

K - List of SOTER polygons with *Eutric Cambisols* in Ecosystem 4

SUID	CMe_%	CMe_SQKM	SQKM_POLY	%_CMe
CR184	25	13.857	1869.761	0.7
PA209	50	0.571	734.542	0.1
PA56	60	50.952	1787.279	2.9
PA57	40	0.829	1289.929	0.1
PA58	60	13.866	3245.329	0.4
PA59	50	147.574	3353.956	4.4
PA60	50	132.917	5866.494	2.3
PA61	40	56.784	2084.145	2.7
All		417.350	20231.435	1.7

Note: Extrapolation criteria: *Eutric Cambisols* having LGP 4, slopes 15-30% and elevation <300 m

World Soil Information

ISRIC - World Soil Information is an independent foundation with a global mandate, funded by the Netherlands Government. We have a strategic association with Wageningen University and Research Centre.

Our aims:

- *To inform and educate - through the World Soil Museum, public information, discussion and publication*
- *As ICSU World Data Centre for Soils, to serve the scientific community as custodian of global soil information*
- *To undertake applied research on land and water resources*