ANNUAL REPORT 1993

LAND USE PROGRAM

For Internal Circulation
and Discussion Only

CIAT Centro Internacional de Agricultura Tropical

CONTENTS

List of Maps

List of Tables

LAND USE PROGRAM
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Executive Summary

1. Program Development

The basic research themes of the Program were defined in 1993. Those are:

a. Understanding and anticipating trends of land use in tropical America.

b. Analyzing the spatial distribution of land use patterns in relation to ecological factors in selected areas of tropical America.

c. Understanding the role of cross-scale (micro/macro) interactions in land use dynamics.

d. Identifying and developing policy-relevant indicators of sustainable land use.

e. Providing GIS services to other Programs.

2. Indicators of Agricultural Sustainability

A participative process for defining a CIAT-wide (and a potential inter-institutional) framework and research strategy on indicators of sustainable agriculture and land use was initiated in 1993. A Report on Measurements and Indicators of Sustainability was produced. An inter-institutional project proposal is being discussed.

3. GIS Network Installation

Starting this year, a GIS network has been set in place using ARC/INFO running under UNIX on a SUN based system. The 386 and 486 based microcomputers are now linked to a powerful SUN server 690-52, while for the present still remaining their links to the mainframe. Data input and output have been considerably enhanced with the addition to the network of a Calcomp 68436 electrostatic plotter, a Context 8000 scanner and a QMS 860 large format laser printer. The network also includes 2 Sun Sparc 10 workstations.

Satellite image processing is implemented with the ERDAS software package. A version of Oracle has been mounted on the Sun 690 server, greatly improving performance over the IBM 4361 based version.

4. Staff training

The move to a more sophisticated hardware and software has meant considerable expenditure on staff retraining. Initial training in ARC/INFO for one person was donated by Mr. Jack Dangermond, Chairman of ESRI. After taking this course at Redlands, California, the analyst developed course work for the rest of the technical staff of the agricultural geography and GIS sections of the program.

5. Database Operations

a. GIS. The many map coverages already existing in CIAT are being transposed to ARC/INFO. These include: the administrative units of many countries in Latin America, the data files that relate to them; the climate maps produced from the CIAT databases in the past; the crop distribution files; and elevation and soils maps that we have produced.

b. Oracle. New Oracle database tables have been prepared for a number of GIS applications. These include the land system study, Cochrane et al (1984), FAO soils map, the vegetation map of South America and the soils coverage of the

Altillanura study area in Meta, Colombia among others. These are being used to develop user friendly interfaces to the data coverages for the use of CIAT scientists outside the land use program. Within the program new applications for work control, map classification and contacts list have been developed and are being implemented.

c. Climate. The climate database has been left for the time being on the mainframe. This system was written in FORTRAN and IBM Assembler years ago and will need substantial modification to produce an enhanced version running under UNIX. New data entry, error checking and updates have been proceeding throughout the year. The database now holds data from over 18,000 stations throughout the tropics. A considerable addition has been the upgrading of our holdings for Asia in preparation for the production of an interpolated climate data set for Asia to serve the Cassava program environmental classification.

d. Data exchange. A comprehensive network of data exchange has been in place for many years. Data exchange with the Canadian Remote Sensing Agency is particularly gratifying as the CIAT datasets have been incorporated in the CD-ROM database 'Global Change Encyclopedia' which as participants we now receive free of charge. As depositors in the NGCD at Boulder, we also receive any data free of charge.

6. Stochastic Rainfall Models

In collaboration with IFDC the work on Markov rainfall models has proceeded apace. The first publication from this has appeared and describes the testing of the third order Markov model with resampling of parameters. It shows that for tropical situations the model outperforms other simpler applications and that the resampling of parameters accurately simulates the year to year variance which other models fail to account for.

Work has proceeded with the generalization of the model to provide interpolated mapping of the model parameters to interface with GIS linked models of cropping risk. We have conclusively proved that the order of the model required is closely associated with the climate system. The third order is needed for tropical climate systems. The model needs only be first or second order for many temperate systems. This resolves a controversy of many years between researchers in temperate countries and the tropics. It is postulated that the frontal weather systems of the temperate regions decouple the longer lag periods of the model necessary for tropical simulation.

7. World Trade in Plant Nutrients

World trade is usually measured in monetary terms. A large proportion of the exports of the developing countries are agricultural or forestry products. These products carry with them the basic plant nutrients N, P, K. This study looks at the balance of trade in terms of these nutrients. Years 1961 and 1985 were taken as base years. The 1960s give a view of the newly post colonialist world pre green revolution, 1985 the last years of the cold war.

World trade figures for all agricultural and forestry products were taken from the FAO publications and data tapes. Tonnages of product were converted into elemental equivalents of N P K. Fertilizer trade figures were obtained from IFDC and are mapped for comparison. Preliminary observations show that the obvious sink for these elements is the developed world, with Europe being particularly noticeable. India clearly shows the benefit of the green revolution; in 1961 it was a net importer of plant nutrients in products, by 1985 it had become a strong exporter. The trade in fertilizer has yet to be analyzed.

8. Latin America Rice Distribution

This study was initiated some years ago. The distribution was mapped in two stages. A first approximation was constructed using available secondary information. The maps produced were plotted and sent out to collaborators throughout Latin America. The maps were

returned to CIAT with corrections and recompiled into the 'second approximation'. The resulting distribution was overlaid with the environmental classification based on the CIAT databases and a breakdown of the rice growing environments of the continent was compiled. A document is in preparation for publication.

9. Asian Cassava Distribution

This is one of the last commodity distributions to be scheduled, necessary for the priority setting of the cassava Biotechnology Network in Asia. This completes the studies already made for Africa and Latin America.

Recent census data have been compile in tabular form. The administrative units maps of all cassava growing countries in Asia have been digitized and are to be provided in draft form to the cassava program to assist in a questionnaire census of cassava processing. The administrative boundary maps are to be superimposed on the Digital Chart of the World (DCW) and the tabular data will be used to distribute the areas planted to cassava in each of the administrative units. The distribution map will be used to compile an inventory of cassava growing environments.

10. Latin America Protected Areas

When embarking on the strategic planning exercise, it was necessary to compile a digital coverage of these areas to discount them from the analysis. This project has now matured into a maintenance and update stage and will be carried on as a basic resource for the Land Use Program. Recent developments have included the publication of the CIAT working document 'Legally protected areas of Latin America'. While this serves as detailed documentation of the database an interesting environmental classification of the protected areas is included. To produce this we used the CIAT climate database to produce coverages of the CIAT 'Natural Resource Management' (NRM) classification (see Strategic Plan Supplement), the Koppen climate classification and the Holdridge Life Zone map. They were overlaid on the protected area coverage and an inventory of protected areas was produced showing the area protected for each environmental class. The inventory highlighted the fact that the tropical amazonian rainforest is not the environment at greatest risk of disappearing. Vast areas are still untouched and up to 30 percent of what remains is legally protected. The smaller areas of montane rainforest, dry tropical forests, highlands and agriculturally productive lands have diminishingly small areas undisturbed and very little of the area legally protected.

We are in close contact with the World Conservation Monitoring Centre in this project.

11. Site Selection for Forest Margin Areas, Brazil

Following the initial agro-ecosystem analysis, the individual areas of forest margins in South America were processed with secondary data on agricultural and pastoral production data to further characterize the potential study areas. Satellite images were used for representative areas in Para (Paragominas) and Acre/Rondonia. These were digitized differentiating broad land use categories and overlaid with digitized soil, geology and vegetation maps. The results were presented in a report which is being used in consultation with CIAT's partners in Brazil to define the final study area.

12. Site Selection Cerrados Region, Brazil

Last year saw the completion of an innovative classification of the Cerrados region of Brazil to determine appropriate study areas for joint research with EMBRAPA and local agencies. Data from the climate database and the land system study were used to provide images of climate, soils and terrain for the region. These were complemented by data from the Brazilian agricultural censuses from 1970, 1975 and 1980. 38 images were combined using Factor analysis to produce 12 factor images, a statistical subsample was extracted from these and a two stage cluster analysis was used to

produce 11 representative classes of cerrados demarcated by biophysical and land use patterns. These were used to characterize 12 potential study areas in respect to the areas of savanna represented in the region. The study was used in Brasilia to select candidates for the final study area.

13. Study Area Characterization. Altillanura Colombia.

The study area of Altillanura between Puerto Lopez and Puerto Gaitan in the department of Meta (eastern Colombia) has been selected for in depth study by the Savannas Program of CIAT. The Land Use Program is developing a detailed GIS coverage of the region. Soil maps at a scale of 1:100,000 have been digitized and a simple user interface has been developed. The road and savanna track access to the area can be overlaid to estimate access time.

Work is proceeding to produce a digital elevation model of the area with sufficient precision to be useful for running erosion models. The 1:25,000 topographic maps of the area are being digitized along with the stream lines and spot heights to be used as input.

14. Resource degradation evaluation. Hillsides.

An assessment of the state of degradation in the hillsides of tropical america was required for planning purposes in the CIAT Hillsides Program.

The image of rainy months (rainfall >60mm) was calculated from the CIAT climate database. An image of soil depth was calculated from the image of dominant FAO soil units held in the database in conjunction with tables of soil properties developed by the Agroecological Studies Unit.

The levels of degradation were estimated from the "World Map on the Status of Human-Induced Soil Degradation' UNEP/ISRIC 1990. Data from the digitized version of the map were analyzed to extract the areas involved in water, wind and chemical degradation at various levels of severity. Also extracted were the base causes of the degradation and the rates of degradation in the recent past.

Of about 92,000,000 hectares mapped as hillsides in this study water erosion was by far the most important. Moderate water erosion which strongly reduces agricultural productivity at the farm level was found to occur in 14,000,000 hectares. Strong water erosion unreclaimable at the farm level accounted for 11,600,000 hectares. Together some 26 percent of the total area was subject to serious erosion. The main causes were equally deforestation, overgrazing and agricultural activity.

15. Study Area Characterization. Northern Cauca, Colombia

This study area of the CIAT Hillsides Program has been the scene of previous activity of the program. Coverages of the area in topography, climate, soils, land use, access, population, among others, are now documented in the program map coverage database. The program is preparing for a major thrust in the area.

16. Special Projects

The financing of the project "Diagnosis of the Agricultural Land Use in Southwest Brazilian Amazon" has been approved by the IDB. The project will be implemented in 1994.

ANNUAL REPORT 1993

1. Program Development

The basic research themes of the Program were defined in 1993. Those are:

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b. Analyzing the spatial distribution of land use patterns in relation to ecological zones and factors in selected areas of tropical America.

c. Understanding the role of cross-scale (micro/macro) interactions in land use dynamics.

d. Identify and developing policy-relevant indicators of sustainable land use.

e. Providing GIS services to other Programs.

The recruitment process for a Senior Tropical Ecologist has been launched. New areas of cooperation with other CIAT Programs have been discussed.

2. Indicators of Agricultural Sustainability

A participative process for defining a CIAT-wide (and a potential inter-institutional) framework and research strategy on indicators of sustainable agriculture and land use was initiated in 1993. The process involved: a) a consultation meeting with the CIAT's Program Leaders, the AD of Institutional Relations, and the Head of the Impact Assessment Unit; b) the preparation of a draft CIAT Project Profile; c) the setting up of an inter-institutional collaborative team (including CIAT, CIMMYT, and an external consultant), which through intensive team work and extensive consultations with CIAT's and CIMMYT's researchers, produced a report on Measurements and Indicators of Sustainability to be published by CIAT. An inter-institutional project proposal is being discussed.

3. GIS Network Installation

Considerable effort has been expended during this period on the expansion and updating of the database and GIS hardware and software. Up until this year almost all geographic analysis has been done using basic software (Fortran, Atlas*Draw, Idrisi) on the IBM mainframe and linked IBM compatible microcomputers. The databases have been partly translated to ORACLE on the IBM 4361.

Starting this year a GIS network has been set in place using the far more sophisticated and costly ARC/INFO package running under UNIX on a SUN based system. The 386 and 486 based microcomputers are now linked to a powerful SUN server 690-52, while for the present still retaining their links to the mainframe. Data input and output have been considerably enhanced with the addition to the network of a Calcomp 68436 electrostatic plotter, a Context 8000, 800 dpi monochrome scanner and a QMS 860 large format laser printer. The network also includes 2 Sun Sparc 10 workstations.

Satellite image processing is implemented with the ERDAS software package. A version of Oracle has been mounted on the Sun 690 server, greatly improving performance over the IBM 4361 based version.

Work is currently underway to forge the final links to the new optical fibre network being created for CIAT.

4. Staff Training

The move to a more sophisticated hardware and software has meant considerable expenditure on staff retraining. Initial training in ARC/INFO for one person was kindly donated by Mr. Jack Dangermond, Chairman of ESRI. After taking this course at Redlands California the analyst developed course work for the rest of the technical staff of the agricultural geography and GIS sections of the program. Basic concepts and usage of ARC/INFO are now in place in the program. The next stage is well under way. This is to replace the process of digitizing in Atlas*Draw by the rather more complicated, but more reliable, one in ARC/INFO. Further training in network use and UNIX is well under way.

5. Database Operations

a. **GIS**. The many map coverages already existing in CIAT are being transposed to ARC/INFO. These include: all the maps digitized for the various CIAT projects over last 7 or 8 years; the administrative units of many countries in Latin America, the data files that relate to them; the climate maps produced from the CIAT databases in the past; the crop distribution files; elevation and soils maps that we have produced. Other coverages include the Land system study of Cochrane et al, the Brazil soils map 1:5,000,000

The transfer of all the remaining map data will take much time. Translation, verification and redocumentation will probably occupy the GIS unit for many months to come.

b. **Oracle**. New Oracle database tables have been prepared for a number of GIS applications. These include the land system study, preliminary coverages of the soils coverage of the Altillanura study area in Meta, Colombia among others. These are being used to develop user friendly interfaces to the data coverages for the use of CIAT scientists outside the land use program.

Within the program new applications for work control, map classification and contacts list have been developed and are in the process of implementation.

c. **Climate**. The climate database has been left for the time being on the mainframe. This system was written in FORTRAN and IBM Assembler many years ago and will need substantial modification to produce an enhanced version running under UNIX. P. Jones, the original author, will lead the translation of the approximately 6000 lines of code as soon as FORTRAN and a graphics interface is loaded on the new system. It is envisaged that the task should take less than 4 months.

New data entry, error checking and updates have been proceeding throughout the year. The database now holds data from over 18,000 stations throughout the tropical world. A considerable addition has been the upgrading of our holdings for Asia in preparation for the production of an interpolated climate data set for Asia to serve the Cassava Program environmental classification.

d. **Data exchange.** A comprehensive network of data exchange has been in place for many years. The program has during the last year sent data to:

- The University of Washington, USA.
- GRID Geneva, Switzerland.
- GRID Nairobi, Kenya.
- IRRI, Philippines.
- HIMAT, Bogotá, Colombia.
- University of East Anglia, Climate Research Unit, UK.
- National Geophysical Data Center, Boulder, Colorado, USA.
- IFDC, Muscle Shoals, Alabama, USA.
- Canadian Remote Sensing Agency, Canada.

The data exchange with the last mentioned is particularly gratifying as the CIAT datasets have been incorporated in the CD-ROM database 'Global Change Encyclopedia' which as participants we now receive free of charge. As depositors in the NGCD at Boulder we also receive any data free of charge. This includes access to their comprehensive CD-ROM production.

6. Stochastic Rainfall Models

In collaboration with IFDC the work on Markov rainfall models has proceeded apace. The first publication from this research theme has now been published (Jones & Thornton 1993) and describes the testing of the third order Markov model with resampling of parameters. It shows that for tropical situations the third order model outperforms other more simple applications and that the resampling of parameters accurately simulates the year to year variance which other models fail to account for.

Work has proceeded with the generalization of the model with an aim to provide interpolated mapping of the model parameters to interface with GIS linked models of cropping risk. We have conclusively proved that the order of the model required is closely associated with climate system. The third order is needed for tropical climate systems. The model need only be first or second order for many temperate systems. This resolves a controversy of many years standing between researchers in temperate countries and the tropics. It is postulated that the frontal weather systems of the

temperate regions decouple the longer lag periods of the model necessary for tropical simulation. A publication on this is forthcoming.

7. World Trade in Plant Nutrients

World trade is usually measured in monetary terms. The balance of trade is often unequal, Japan could be cited as an example. A large proportion of the exports of the developing countries are agricultural or forestry products. These products carry with them the basic plant nutrients N, P, K. This study looks at the balance of trade in terms of these nutrients. Years 1967 and 1985 were taken as base years. The 1960s give a view of the newly post colonialist world pre green revolution. 1985 the last years of the cold war. It will be interesting to compare the pattern established as the post cold war world develops.

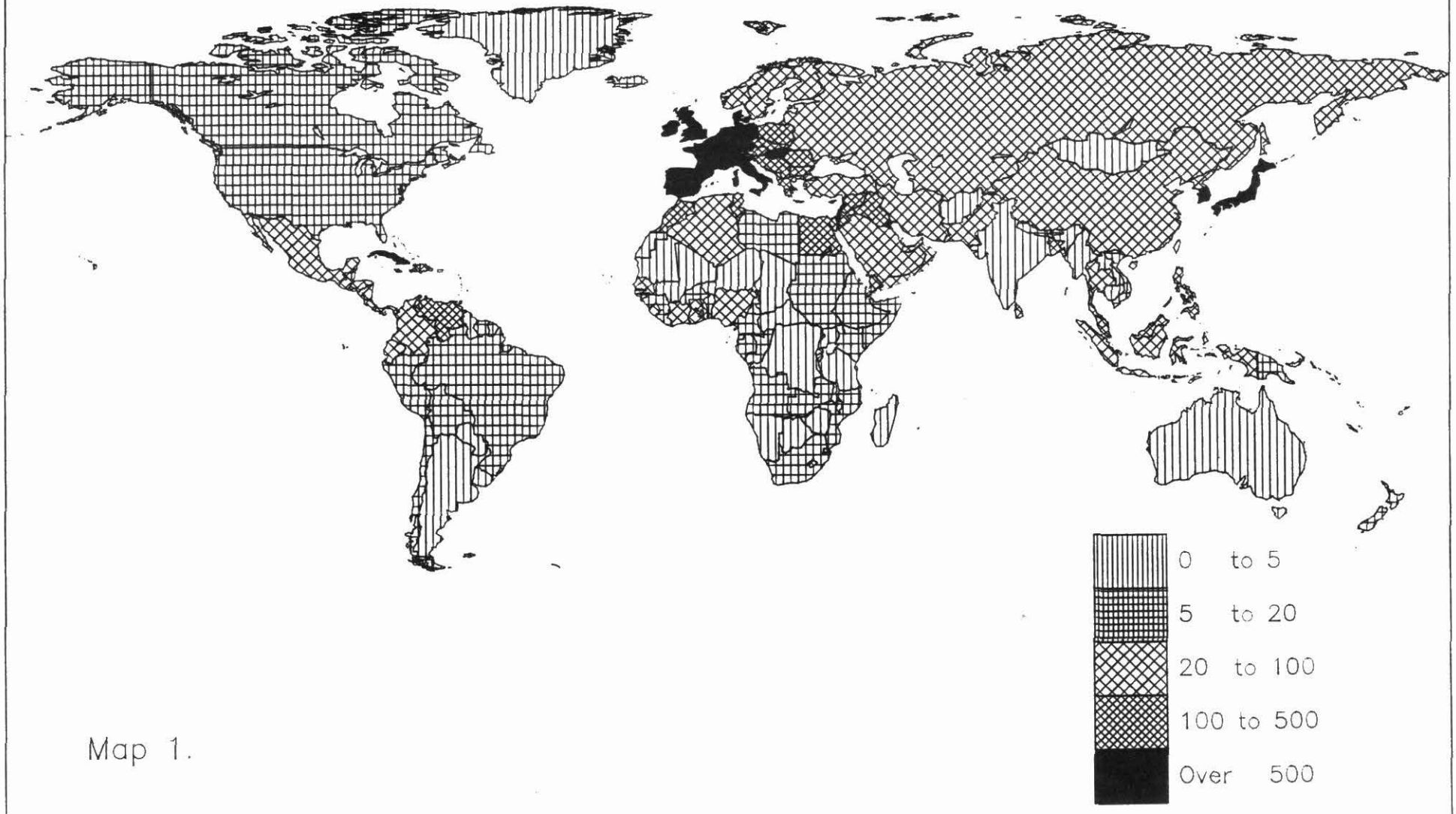
World trade figures for all agricultural and forestry products were taken from the FAO publications and data tapes. Tonnages of product were converted into elemental equivalents of N, P, K and mapped using Atlas*Graphics. Fertilizer trade figures were obtained from IFDC and are mapped for comparison. Preliminary observations show that the obvious sink for these elements is of course the developed world. Europe is particularly noticeable in this. India clearly shows the benefit of the green revolution in 1967 it was a net importer of plant nutrients in products, by 1985 it had become a strong exporter. Many African nations are strong exporters and the outward flow is not balanced by fertilizer imports.

Map 1 shows the importation of nitrogen in agricultural and forest products for the year 1985 expressed as kilogram per square kilometer to correct for size of country. Europe and Japan are notable sinks. Cuba is unusual as an underdeveloped country with a marked importation of nitrogen.

Map 2 gives an example of the balance of nutrient flow. The net balance of potassium for the year 1985.

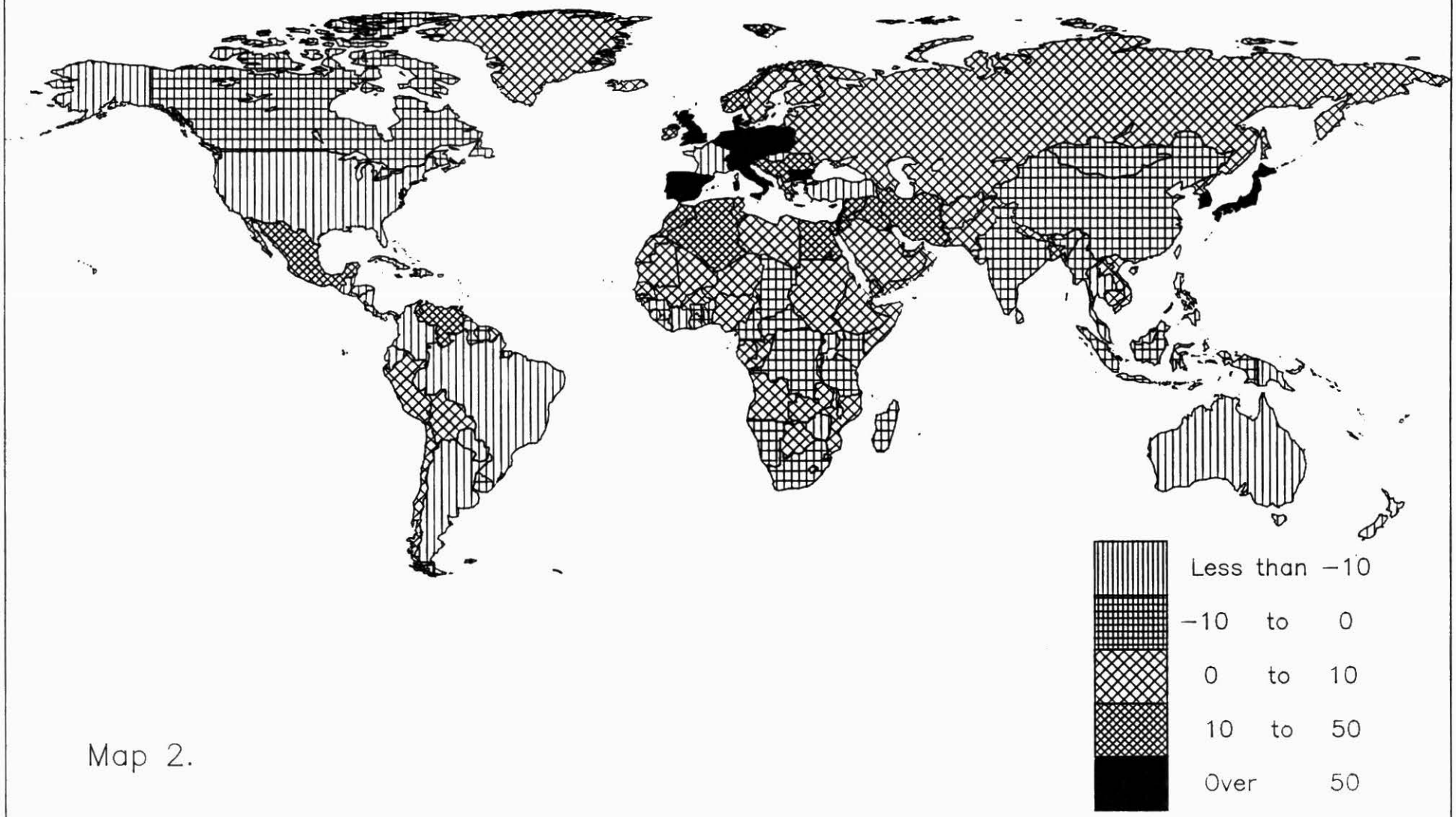
Map 3 shows the change in net balance of trade in phosphorus between the years 1961 and 1985. The balance has strengthened towards imports in many countries, notably Spain Italy Germany and some countries in the middle East. It could be argued that this has been due to the strengthening of the economics in these

IMPORTS OF NITROGEN 1985 (kilos per Km2)



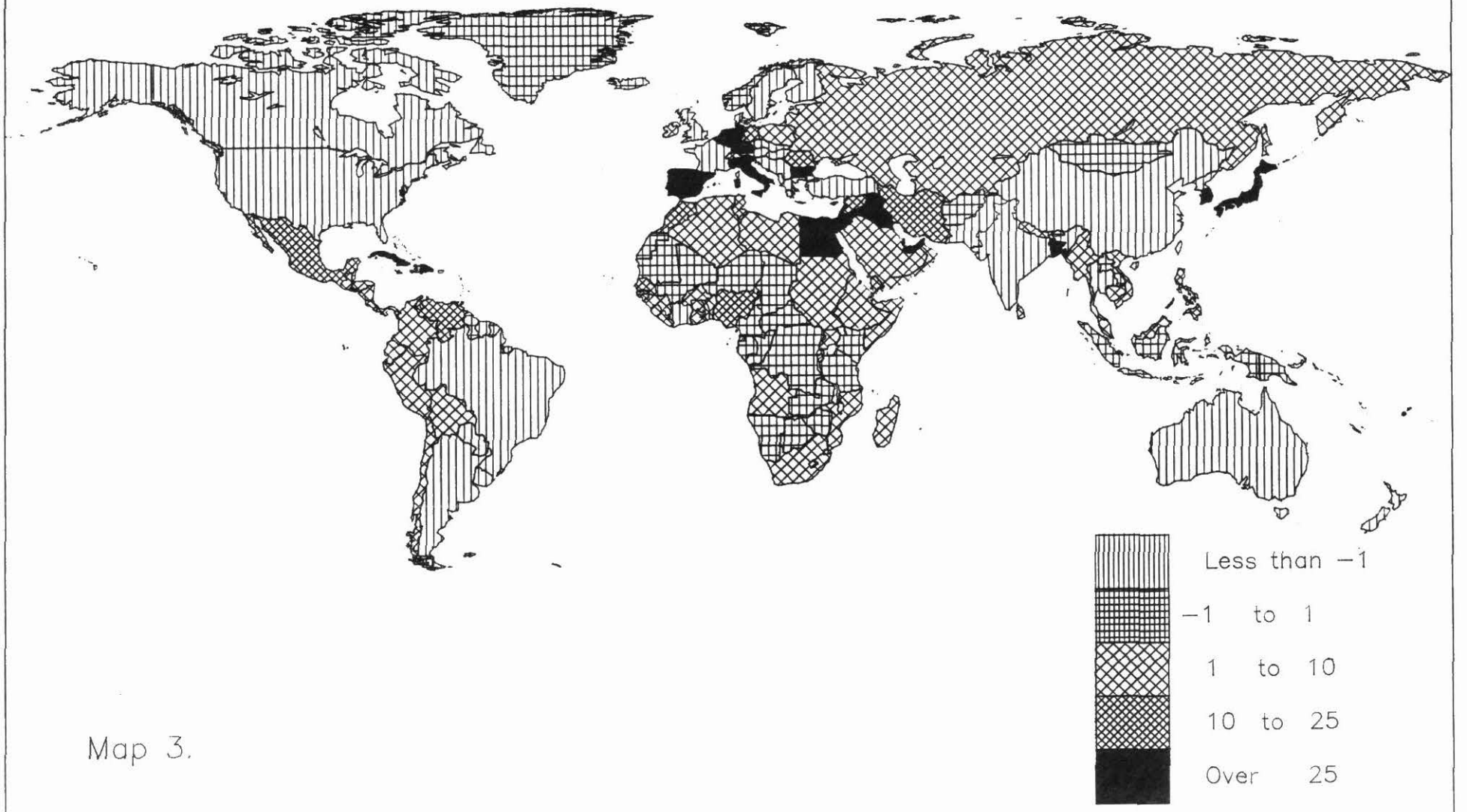
Map 1.

NET BALANCE OF POTASSIUM 1985 (Kilos per Km2)



Map 2.

CHANGE IN NUTRIENT BALANCE
PHOSPHORUS 1961 TO 1985 (Kilos per Km2)



Map 3.

countries, whereas traditional colonial importers such as England and France backed by the EEC economy agricultural policy have reduced imports.

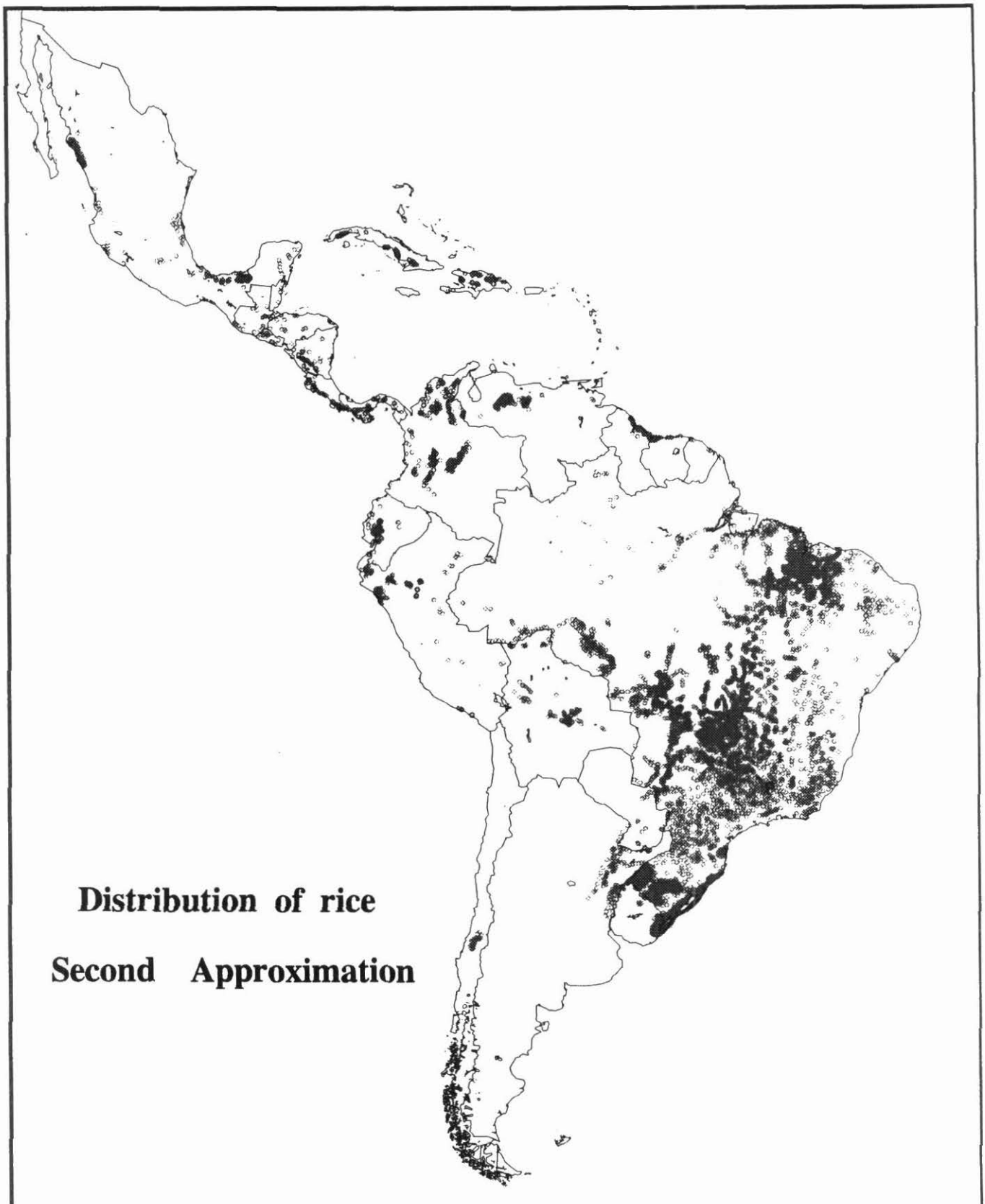
Further analysis is needed to gain a full appreciation of the maps. A publication will be forthcoming when this is completed.

8. Latin America Rice Distribution

Crop distribution studies have been a central theme of the Agroecological Studies Unit. This will be diminished in the Land Use Program in future as the dominant study becomes the management of natural resources. This study was initiated some years ago in the Agroecological Studies Unit. The distribution was mapped in two stages. A first approximation was constructed using available secondary information, mainly from agricultural census data. The maps produced were plotted and sent out to collaborators throughout Latin America. Corrections were drawn on the maps and additional information on the dominant cultural practices was noted. The maps were returned to CIAT and recompiled into the 'second approximation'. The resulting distribution, Map 4, was overlaid with the environmental classification based on the CIAT databases and a breakdown of the rice growing environments of the continent was compiled.

Table 1 shows the breakdown of the different rice cultural systems by season length. Not surprisingly irrigated rice is not highly correlated with season length. The lowland rainfed rice, although not a high proportion of Latin American rice production is highly specific to the 4 to 6 month season.

Table 2 highlights the fact that much of Latin American rice is grown on acid soils. This hold true even for about a fifth part of the irrigated rice. Only just over one third of the rice is grown on constraint free soils.



Distribution of rice

Second Approximation

Land Use Program

CIAT 1993

Map 4

Table 1. The 2nd Approximation of Rice Distribution in Latin America by the Season Length (Number of Consecutive Wet Months where P>1.2 PET).

	CULTURAL SYSTEM					
Wet Months	Irrigated	Lowland rainfed	Mechanized	Traditional (Manual)	Frontier (Manual)	Total
0	187	8	6	4	4	209
1 to 3	216	16	89	48	5	374
4 to 6	956	328	1699	519	291	3793
7 to 9	788	40	1586	202	404	3020
10 to 12	546	25	160	29	44	804
Total	2693	417	3540	802	748	8200

Table 2. The 2nd Approximation of Rice Distribution in Latin America by Soil Restriction, based on the FAO Soil Legend.

	CULTURAL SYSTEM					
Soil Restriction	Irrigated	Lowland rainfed	Mechanized	Traditional (Manual)	Frontier (Manual)	Total
None	1467	169	840	294	186	2956
Acidity	610	167	1968	293	486	3524
Physical	551	72	716	187	75	1601
Acidity and Physical	1	0	2	0	0	3
Salinity	64	9	14	28	1	116
Total	2693	417	3540	802	748	8200

9. Asian Cassava Distribution

One of the last commodity distributions to be scheduled, this distribution is necessary for the priority setting of the cassava Biotechnology Network in Asia. The cassava distribution needs to be characterized for its growing environments to complete the studies already made for Africa and Latin America. It is planned to produce a mapping of the end uses of cassava with particular emphasis on the post harvest processing applied.

Recent census data have been compiled by R. Howeler and provided to the land use program in tabular form. The administrative units maps of all countries in Asia have been digitized and are to be provided in draft form to the cassava program to assist in a questionnaire census of cassava processing. The administrative boundary maps are to be superimposed on the Digital Chart of the World (DCW) and the tabular data will be used to distribute the areas planted to cassava in each of the administrative units.

Once complete, the distribution map will be used to compile an inventory of cassava growing environments. To do this we will need an interpolated climate and soils dataset for Asia. To this end we have initiated various data exchanges with IRRI and others to augment our climate database for the area. A subset of the FAO soils map and the NOAA digital elevation model must be made for the area and the climate data interpolated using inverse square weighted distance algorithms developed in the unit.

10. Latin America Protected Areas

In order to discount legally protected areas, native reserves, national parks etc. when embarking on the natural resource strategic planning exercise, it was necessary to compile a digital coverage of these areas for Latin American. This project has now matured into a maintenance and update stage and will be carried on as a basic resource for the land use program. Recent developments have included the publication of the CIAT working document 'Legally protected areas of Latin America'. While this serves as detailed documentation of the database an interesting environmental classification of the protected areas is included. To produce this we used the CIAT climate database to produce continent wide coverages of the CIAT 'Natural Resource Management' (NRM) classification (see Strategic Plan Supplement),

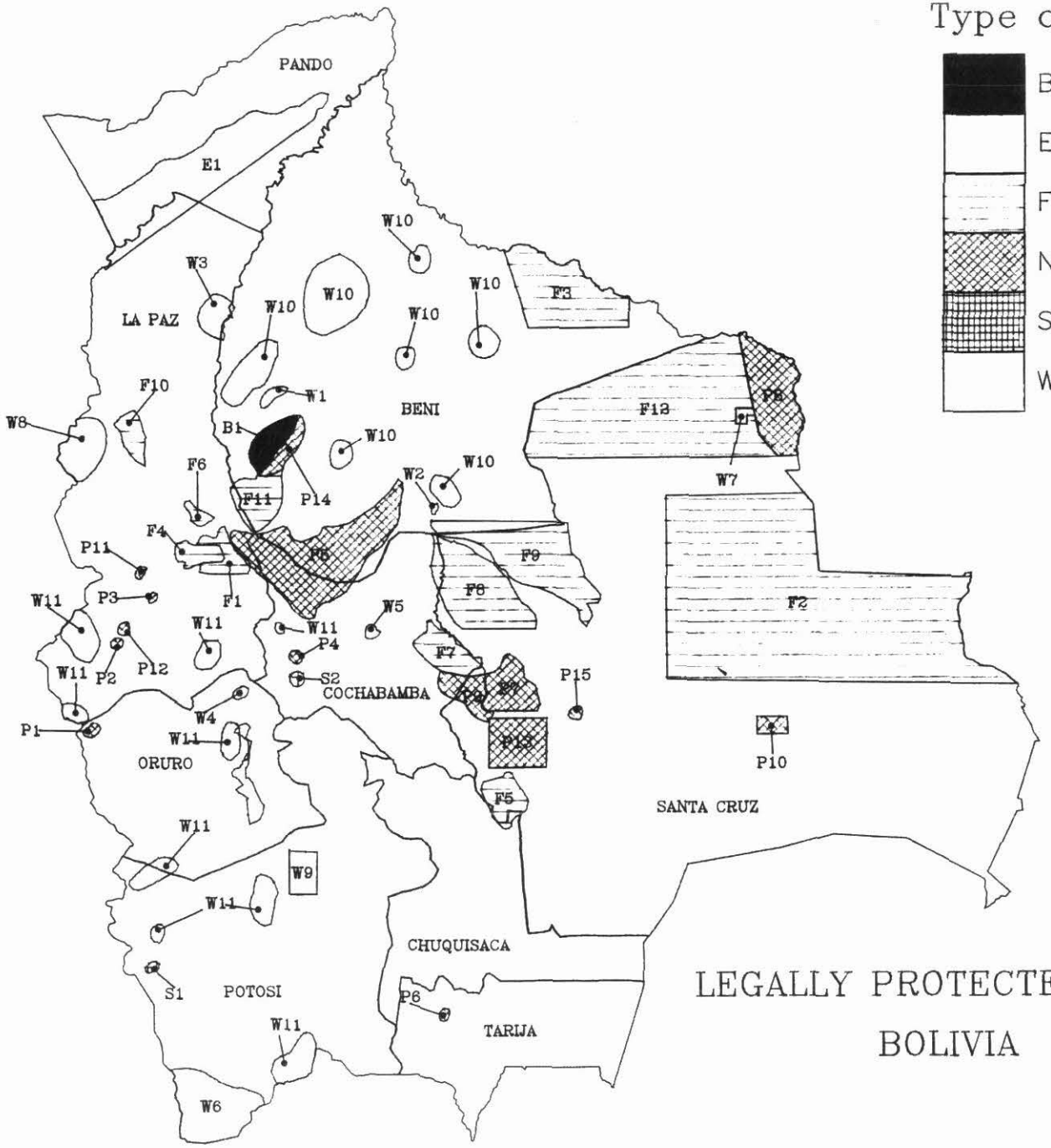
the Koppen climate classification and the Holdridge Life Zone map. All three are the most complete and up to date versions of these classifications. They were overlaid on the protected area coverage and an inventory of protected areas was produced showing the area protected for each environmental class.

Map 5 shows an example of the coverage for Bolivia. Note the differentiation by type of reserve. We attempted to standardize reserve area types but this was difficult in some cases as designation varied from country to country. Forest reserves are a particularly difficult class as in some countries, ie Colombia, all Forest is declared reserve until logging permits are conceded. Whereas in other countries forest reserves are purposely designated for the preservation of the forest.

The inventory (see Table 3) highlighted the fact that the tropical amazonian rainforest is by no means the environment at greatest risk of disappearing. Vast areas are still untouched and up to 30 percent of what remains is (at least on paper) legally protected. The smaller areas of montane rainforest, dry tropical forests, highlands and agriculturally productive lands have diminishingly small areas undisturbed and very little of the area legally protected. These fast disappearing areas are urgently in need of conservation and must be taken into account in all of CIAT's planning.

11. Site Selection for Forest Margin Areas, Brazil

Site selection for the forest margins in Brazil has gone through a number of stages. Following the initial Agro-ecosystem analysis the individual areas of forest margins in the South American section of CIAT's mandate area were processed with secondary data on agricultural and pastoral production data to further characterize the potential study areas. Satellite images were purchased for representative areas in Para (Paragominas) and Acre/Rondonia. These were digitized differentiating broad land use categories and overlaid with digitized soil, geology and vegetation maps. The results were presented in a report now available which is being used in consultation with CIAT's partners in Brazil to define the final study area.


Type of Reserve
BIOLOGICAL
ECOLOGICAL
FORESTAL
NATIONAL PARK
SPECIAL
WILDLIFE REF.
PANDO
E1
LA PAZ
BENI
COCHABAMBA
ORURO
POTOSI
CHUQUISACA
TARIJA
SANTA CRUZ
W1
W2
W3
W4
W5
W6
W7
W8
W9
W10
W11
B1
S1
S2
P1
P2
P3
P4
P6
P10
P11
P12
P14
P15
F1
F2
F3
F4
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F13
LEGALLY PROTECTED AREAS
BOLIVIA

Map 5

TABLE 3. Latin American protected areas by Holdridge life zone.

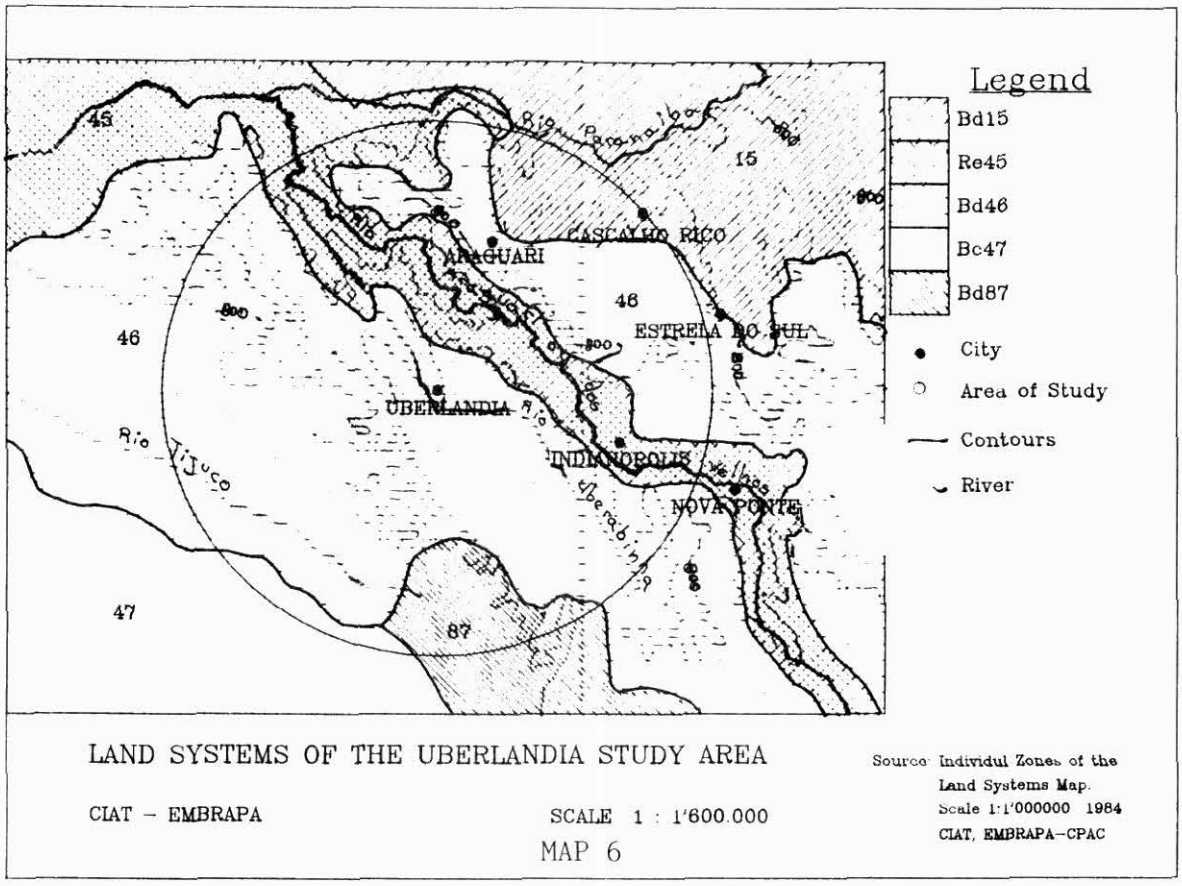
LIFE ZONE	Total Area Km^2	%	Accessible Area Km^2	% of Total	Protected Area Km^2	% of Total
Desierto Tropical	33533	0.2	31641	94.4	998	3.0
Maleza Desertica Tropical	15269	0.1	12184	79.8	0	0
Bosque Espinoso Tropical	7810	0.3	42449	88.8	7043	14.7
Sabana Tropical	503611	3.0	379005	75.3	11879	2.4
Bosque Seco Tropical	2647794	15.6	1962136	74.1	282662	10.7
Bosque Humedo Tropical	4479001	26.4	1604201	35.8	834364	18.6
Bosque Muy Humedo Tropical	44793	0.3	33945	75.8	13929	31.1
Desierto Subtropical	71302	0.4	55695	78.1	0	-
Maleza Desertica Subtropical	47029	0.3	41408	88.0	0	-
Bosque Espinoso Subtropical	258069	1.5	194757	75.5	3925	1.5
Sabana Subtropical	1425031	8.4	1219118	85.6	40382	2.8
Bosque Humedo Subtropical	4645564	27.4	3529379	76.0	440320	9.5
Bosque Muy Humedo Subtropical	921784	5.4	297708	32.3	334757	36.3
Bosque Pluvial Subtropical	1941	0.1	14657	75.5	17070	87.9
Desierto Montano Bajo	141643	0.8	138545	97.8	5455	3.9
Chaparral Montano Bajo	16600	0.1	14684	88.5	0	0
Estepa Montano Bajo	91156	0.5	82793	90.8	629	0.7
Bosque Seco Montano Bajo	229995	1.4	189137	82.2	8710	3.8
Bosque Humedo Montano Bajo	227603	1.3	209516	92.1	28642	12.6
Bosque Muy Humedo Montajo Bajo	53192	0.3	44736	84.1	18724	35.2
Bosque Pluvial Montano Bajo	2019	0.0	1352	66.9	341	16.9
Desierto Montano	47728	0.3	47728	100.0	1315	2.8
Maleza Desertica Montano	27662	0.2	23759	85.9	321	1.2
Estepa Montano	186845	1.1	124957	66.9	6165	3.3
Pradera ó Bosque Humedo Montano	230655	1.4	191701	83.1	9358	4.1
Bosque Muy Humedo Montano	72107	0.4	68051	94.4	18980	26.3
Bosque Pluvial Montano	12860	0.1	7776	60.5	6461	50.2
Desierto Sub-Alpino	23004	0.1	22863	98.6	329	1.4
Maleza Desertico Sub-Alpino	23870	0.1	15763	66.0	1305	5.5
Bosque ó Páramo Humedo Sub-Alpino	55268	0.3	38509	69.7	8013	14.5
Bosque ó Páramo Muy Humedo Sub-A.	93687	0.6	83119	88.7	3370	3.6
Formación Pluvial Sub-Alpino	12405	0.1	9735	78.5	2029	16.4
Tundra Desertica Alpina	19992	0.1	17711	88.6	1646	8.2
Tundra Humeda Alpina	31701	0.2	25855	81.6	2286	7.2
Tundra Muy Humeda Alpina	60229	0.4	47868	79.5	4478	7.4
Tundra Pluvial	64273	0.4	56973	88.6	2364	3.7
Formacion Nival	77519	0.5	74267	95.8	2954	3.8
		100.0				

12. Site Selection Cerrados Region, Brazil

Last year saw the completion of an innovative classification of the cerrados region of Brazil to determine appropriate study areas for joint research with EMBRAPA and local agencies. Data from the climate database and the land system study were used to provide images of climate, soils and terrain for the region. These were complimented by data from the Brasilian agricultural censuses from 1970, 1975 and 1980. These were combined to produce a set of images showing average land use patterns and the trend in land use during the ten years. Some 38 images were combined using Factor analysis to produce 12 factor images, a statistical subsample was extracted from these and a two stage cluster analysis was used to produce 11 representative classes of cerrados demarcated by biophysical and land use patterns. These were used to characterize 12 potential study areas in respect of the areas of savanna represented in the region. The study was used in a workshop in Brasilia to select candidates for the final study area.

The final site selection now points towards Uberlandia as the study area. The area description as given in the study is as follows.

> *The area around Uberlandia consists of the valleys of the rivers Araguari, Uberabinha and Tijuco and extends northwards into the Paranaiba valley. The land systems and soil units follow the NW - SE trend of these valleys. The area between the rivers Tijuco and Uberabinha constitutes almost all of the south west half of the zone. The relief is generally flat to gently rolling. The soils are mainly latassolo vermelho-amarelo distrofico and latossolo vermelho escuro alico. To the south textures are very heavy while the northern parts are moderately textured with some areas of sands. Low lying areas, about 15% of the region, are subject to flooding and have less acid, but hydromorphic soils. The main vegetation is campo cerrado but almost all of the area has been cleared for pasture or crops. The valley of the river Araguari and the lower valley of the Uberabinha to the north of Uberlandia have a flat to gently rolling topography with less acid soils. These are heavy to very heavy textured latossolo roxo distrofico and eutrofico. The lower reaches of the Araguari are dominated by hydromorphic soils. Vegetation was mainly semideciduous forest with some campo cerrado but almost all has been cleared for pasture and crops.*
>
> *To the north east in the municipio of Araguari the terrain becomes more broken and a complex of soils is found. Immediately around the town of Araguari the soil is latossolo vermelho-escuro distrofico, medium textured gently rolling relief. Around this is a complex of eutrophic podsolics interspersed with alic cambisols. The vegetation was a mixture of semideciduous forest and campo cerrado depending on soil and topography. Altitude is between 750 to 800 metres and an annual rainfall of about 1500mm gives a dry season of five and a half to six months. The growing season temperature is 22.6°C. The area was a strong producer of rice, beans and maize in 1970. By 1980 the production of rice and beans had diminished and considerable areas of soybean were planted. Modal land holdings are generally between 20 - 500ha by number of holdings and also less than 500ha by total area which indicates a very even distribution of land holding size.*



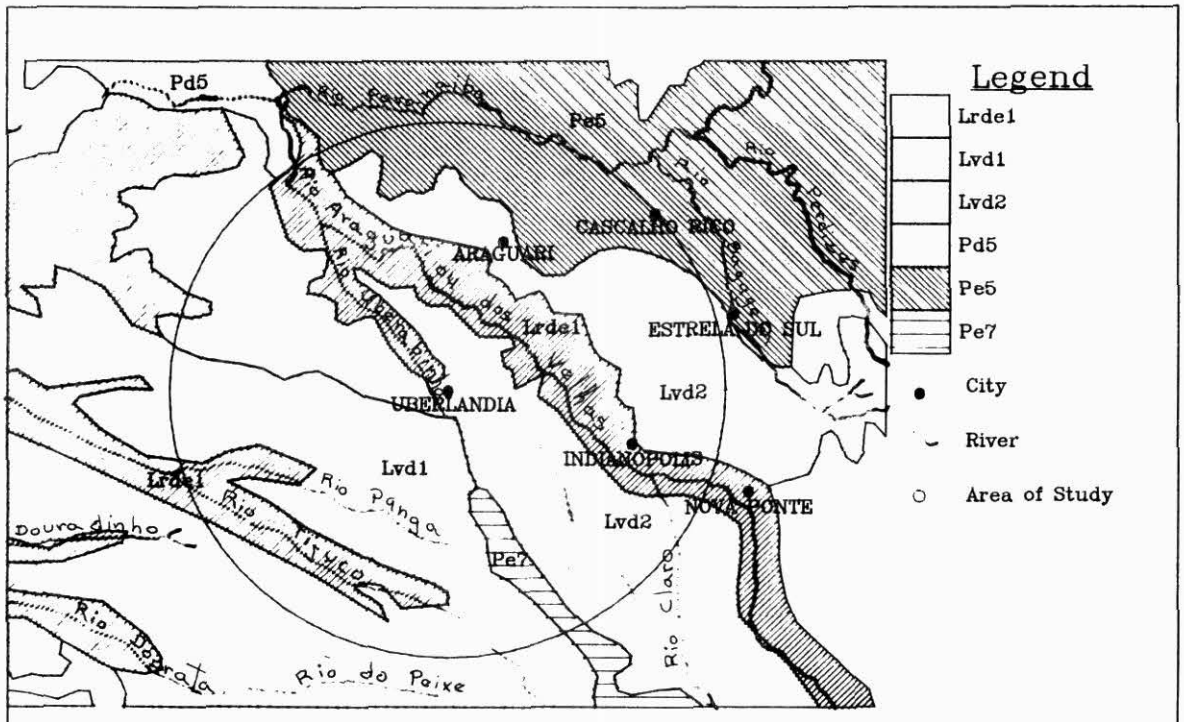
LAND SYSTEMS OF THE UBERLANDIA STUDY AREA

CIAT – EMBRAPA

SCALE 1 : 1'600.000

Source: Individul Zones of the Land Systems Map. Scale 1:1'000000 1984 CIAT, EMBRAPA–CPAC

MAP 6



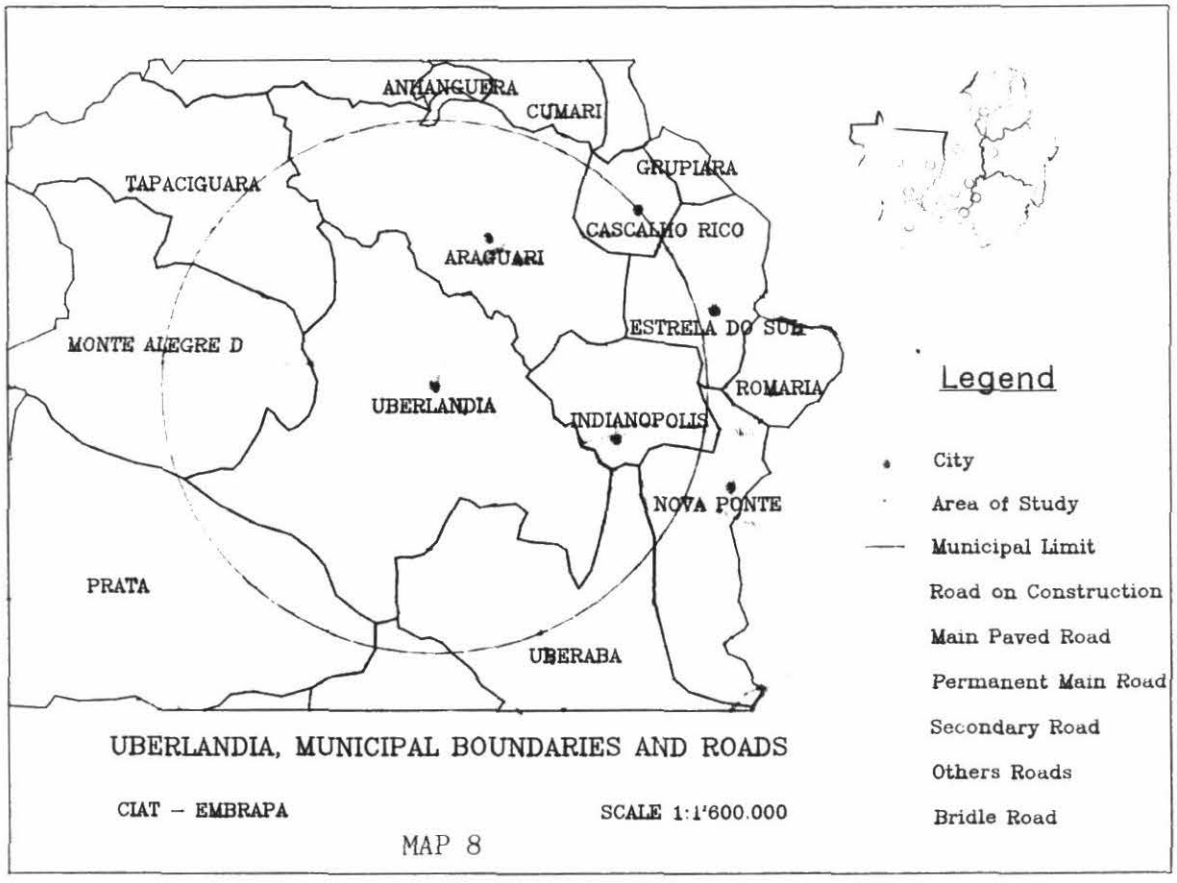
SOILS OF THE UBERLANDIA STUDY AREA

CIAT – EMBRAPA

SCALE: 1:1'600.000

Source: Mapa de Solos Do Brasil Escala 1:5'000.000 1981 EMBRAPA

MAP 7



UBERLANDIA, MUNICIPAL BOUNDARIES AND ROADS

CIAT – EMBRAPA

SCALE 1:1'600.000

MAP 8

A spinoff from this study is that the digital elevation model calculated for the study has been requested by the National Geophysical Data Centre, NGCD Boulder Colorado, as the most advanced dataset for the region. At a precision of 2 minutes of arc this dataset has a resolution of approximately 3 kilometers. If resources are available it is planned to increase the resolution to 1 km and extend the data set through the other areas of interest in South America.

13. Study Area Characterization. Altillanura Colombia

The study area of Altillanura between Puerto Lopez and Puerto Gaitan in the department of Meta in eastern Colombia has been selected for in depth study by the Savannas Program of CIAT. The Land Use Program has undertaken to develop a detailed GIS coverage of the region. A convention has been signed with the Instituto Geografico Augustin Codazzi (IGAC) in Bogota to exchange data, the institute will be providing a semi-detailed soil survey of the area to augment the presently available information. Soil maps at a scale of 1:100,000 have been digitized and a simple user interface has been developed.

Part of the area is covered be a recent thesis of a student working in land scape mapping with ITC in Holland. The map produced has been digitized and entered into the system. The road and savanna track access to the area can be overlaid to estimate access time.

Work is proceeding to produce a digital elevation model of the area with sufficient precision to be useful for running erosion models. The 1:25,000 topographic maps of the area are being digitized along with the stream lines and spot heights to be used as input for the cubic laplacian splines fitting programs developed be M.F.Hutchinson of the Australian National University, Canberra. A discrepancy of about 25 meters has been noted between two different series of maps and field work is planned in association with IGAC using highly accurate Geographic Positioning Systems (GPS) to resolve the problem.

Negotiations have been initiated with the Colombian Ministry of Agriculture to collaborate in an ongoing monitoring of the actual land use of the region. The land use program of CIAT will use present data to prepare a sampling framework for the Ministry to use in a twice yearly monitoring of the area using remote sensing and extensive sampled ground truthing.

14. Resource Degradation Evaluation. Hillsides

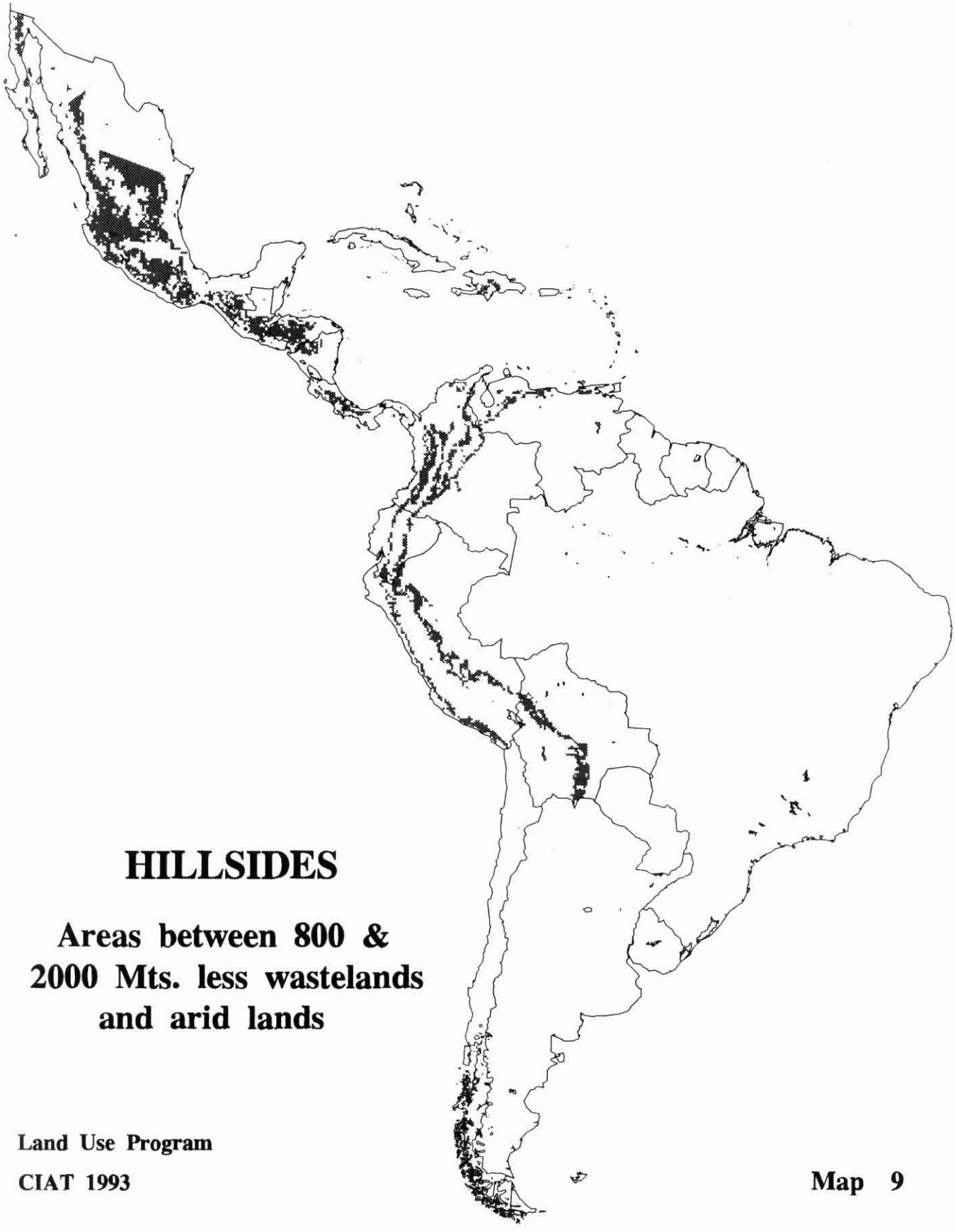
An assessment of the state of degradation in the hillsides of tropical america was required for planning purposes in the CIAT Hillsides Program. The definition of hillsides was extended from the original restricted one used for the natural resource management planning exercise. This was necessary to give a broader overview of the problems in central america and the andean region. All land between 800m and 2000m excluding highlands in Brazil, Chile, Argentina and the Guyana shield. Arid areas with less than 3 growing season months were excluded. The elevation image from the CIAT database was processed to give an image of the areas included. See Map 9.

The image of rainy months (rainfall >60mm) was calculated from the CIAT climate database. An image of soil depth was calculated from the image of dominant FAO soil unit held in the database in conjunction with tables of soil properties developed by the Agroecological Studies Unit.

The levels of degradation were estimated from the 'World Map on the Status of Human-Induced Soil Degradation' UNEP/ISRIC 1990. This map was digitized and transposed to geographic coordinates. Images of the various types of degradation were formed. These were analyzed to extract and tabulate the areas involved in water, wind and chemical degradation at various levels of severity. Also extracted were the base causes of the degradation and the rates of degradation in the recent past.

Of about 92,000,000 hectares mapped as hillsides in this study water erosion was by far the most important effect. Very small areas of wind erosion or chemical deterioration were noted. Moderate water erosion which strongly reduces agricultural productivity but which can be corrected at the farm level was found to occur in 14,000,000 hectares. Strong water erosion unreclaimable at the farm level accounted for 11,600,000 hectares. Together some 26 percent of the total area was subject to serious erosion.

The main causes were equally deforestation, overgrazing and agricultural activity.



HILLSIDES

Areas between 800 & 2000 Mts. less wastelands and arid lands

Land Use Program

CIAT 1993

Map 9

15. Study Area Characterization. Northern Cauca, Colombia

This study area of the CIAT Hillsides Program has been the scene of previous activity of the program. Coverages of the area in topography, climate, soils, land use, access, population among others are now documented in the program map coverage database. These comprised the work of two thesis students. The program is preparing for a major thrust in the area and has purchased all available topographic maps of the area in preparation for the development of a detailed elevation model of the area. In this case the elevation model is necessary not only for running erosion models but is indispensable for the interpretation of satellite images.

16. Special Projects

The financing of the project "Diagnosis of the Agricultural Land Use in Southwest Brazilian Amazon" has been approved by the IDB. The project will be implemented in 1994.

17. New Institutional Contacts Established with Research Institutions

Institutional contacts implying potential future cooperation were established through the Land Use Program with:

- The Inter-American Group on Sustainable Development of Agriculture and the Natural Resources.
- The International Geosphere-Biosphere Programme (IGBP) and the Human Dimensions of Global Environmental Change Programme (HDP), in relation to their joint core project on land-use/cover change (LUCC), and IGBP/DIS on soils database.
- The Earth Council, Costa Rica.
- The Inter-American Institute for Global Change Research (IAI).

- The New World Dialogue on Environment and Development.
- The United Nations University, Tokyo.
- The 2050 Sustainability Project (World Resources Institute/Brooklyns Institution/Santa Fe Institute), USA.
- The International Institute for Applied Systems Analysis, Austria.
- The Beijer Institute (The International Institute of Ecological Economics of the Royal Swedish Academy of Sciences).
- The INDERENA (The Colombian National Institute for the Renewable Natural Resources and the Environment).
- The Ministerio de Agricultura, Colombia.
- The Instituto Geográfico Agustín Codazzi, Colombia.
- The University of Kanel, Germany.
- The Hohenheim University, Stuggart, Germany.
- The National Geophysical Data Centre, Boulder, Colorado.
- The World Conservation Monitoring Centre, Cambridge, U.K.
- The University of Washington, Seattle.
- The University of Georgia, GIS Laboratory, Athens, Ga.

18. Publications 1993

Carter S.E. and Jones P.G. (1993). A model of the distribution of cassava in Africa. Applied Geography. (Forthcoming).

Gallopin, G.C. (1993). "Integrated Approaches to Land Uses for Tropical Regions". UNU Symposium on Eco-Restructuring, Tokyo, Japan.

Jones, P.G. and Thornton, P.K (1993). A rainfall generator for agricultural applications in the tropics. Agricultural and Forest Meteorology. 63:1-19.

Loker, W.M.; Carter, S.E.; Jones, P.G.; and Robison D.M. (1993). Identification of areas of land degradation in the Peruvian Amazon using a Geographic Information System. Interciencia 18:133-142.

Thome, J.; Jones, P.G.; Beebe, S.; and Iwanaga, M. (1993). The combined use of agroecological data and characterization data to establish the CIAT *Phaseolus vulgaris* core collection. Proceedings of the core collection workshop. Brasilia. Aug (1992).

Robison, D. M., et al. (1993). Areas legalmente protegidas y su relación con la frontera agrícola en el Trópico Americano. Documento de Trabajo No.119. CIAT, Cali, Colombia.