CIAT 1989

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REPORT

AGROECOLOGICAL STUDIES UNIT

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Centro Internacional de Agricultura Tropical

PREFACE

This is the report of the Agroecological Studies Unit presented in 1989. The Unit does not usually produce an annual report. We are a service unit for the CIAT commodity programs and usually the findings and results of the year are reported in the annual reports of those programs. This year major results for the Rice Program are to be found in their annual report.

The Unit is taking the opportunity of having a space reserved for our presentation in the Annual Program Review to produce a report on the Unit which covers our aims, methods, data and goals. We have never before written a comprehensive review of what we do in order to satisfy the needs of the CIAT scientists. We beg your indulgence if some of the examples seem familiar to you. They were all produced for your benefit and many if not most have been reported before.

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INTRODUCTION

The aims of the Unit are:

1. To assist management in setting research priorities.

2. To assist scientists in defining the geographic extents of researchable problems.

3. To evaluate the potential areas of impact of new technologies resulting from research.

4. To identify new areas of research.

In order to achieve these aims the Unit counts on various data sources and handling methods and attacks the problem at various scales. The data are either secondary or primary. Secondary data are collected as maps, census data and surveys and compilations of machine readable data obtained by exchange or purchase from national or international organisations. Primary data are collected by field survey by the staff of the unit, examples will be given below.

Studies of the environments, both physical and socioeconomic, of our commodities start with the geographic distribution of the commodity at the continental scale. These give a broad view of the situation of the commodity in the geographical context of the target regions and produce a catalogue of environmental contraints for research planning. This phase is followed by identification of regions of specific interest for more detailed study. These may be semidetailed regional analyses at medium scale or may include detailed fieldwork involving surveys to define and describe cropping microregions.

DATA AND DATABASE

GENERAL SCHEMA

To manage the data for these studies the unit has developed the CIAT agro-ecological database. This was originally defined in three logical sections, and implemented in IDMSR.

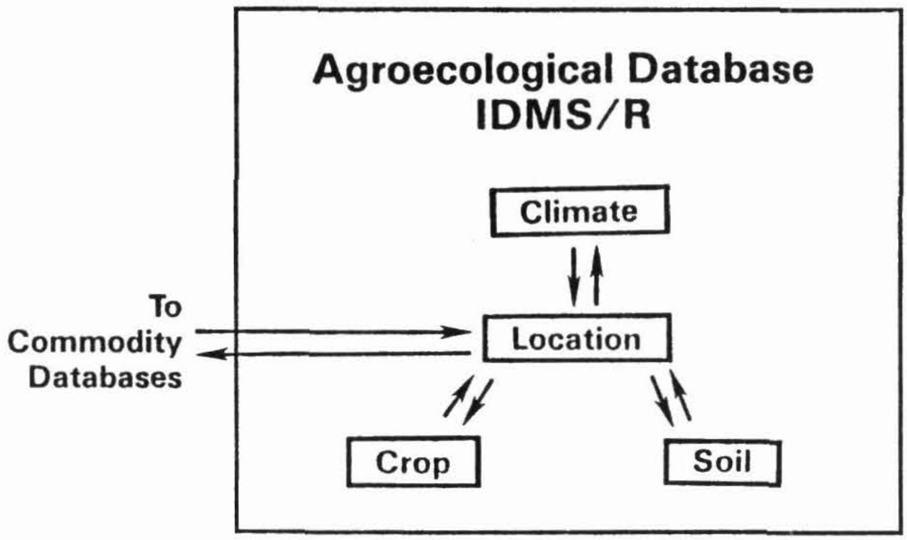


Fig. 1. Schematic Representation of the Unit's data as Originally Envisaged.

With growing experience of the use of these data, availability of new large datasets and the evolution of Geographic Information Systems (GIS), mapping packages and image analysis software this concept is currently undergoing a broadening of definition.

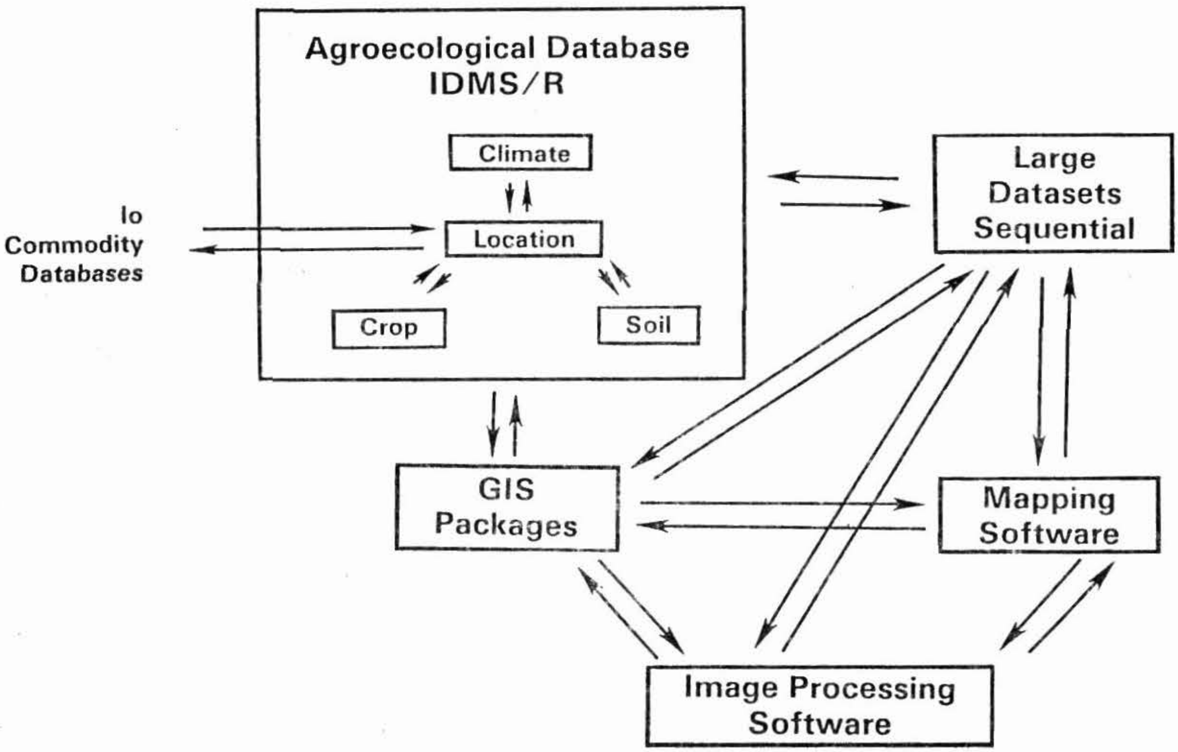


Fig. 2. Schematic Representation of the Management as it is Evolvin at Present.

CLIMATE DATABASE

Development has continued with the CIAT Climate database. Data have now been compiled from 101 referenced sources for 16200 meteorological stations throughout the tropics. The data are long term monthly means. The distribution of the data occurrences are as in Table 1.

Extensive error checking and correction have recently been completed for Latin America and Africa. The files for Asia are awaiting error processing for early 1990. The procedures check for internal consistency using a fourier transform and for spatial consistency with terrain and with surrounding stations (Jones 1987).

TABLE 1. Number of station records holding data of each type in the CIAT Climate Database.

	Latin America	Africa	Asia
Precipitation	7278	5307	3618
Dependable Precipitation	1931	149	150
Potential Evaporation	1839	1298	447
Rain days	1840	782	711
Max temp	1750	1333	1007
Min temp	1748	1319	1007
Mean temp	6294	5019	1772
Relative Humidity	1429	464	346
Dew point	1240	1204	257
Global Radiation	1850	1030	476
Sunlight hours	2130	1089	351
Cloud cover	585	340	381
Windspeed	432	1053	417

The database has been supplied to the following users:

ICARDA	Allepo	Syria
ICRISAT	Niamey	Niger
IITA	Ibadan	Nigeria
ILRAD	Nairobi	Kenya
IRRI	Los Baños	Philippines
Oxford University	Oxford	England
ISRIC	Wageningen	Holland
FAO	Rome	Italy
Cornell University	Ithaca	USA
CSIRO	Canberra	Australia
CGN	Wageningen	Holland
UNEP/GEMS/GRID	Nairobi	Kenya

At the time of writing enquiries have been received from:

University of California	Berkeley	USA
Iowa State University	Ames Iowa	USA
Canadian Centre for Remote Sensing	Ottawa	Canada
USDA Soil Conservation Service	Washington	USA

Due to the increasing demand for these data the Unit has initiated a scaled pricing policy to recoup some of the production costs. Organisations exchanging data will continue to receive data free of charge and institutions in the developing world will pay only a minimal charge to cover the costs of tape and postage.

MACHINE READABLE DATA RECEIVED FROM OTHER SOURCES

In addition to providing data for various institutions, the work of the Unit has been greatly assisted by geographic datasets purchased, or exchanged. Notable additions to the climate data have in the past been received from Cornell University and CSIRO. More recently FAO have provided a vector digitized version of the FAO soil map of the world at 1:5,000,000 and GEMS/GRID have provided an alternative raster based version both free of charge in exchange for data and programming assistance. Purchased data sets include World Database II from the CIA and digital terrain models ETOPO5 and TGP-0060 from NOAA. These latter soils and mapping files occupy some 1,200 Mb of tape storage and are evidently unsuited to incorporation in the direct access database. This is one of the reasons for developing the more flexible data management procedures mentioned above.

METGRID FILES. CLIMATE AND SOILS MAPPING.

While the climate database contains data from a large number of stations, the coverage is highly uneven. In order to make continental scale mapping feasable it is necessary to produce an interpolated dataset registered on a regular grid. The term 'Metgrid file' was coined within the unit to describe this particular raster format. The original Metgrid files were produced by the unit during 1986 using a half degree grid for Latin America and a 0.2 degree grid for Africa. These files lacked some definition, particularly in local elevation estimates, but were of considerable use in mapping climate homologues between Latin America and Africa.

With the arrival of the digital terrain and soils datasets a new set of Metgrid files was started. The datasets are on a 10 minute grid and contain latitude, longitude, representative soil class, elevation and interpolated mean monthly rainfall, maximum and minimum temperatures. The interpolation method is to find the five nearest meteorological stations from the database, reduce all temperatures to sea level using a lapse rate model representative for tropical climates and to estimate the interpolated values using an inverse squared distance weighting factor. The temperature values are then recalculated to represent the modal elevation of the grid cell.

To date the file for Africa is complete and that for Latin America is well under way. A single file for Asia should be available in the first half of 1990.

Climate Homologue Mapping

Climate homologue indices can be designed using specific attributes of the climate for a particular purpose. These lead to special purpose classifications, examples of which are discussed later. It is often however useful to map a general climatic similarity, or rather difference, index. A well tried difference measure is the euclidean distance. Calculating euclidean distances between climates is not however straightforward. This is because we cannot simply compare month with month since we are interested in the overall form of the climate through the year and not exactly when events occur. For example a climate with a three month dry season in the northern hemisphere may be almost identical with its counterpart in the southern hemisphere even though the timing of the seasons differs by about six months.

A Fourier transform can change the twelve monthly data into a set of six frequencies, each with its amplitude and phase angle. By rotating the frequencies about the phase angle of the lowest frequency of the rainfall data the effect of date of season can be automatically eliminated and a euclidean distance calculated directly from the paired frequency amplitudes. This can be regarded as the root mean square difference between the two data curves. After standardisation by the continental mean and variance the differences in rainfall and temperatures can be combined into a climate difference index.

Using the Metgrid files a map of climatic similarity to a given place can be readily produced by mapping the combined distance measures in reverse order. This technique has been used for the cassava program to identify areas of similarity to collection sites of cassava mite predators. It has also been used to map areas throughout Central America similar to proposed trial sites for the pastures program.

SECONDARY DATA ACQUISITION

Secondary data collection and analysis is undertaken for each of the CIAT commodities. Here we provide an example, to illustrate the different types of information dealt with.
Purchase of maps for the working collection is proceeding at a steady rate. Much information however lies in the National Institutes that originally produced it and is not readily available. The following project has been reported before in the annual reviews of the Pastures Program. The Principal Staff participation in this sub-project unfortunately finished in March 1989. Processing is being continued at a very reduced rate but has not been abandoned.

To assist the Tropical Pastures Program in its move to Central America and the Caribbean, the Agroecological Studies Unit has created a database of agro-ecological information. This includes information on soils, actual land use (pastures) and climate. Although the Pastures Program is mainly interested in the moderately acid and infertile pastures areas, the data collection is sufficiently complete to be of use to other CIAT commodities who have an interest in Central America and the Caribbean.

The initial work consisted of reviewing the information available in CIAT. This was followed by the selective collection of secondary information from national and international institutions visited throughout the region and other places to complement that held by CIAT. The information was then extracted, standardized and mapped for each of the countries involved. The final results are still being incorporated into CIAT's database. The countries visited were Panama, Costa Rica, Nicaragua, Honduras, El Salvador, Guatemala, Mexico, Belize, Dominican Republic, Haiti, Cuba and the United States (Land Tenure Center, University of Wisconsin).

Numerous institutions were visited (See Table 2). The first ones to be contacted during the meeting of the Red Internacional de Evaluación de Pastos Tropicales, RIEPT, in David, Panama in 1987 were those related to agriculture, pastures, or animal production. Contacts were then extended to other institutions related to statistics and census, geography, natural resources, meteorology, etc. More than 95 institutions were visited during these trips. Many of these were different to those normally visited by CIAT scientists.

It is surprising, but very reassuring, that large quantities of basic data exist in machine readable formats in these Central American countries. It was gratifying that they proved to be so readily available to CIAT.

Soils Information

The collected soil maps range in numbers from one each for Nicaragua, Honduras and El Salvador, to more than 130 for Panama at scales between 1:20,000 for Panama and 1:1.000.000 for Honduras and Mexico. All maps are being rescaled at 1:500.000. For Belize, the soil classification system is a local one and the legend is not self-explanatory. Guatemala has an old local system consisting only of profile descriptions and it was necessary to reclassify these descriptions into FAO/Soil Taxonomy. The Cuban system was difficult to transfer into FAO/Soil taxonomy systems especially for their mountain soils. Panama, Costa Rica, Nicaragua, Honduras, El Salvador and Dominican Republic are all classified with old U.S. systems or with different levels and modifications of Soil Taxonomy. Mexico used a modified version of the FAO, 1974 system. Soils information for Haiti has been supplied by the agricultural Development Support Project, ADS-II (USAID) database.

The soil maps with varying scales and classification systems for the different countries will follow a series of transformations until a uniform soils map for the whole region is produced. Initially all the maps are rescaled to 1:500.000. The different classification systems have been standardized, and the soil mapping units matched across borders using additional help from geology, vegetation and topography maps as well as landsat imagery.

TABLE 2. Number and type of Institutions visited in the search for data in Central America.

COUNTRY	* 1	2	3	4	5	6	7	8	
PANAMA	1	3	3	2	1	1		1	12
COSTA RICA	1	2	2	1	1		1	1	9
NICARAGUA	1	3	1	1	1				7
HONDURAS	1	2	1	1	1	2	1		9
EL SALVADOR	2	1	4	2	2	1			12
GUATEMALA	1	1	3	2	1				8
BELIZE	1	1	2	1					5
MEXICO	4	1	1	1	1	1		1	10
DOMINICAN REPUBLIC	1	3	1	3	2	1		1	12
HAITI	1	1	1	1	1			1	6
CUBA	1	1	1		1				4
(USA)							1		1
	15	19	20	15	12	6	3	5	95

* 1: Statistics, Census

2: Geographic

3: Agricultural, Pastures, Animal production

4: Meteorological, Hydrological

5: Natural resources (Soils)

6: Economics, Other technical

7: Universities, Training

8: International

Land Use Information

The compiled information for actual land use (pastures) consists mainly of agricultural census'; actual land use maps of varying scales between 1:200.000 and 1:1.000.000; and other information such as livestock surveys and reports, annual statistical reports and sector plans (diagnosticos ganaderos, encuestas ganaderas, anuarios estadisticas, plaes operativos) and Landsat imagery. All the data will be standardized, mapped and rescaled at 1:500.000.

Figure 3 is an example showing the number of hectares of pastures and their distribution in Panama and Costa Rica based on the map "División Politico Administrativo de Panamá,1970"; the "Mapa Físico-Político de Costa Rica, 1974"; the information on pastures by "corregimiento" or district from the Panamanian agricultural census of 1980; and from the Costa Rican agricultural census tables 1984; the information of geographic coordinates from the Panama and the Canal Zone Gazetteer, 1969; and the Costa Rica Gazetteer, 1983; and the information on coasts, islands, lakes, rivers and boundaries from the CIAT database.

Climate Information

Historic daily meteorological data have been collected in a variety of forms, either as documents, diskettes or magnetic tapes. This is being catalogued for future detailed studies.

Long term climatic data have been incorporated into the existing CIAT climate database.

Assembling the Database

Digitization of the Soil maps is still continuing. Data on pasture areas and heads of cattle will be transcribed from the census information and converted into geographic data files. Digitization of actual land use (pastures) maps will follow. An overlay of this

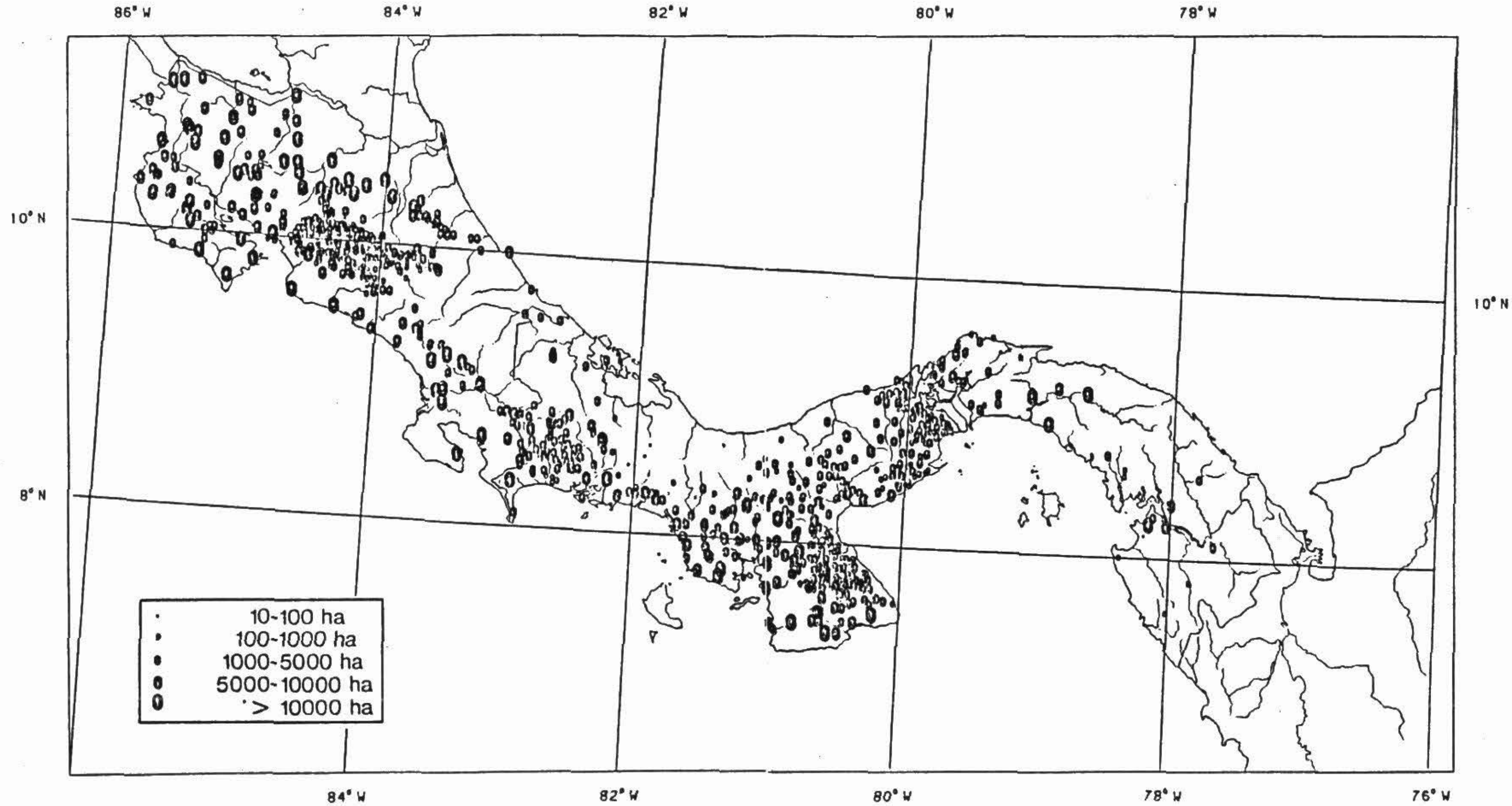


Fig. 3. Pastures (ha) in Costa Rica and Panama.

information with that already contained in the climate database will allow an accurate analysis of the situation of pastures in Central American and the Caribbean.

STOCHASTIC RAINFALL MODELS

Average climatic conditions are useful to define a broad scale classification of environments. Farmers live in the real world where the variability of the weather and the concomitant risks weigh heavy in planning their alternatives. For small farmers these risks are critical.

In order to assess these risks long runs of daily weather data are necessary. Apart from studies at certain sites of interest it is impracticable to store and use real historic data. If a stochastic simulation can regenerate sequences of data from the wide coverage of mean data held in a climatic database then these restrictions could be overcome.

Markov models of rainfall have been used for many years (Sterne, Denett and Dale, 1982; Richardson and Wright, 1984), but have generally been less satisfactory in the tropics than they have in temperate climes. Also, as yet, there is no proven method of estimating the model coefficients from agregated mean data.

The unit has been working on this problem for many years and partial solutions have evolved. It has been found that the third order Markov model is superior to some lower order models commonly used for temperate regions (Richardson and Wright, 1984; Hutchison, 1987). Programs for estimating the coefficients and a method of estimating the probability matrix using GLIM (Baker and Nelder, 1979) have been developed that greatly simplify this potentially complex model.

However the model still did not accurately simulate the year to year variation that one would expect (as shown in Figure 4, redrawn from Jones, 1987).

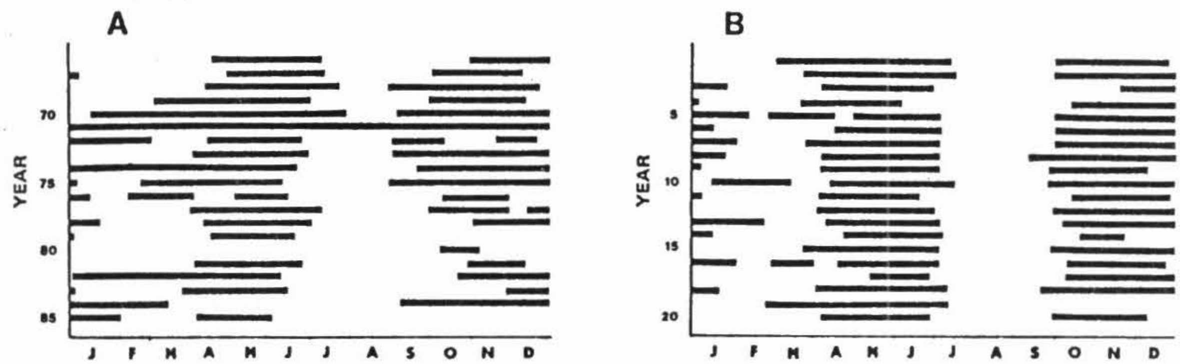


Fig. 4 Estimated Growing Season Periods Palmira.
A. Historic Daily Data.
B. Rainfall Simulated With 3rd Order Markov Model.

This year it would appear that a major breakthrough has been made in this respect. The model has been extended to include an annual resampling of the conditional probability matrix in a manageable form. The probability matrix of the CIAT model is built from the monthly base probabilities and a restricted set of probability lag factors all in probit transform. The daily 8 x 365 probability matrix is then interpolated using the Fourier transform technique mentioned earlier.

This reduces the annual resampling to taking a sample from a 12 dimensional normal population. Some problems still remain, such as what is the best way to estimate the variance - covariance matrix of this population, but it does not appear that these are insuperable.

Testing of the model is being done in collaboration with IBSNAT. Dr.P.Thornton at the University of Edinburgh is at present running testbed studies of the model against the basic third order Markov model and the simpler one of Richardson. First results for three sites (Palmira, Guatemala City and Tillabery, Niger) indicate that the improved model has the power to accurately simulate the annual variances of annual rainfall and of major events such as the start and end of the season.

Detailed analyses of the trials reveal that there is still some conflict with reality in the details of length of dry spells and run off from wet events. The collaborators are confident that these can be solved.

CROP GEOGRAPHY

Over the last six years the Unit has dedicated a significant proportion of its resources to the examination of where CIAT's crops are grown. This work is both descriptive and analytical. The geographic distribution of each field crop has been identified, and then examined in relation to environmental and, in some cases, socio-economic conditions. The purpose of this work has been to inform management and researchers about:

(i) the relative significance of environmental constraints within the geographic range of each crop;

(ii) the overall importance of specific sets of environmental conditions, essentially those pertaining in areas where CIAT programmes work or have worked;

(iii) areas where a crop is important, or general constraints overlooked or under-emphasized in CIAT research.

(iv) general relationships between the environmental conditions in which each crop is grown and the socio-economic status of producers and the resources and technologies they have at their disposal.

Studies of *cassava, beans and rice* in Latin America and cassava in Africa are at or near completion, and are reported here. For tropical pastures, work has only been started for Central America, as reported above.

CASSAVA

Cassava in Latin America

The geographic distribution of cassava in Latin America was mapped in 1983 at a scale of 1:5,000,000 from available data contained in census statistics, government reports and miscellaneous publications. Since 1981 CIAT's Cassava Programme had utilised a preliminary classification of ecosystems, to take into account the diversity of environments where cassava was grown. This was based upon the range of environmental conditions found in Colombia, with a separate class representing sub-tropical areas. Inadequacies of this system, fully recognised by team members, were the absence of some important cassava-growing environments from Colombia, and the lack of a rational organising framework with which to relate different environments to one another. Published climatic classifications gave little or no information about cassava-specific climatic conditions which were known to the CIAT programme scientists. These included the crop's tolerance of drought, hence what constituted a dry period; the growing season temperatures which affected crop vigour; daily temperature ranges, which in conjunction with relative humidity affected disease pressures; and seasonality where day-length and cold tolerance became important in subtropical areas.

We devised a hierarchical climatic classification based on this knowledge of the crop (Figure 5). To this we added a further layer of classes based on the soil restrictions important to the growth of cassava; fine texture, permanent and potential depth restrictions, seasonal flooding, waterlogging and acidity. We now recognise presence of calcium carbonate as a further restriction in this list.

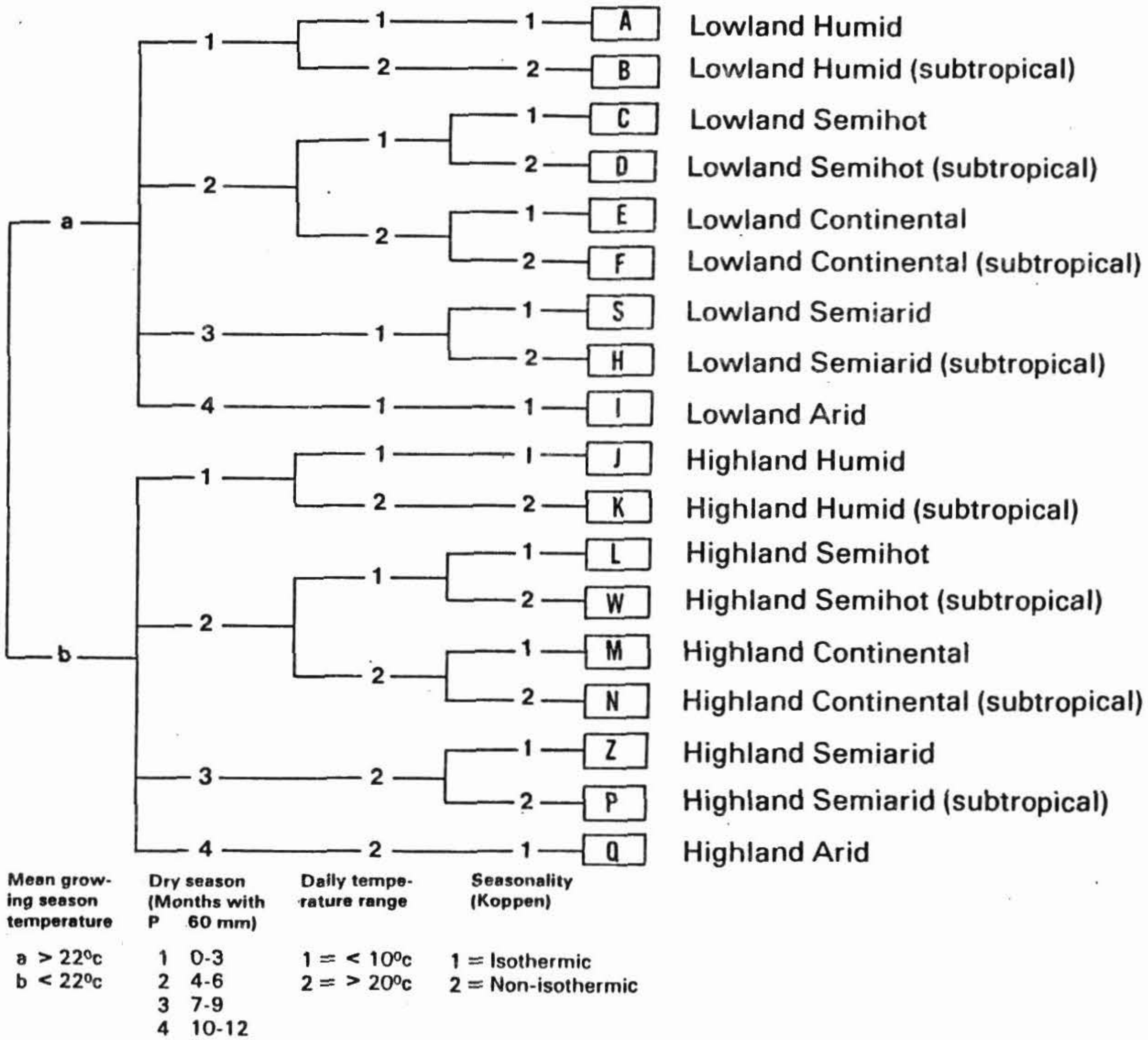


Fig. 5.Climatic classification for cassava

To map these environmental classes, we initially used some surrogate data; altitudinal limits from topographic maps to distinguish between highland and lowland; dry season length and seasonality from CIAT's computerized climate database, and the Papadakis climate classification to distinguish areas of high and low daily temperature range. We are now able to define the individual classes directly from the climatic database and either map them on the mainframe plotter or transfer them to geographic analysis packages as digital maps using the Metgrid files.

Table 3 illustrates how cassava was distributed in Latin America in relation to general climatic and soil restrictions. These data were derived by mechanically overlaying the cassava map onto a map of climate-soil homologues and then counting how may 1000 ha points fell into each homologue.

TABLE 3. Cassava distribution in Latin America by climatic conditions and soil restrictions. (Total hectareage = 1,816,000).

a: Climate			**% of total hectareage**
Altitude	:	Lowland	77.3
		Highland	22.6
Dry season	:	Humid	45.4
		Seasonally dry	38.6
		Semi-arid	14.6
		Arid	1.3
Daily temperature regime	:	Hot	32.2
		Semihot	67.7
Seasonality	:	Tropical	70.9
		Subtropical	29.0
b: Soils			
1.	Fine texture		0.6
2.	Permanent depth restrictions		17.1
3.	Potential depth restrictions		2.8
4.	Seasonal drainage problems		6.8
5.	Permanent drainage problems		8.8
6.	High acidity		42.6
7.	No restriction		23.6

The overlay exercise prompted the following conclusions:

(i) Over three-quarters of the cassava area in Latin America is found in the lowland tropics, only 23.7 percent in the highland climates.

(ii) Over fifty percent of the hectareage is grown in areas with a significant dry season, and some 15 percent grown in semi-arid climates.

(iii) Over 40% of the crop is grown on acid soils, and another 20% on shallow soils. Less than a quarter of the area covered has no restrictions for cassava.

(iv) The crop's distribution indicated strongly that it is grown in climates and soils which are usually classed as unfavourable to it. This illustrates the fallacy that the ideal distribution can be inferred from it's environmental requisites. The rule is that a crop is grown where nothing else yields a better result.

Cassava in Africa

Over the last two years we have undertaken work on Africa cassava, for two reasons. First, part of CIAT's contribution to the Collaborative Study of Cassava in Africa (COSCA) was to provide information about the crop's distribution to devise a spatial sampling frame for the project. Second, CIAT's Cassava Programme required similar information to support its efforts to find genetic material for the semi-arid regions of Africa and more generally to help it to support IITA's breeding and biological control programmes.

There has been no useful attempt to map the continental distribution of cassava since the definitive work of Jones (1959). All modern statistics collected by CIAT and in an exhaustive search of the FAO statistics library were used in mapping the crops distribution at a scale of 1:5,000,000. The data relate approximately to 1980, most of the larger producers having had recent censuses.

The distribution map was digitized (each 1000 ha. point's geographic coordinates recorded by computer) and re-mapped on a raster (grid-cell) computer image, using a geographic analysis package, IDRISI (Eastman, 1988). CIAT's African climate database provided information to generate a raster map of average climatic conditions. Grid cells were then classified using the hierarchical system of climates devised for Latin America. The result was a raster climate map which was then imported to IDRISI to analyse the crop distribution data. Soils data from the UNEP/GRID digital soil maps were then used to create a soil restrictions map for cassava within the IDRISI system; individual FAO soil classes were recoded in IDRISI, to amalgamate all those areas with like restrictions.

TABLE 4. Cassava distribution in Africa by climatic conditions and soil restrictions. (Total hectareage = 7,992,000).

a: Climate		% of total hectareage
Altitude :	Lowland	80.06
	Highland	19.94
Dry season :	Humid	43.27
	Seasonally dry	44.91
	Semi-arid	11.82
	Arid	0
Daily temperature regime :	Hot	26.21
	Semihot	73.79
Seasonality :	Tropical	89.76
	Subtropical	10.24
b: Soils		
1.	Fine texture	3.25
2.	Permanent depth restrictions	4.79
3.	Potential depth restrictions	1.88
4.	Seasonal drainage problems	1.18
5.	Permanent drainage problems	3.25
6.	High acidity	54.43
7.	No restriction	31.13
8.	Calcium carbonate present	0.09

Table 4 shows the distribution of cassava in Africa, according to the climatic and edaphic conditions identified for Latin America. In many respects the two distributions are similar, with the rider that there are over four times as many hectares of cassava in Africa as in Latin America.

A smaller proportion of African cassava is grown in subtropical areas. Much of the African subtropical zone is dry and sparsely populated by non-agriculturalists. The relative unimportance of cassava in this zone compared with its counterpart in Latin America can be ascribed to these climatic and cultural factors. Lack of adapted and drought-tolerant germplasm in Africa are further possible causes of the observed difference. In Africa a greater proportion of cassava is grown on acid soils, fine textured soils, and soils with no restrictions, whilst shallow soils and potential drainage problems appear to be less important than in Latin America.

REGIONAL SURVEY OF CASSAVA PRODUCTION

Spatial variation within the regions in which CIAT's commodity programmes work is an important factor to consider in planning research and in interpreting the results obtained. With this in mind, in 1984 the Unit embarked on a series of studies of cassava producing regions, following on from the distribution study undertaken the previous year. The work entailed a more detailed examination of obvious spatial concentrations of the crop which were identified from the cassava map.

The aims of the work were therefore:

- To devise a methodology to subdivide producing regions (which at the small, continental scale of agroecosystem definition appeared to be homogeneous).
- To describe and explain geographical variation within cassava growing regions in such a way as to enable researchers to take account of this in planning and interpreting their work.

- To provide information about the circumstances of cassava producers and to identify significant problems which research might not currently be address.
- In some areas the survey work sought specifically to find suitable locations for cassava drying plants.

The studies resulted in the definition of a rapid and inexpensive reconnaissance survey technique to supplement secondary data and provide both general and crop-specific information, for areas of 10,000 to 30,000 km_. By comparison of the survey results from different areas, a number of common elements have been identified, some specific to cassava and some general.

North Coast of Colombia

We began to develop survey techniques with a study of Colombia's North Coast. After reviewing secondary data we conducted informal surveys with farmers and government officials.

A questionnaire survey was devised to identify the spatial patterns in environmental conditions as they affected cassava, and to search for spatial patterns in a number of socio-economic factors including land tenure. This was directed at groups of local inhabitants. The survey area consisting of parts of the departments of Cordoba, Sucre, Bolivar, Atlantico and Magdalena, was divided into a grid of cells. A sample of eighty cells were randomly selected and within each cell a single village was chosen, also at random. The questionnaire was carried out at a total of 65 villages the remainder being inaccessible in the time available.

The study identified both environmental and human influences upon cassava production. Our fieldwork showed that topographic control of soil moisture availability was of greater significance for cassava than total precipitation. Planting patterns and dates, and varietal use varied in accordance with height above the water table and soil texture.

In many areas farmers risked losing their cassava because of poor drainage or flooding.

The major outcome of the survey was to illustrate the variability of land tenure which governed farmers' temporal control over land, and of methods of land preparation and management. The latter varied in accordance with agro-ecological and social conditions.

Secondary data and the findings of the informal and formal surveys were used to subdivide the study area into 20 micro-regions. These have been used in attempts to interprete previous research results. More recently the need for a more subtle characterisation of some parts of the Coast has been recognised to allow more precise interpretation of on-farm trials.

Central Paraguay

The second area studied consisted of Paraguay's Central Region and part of the department of Caaguazu. The work was undertaken in 1985 prior to a collaborative research project between CIAT and the Servicio de Extension Agricola y Ganadera. The survey sought to characterise the likely areas in which the project would be undertaken, as well as a broader surrounding area. The structure of the survey was similar to the Colombian example. Examination of secondary data preceded informal and formal questionnaire survey. A further questionnaire was designed to characterise land use and the importance of cassava in two contrasting areas for a total of 55 farms. Field work took ten weeks in Paraguay. The area selected was subdivided into a 10 km by 10 km grid. Cells which did not have agricultural land-use or were uninhabited were excluded. For the remainder a single settlement was chosen in each using random coordinates, and the questionnaire was completed with a group of inhabitants at each of these. Extension agents acted as enumerators in this stage of the survey.

The issues identified through survey work were land degradation, differential access to markets and the disadvantaged position of smallholders, all of whom grew cassava, in the national political economy. Indebtedness and low prices for their produce locked smallholders and colonists alike into actions which degraded their land. Many farms were not viable as the sole source of employment for rural families.

The survey identified the importance of cassava as a subsistence crop, the need to secure production and the areas where food shortages regularly occurred. The older minifundia areas were clearly distinguished from newer colonies established in the last 30 years. However whilst higher soil fertility in the agricultural colonies permitted surplus cassava production which could be used to increase incomes, long term trends appeared to be leading to the recreation of the minifundia of the central region. There was scope for improvement in cassava processing techniques. Producers could benefit greatly from farmer cooperatives which gave them greater control over marketing and the proportion of the benefits accruing to them from the production of cassava and other crops. Micro-regions were defined using the survey data and secondary information. Information describing each was collated in tabular format, as part of a final report.

Manabi Province, Ecuador

In 1985 the Cassava Programme established a project in Manabi to set up farmer associations and cassava drying plants. Survey work was undertaken by Agroecological Studies to characterise the cassava-producing area of the province, and to identify potential sites for new drying plants.

The area studied was strongly dissected and environmentally diverse so the sample of villages for the questionnaire survey was denser than in the preceding studies. A marked division was identified based on average annual precipitation and altitude. The distribution of farming systems, cropping systems and use of cassava varieties were all found to be signficantly related to mean annual precipitation totals. This finding formed the basis for the subdivision of the area into microregions. Other factors which had a significant influence on cassava production and utilization were accessibility and soil depth, texture and chemistry.

Suitable sites for cassava drying plants were identified along the environmental boundary between the semi-arid lowlands and the more humid highlands. These sites had the combination of favourable environmental and infrastructural conditions specified by the project staff as prerequisites for the success of cassava drying. (More recent experience has shown that they are also viable in the less accessible mountanious areas, where employment opportunities are few and consequently the likely impact of the project is greater).

Implications of the Work for further Regional Characterization

Comparison of the results of the three studies revealed that the following factors should be considered in any attempt to subdivide an area for the purposes of multidisciplinary research (Carter, 1988):

Climate;

Topography;

Soils;

Nature, extent and causes of environmental degradation;

General components of farming and cropping systems;

Farmers varietal requirements;

Government agrarian policies, including social or political bias, Investment, technical assistance and credit provision;

Availability and security of access to land;

Role of the crop(s) under study for income and food;

Farmer organization;

Markets and demand for crop under study;

Access;

Migration and labour availability.

The spatial expression of these factors varies from place to place. It is not always possible to map them, particularly social variables. Indeed, micro-variation in environmental factors is often so great as to preclude precise mapping at anything but very large scales. Given the rate at which social and environmental conditions are changing in rural areas in Latin America, a flexible system of data storage updating and retrieval is warranted to allow specific questions to be answered whilst reflecting the pace of change.

Contribution of the Work to the Unit's Capabilities

The regional survey work led to the development of a fast, cheap and easily replicable reconnaissance survey technique which can be integrated with or supplemented by other techniques such as on-farm surveys, remote sensing, and secondary data analysis. The method can be used for similar work for any of the CIAT commodity programmes. The village-level survey concept has been employed for COSCA phase I. Agroecological Studies can consider offering training in the method, in association with CIAT projects or as part of collaborative activities.

BEAN DISTRIBUTION OF LATIN AMERICA

A continental survey of bean environments (CIAT Annual Report 1978-1979), which produced useful information of a generalized nature about climatological limits and responses of the bean crop, was carried out in the Agroecological Studies Unit. The information obtained however, could not be digitized at the time and it was thus very difficult to combine with existing soils information. As the study was carried out ten years ago, it was decided to update the Latin American bean study using the most recent secondary information available, and using the newest available techniques.

Describing and cataloguing of existing conditions logically begins with an overview, which although bound to contain broad generalisations, is a vital initiation point to the process. The initial step was thus a


LATIN AMERICA
BEAN DISTRIBUTION
≤ 1000 Hectares
1000 - 4000 Hectares
4000 - 8000 Hectares
8000 - 16,000 Hectares
> 16,000 Hectares
Agroecological Studies Unit, 1987
20° N
0° S
20° S
40° S
100° W
90° W
80° W
60° W
40° W

Fig. 6.

continental distribution map of the bean crop in Latin America (Figure 6); our first attempt to digitally record crop distribution. This has now become fully operational, and standard practice in the unit.

Data Selection, Collection and Map Construction

Information source types included:

- Information available in the Agroecological Unit.
- Information collected on trips by bean program scientists.
- Personal communications by mail and from visiting national program scientists from all parts of Latin America and the Caribbean.

Actual information sources included:

- National Agricultural Census
- National Agricultural Production Statistics
- Regional Extension Publications
- Personal Communications.

A further important innovation of importance in the interpretation of the map was the representation of the nature of information used in a data quality map. These maps have previously been used to represent details of information sources in soils maps, but not in distribution maps. (Figure 7).

Important lessons were learned in selection of information. The following guidelines are suggested:

1) Check for degree of consistency with other sources.
2) Use the most recent consistent data.
   In the case where recent data is only available by country as an administrative unit, use this data, and distribute this figure amongst smaller administrative regions using the most recent, consistent, disaggregated data, which may be older.

Fig. 7. Latin American Bean Distribution: The Nature of the Information.

3) Document sources and assumptions for each data set (available in AEU).
4) Acquire the most recent available administrative region maps, in order to be able to use disaggregated information, but take care that these have the same divisions as for the production data.
5) Take care with nomenclature of the species, which varies between and within countries, in order to correctly interpret the data. eg. "Frijol", which in most Latin American countries, refers to Phaseolus vulgaris, in Venezuela refers to Vigna spp. In Brasil "Feijao" includes both Phaseolus and Vigna spp.

The map was constructed using a topographical base map at 1:1,000,000. Dots with a value of 1000 ha of production were distributed within the smallest possible administrative units, based on topography and to be consistent with broad land use maps and landsat images.

Digitizing the distribution allowed the data to be replotted, firstly for checking, and then for overlaying with other information sources at different scales and projections. For the second part of the study the distribution map was overlayed onto the 1:5,000,000 FAO Soils Map of the World. Map transformation routines were developed within the unit. These methods, employing redigitization of the latitude and longitude grid lines is used commonly in AEU not only for fitting of nearly identical maps, but also for plotting data over maps with non standard projections.

Soil Constraints to Latin American Bean Production

A study was conducted using available secondary soils information as an indication of soil types, soil conditions and soil constraints to bean production in Latin American bean growing regions. The results of this study have played an important role in the planning stage of research into bean constraints by the CIAT bean program.

In the study all 1000 ha bean points were labelled with a soil mapping unit. Physical and chemical properties were tabulated for the FAO soil types using information from representative soil profiles and laboratory analyses in the FAO Soils Map of the World continental volumes. Each bean area point was therefore labelled with soil properties.

The method should be briefly described as it the basis for all work which links data to geographic regions. It allows points to be allocated to regions and labelled with the region name (and therefore with any data about the region). An imaginary line travelling in the Y-direction is computed from the point to be allocated. If this line crosses the digitized polygon an even number of times, the point is outside the polygon (in this case the soil unit), and an odd number of times, within the polygon. An algorithm developed in the unit allows all points to be checked with all polygons.

Areas likely to be at risk of nutrient deficiencies or other serious effects were mapped and tabulated. These included areas at risk of potassium, phosphorus, available nitrogen, calcium and magnesium deficiency, low organic matter, cation exchange capacity and pH, shallow rooting depth, drought and manganese toxicity. Bean physiologists were consulted to set deficiency levels.

Figure 8 shows ranges of certain soil properties in the bean zones. Most bean soils have adequate levels of potassium assuming that 0.2-0.3 me $100g^{-1}$ is sufficient for bean cultivation. However, around 15% of the soils, largely in Brasil are extremely deficient (<0.1me $100g^{-1}$ soil), and a further 18% have a deficiency risk (0.15 me $100g^{-1}$). Table 5 shows regional proportions. It confirms that almost a third of Brasil's bean area is at risk from deficiency, due to leaching of this mobile nutrient from predominantly strongly weathered soils.

Figure 8 also shows levels of available phosphorus in the bean soils. The data on phosphorus levels were obtained by various laboratory methods. An effort was made to correct the figures to an equivalent

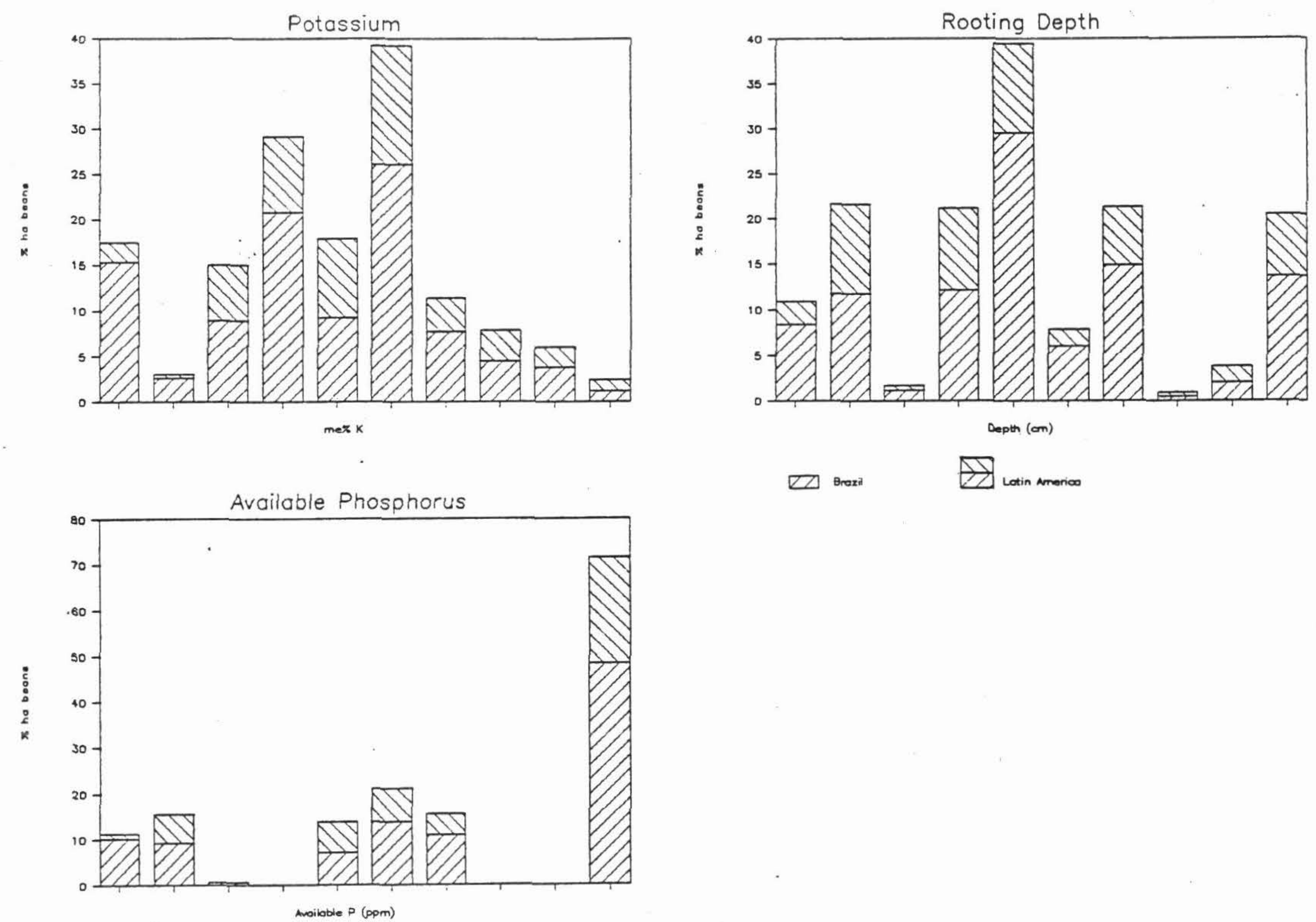


Fig. 8. Soil Constraints in Latin American Beans

Bray II value. Close to half of the area sown to beans has adequate phosphorus levels (more than 10 ppm). A zonal breakdown, shows that all regions except the Southern Cone have phosphorus problems in more than 50% of their bean areas. Of these, half could benefit from fertilisation or use of more efficient phosphorus using varieties (5-10 ppm), and the other half definately deficient (<5 ppm). A significant proportion of the latter zones are in the highly acidic Brasilian soils (Figure 9 and 10). Low pH related phosphorus problems should be distinguished from available phosphorus problems in young volcanic soils resulting from active fixation of phosphorus by amorphous allophanes, which occur in Colombia and Mexico.

Manganese Toxicity

Manganese toxicity is most likely to occur in moderately to very acid soils which run the risk of waterlogging. Because no laboratory analyses for Manganese were encountered in the descriptions and laboratory analyses in the FAO Soils Map of the World volumes, an attempt was made to estimate areas susceptible to Managanese toxicity (Figure 11). The map shows areas with soil pH of less than 5, which have more than 200 mm of rainfall per month for 3 or more months of the year.

The total susceptible area was 724,950 ha, or 12% of the total bean area. Main risk areas are in Brazil, on the acid Ferralsols in the states of Minas Gerais, Southern Goias and Sao Paulo, throughout Central America and in the Southern Mexican States on the poorer volcanic soils (vitric and humic Andosols) and in Antioquia, Colombia.

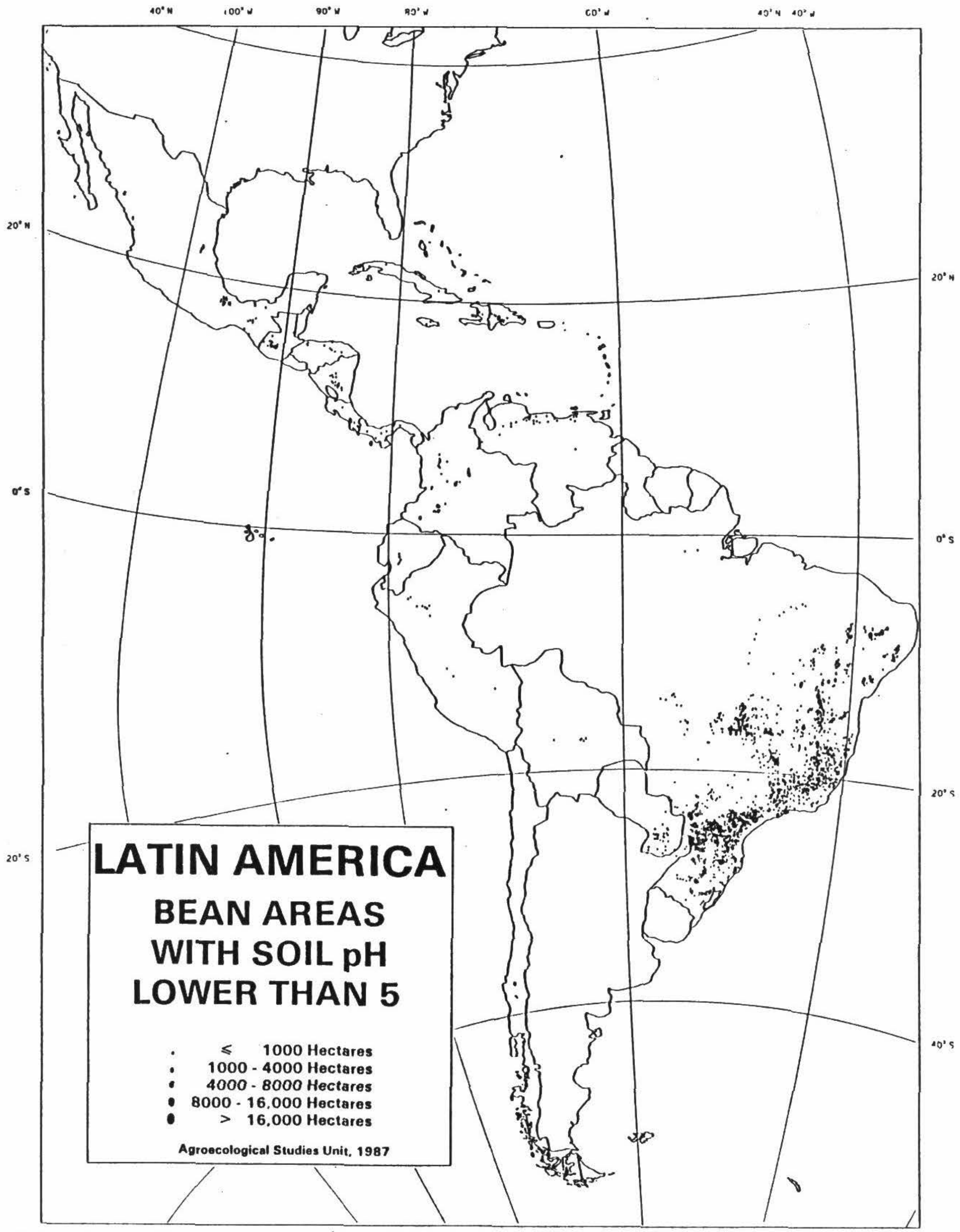
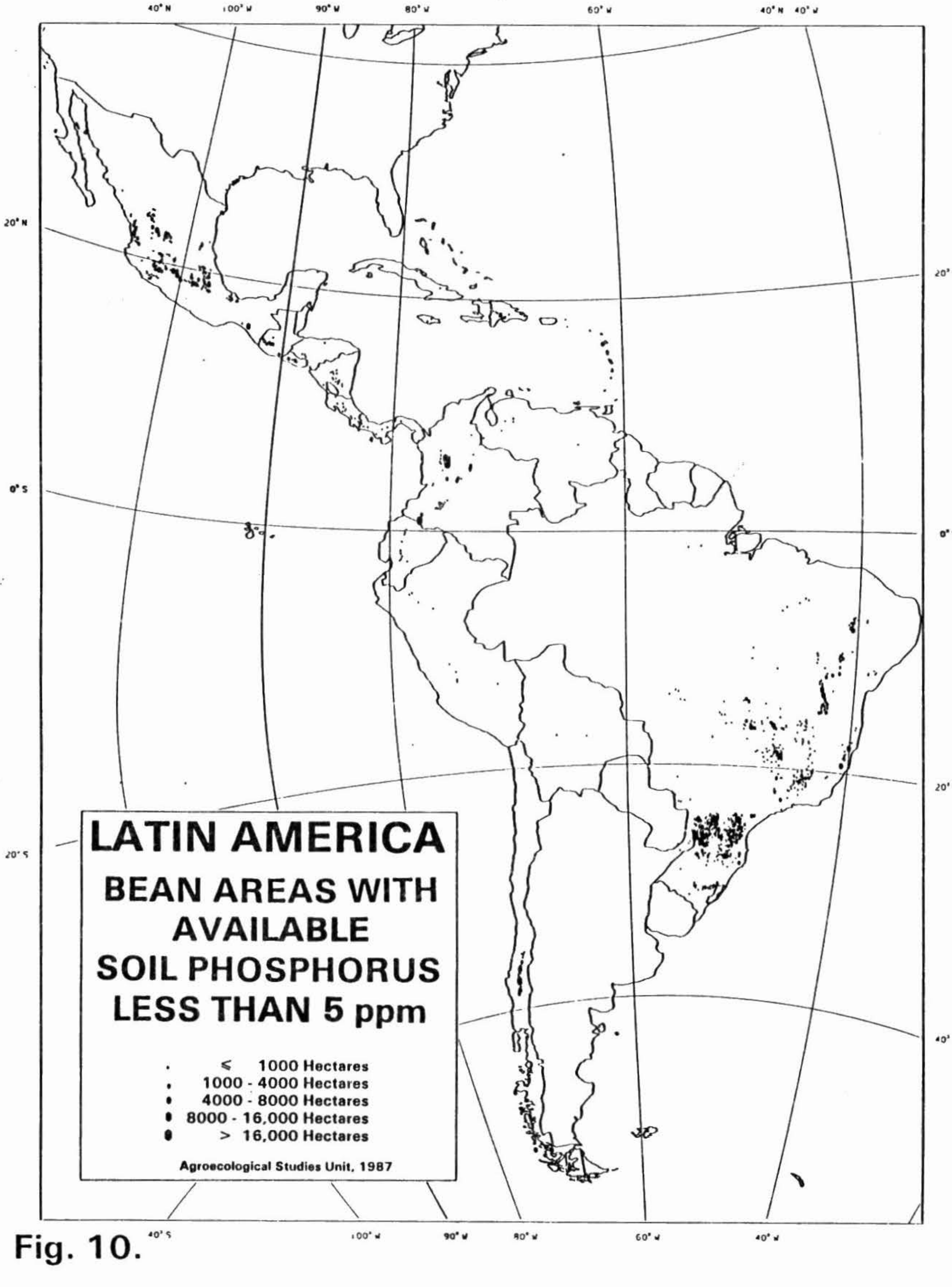

LATIN AMERICA
BEAN AREAS
WITH SOIL pH
LOWER THAN 5
≤ 1000 Hectares
1000 - 4000 Hectares
4000 - 8000 Hectares
8000 - 16,000 Hectares
> 16,000 Hectares
Agroecological Studies Unit, 1987

Fig. 9.


40° N
100° W
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60° W
40° N 40° W
20° N
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0° S
0° S
20° S
20° S
40° S
40° S
100° W
90° W
80° W
60° W
40° W
LATIN AMERICA
BEAN AREAS WITH
AVAILABLE
SOIL PHOSPHORUS
LESS THAN 5 ppm
≤ 1000 Hectares
1000 - 4000 Hectares
4000 - 8000 Hectares
8000 - 16,000 Hectares
> 16,000 Hectares
Agroecological Studies Unit, 1987

Fig. 10.

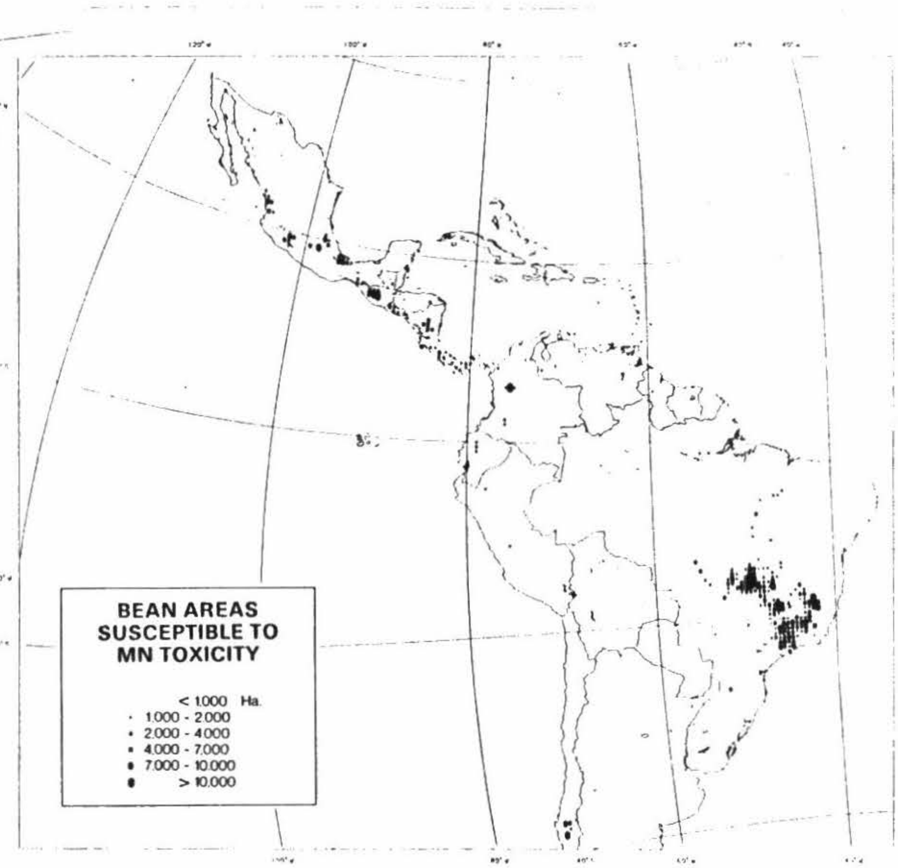


Fig. 11. Bean Areas Susceptible to Manganese Toxicity.

Drought

Figure 12 represents areas of beans in Mexico in dry areas in which bean plants are at risk from drought. Drought was assumed to occur when the number of consecutive months in which rainfall exceeds potential evapotranspiration (Linacre method) is less than the crop phenology for the prevailing temperatures in the predominant wet season. The phenology of a typical bush bean is approximated in Table 5.

TABLE 5. Bean phenology estimated from temperature.

Temp (%)	Days to flower	Growing Season Months
10	210	7
12	180	6
14	160	5
18	120	4
20	90	3
22	80	3
24	80	3
26	80	3
28	80	3
30	90	3

Estimated from bean phenology model; Laing, Jones and Davis (1984).

It was also assumed that beans are planted at the start of the rains. Drought risk is highlighted in the humid zone (central Mexican states) and the semiarid highlands (Chihuahua, Zacatecas and Durango). A small percentage of this is irrigated, but it is largely dryland production. Sonora and Sinoloa, on the west coast, appear as drought areas. These are commercial irrigated zones. The third zone does not appear on Figure 12 and has a distinct type of drought. In southern Mexico beans are sown in relay after maize. Beans are planted towards the end of the growing season. (These areas, in addition to areas where planting is delayed due to excess rain at the start of the wet period, eg. in Gulf of Mexico, Pacific coast, Veracruz, southern Tamaulipas and Chiapas may thus also be susceptible to drought). Despite that exclusion an estimated 76% of the Mexican bean area suffers drought risk. (Table 6). Verification of the importance of drought was carried out in the Durango bean survey described later. The bean Physiology Section has previously reported on deep rooting as a mechanism for drought tolerance in beans. Figure 8 shows that this would be ineffective in around 20% of existing

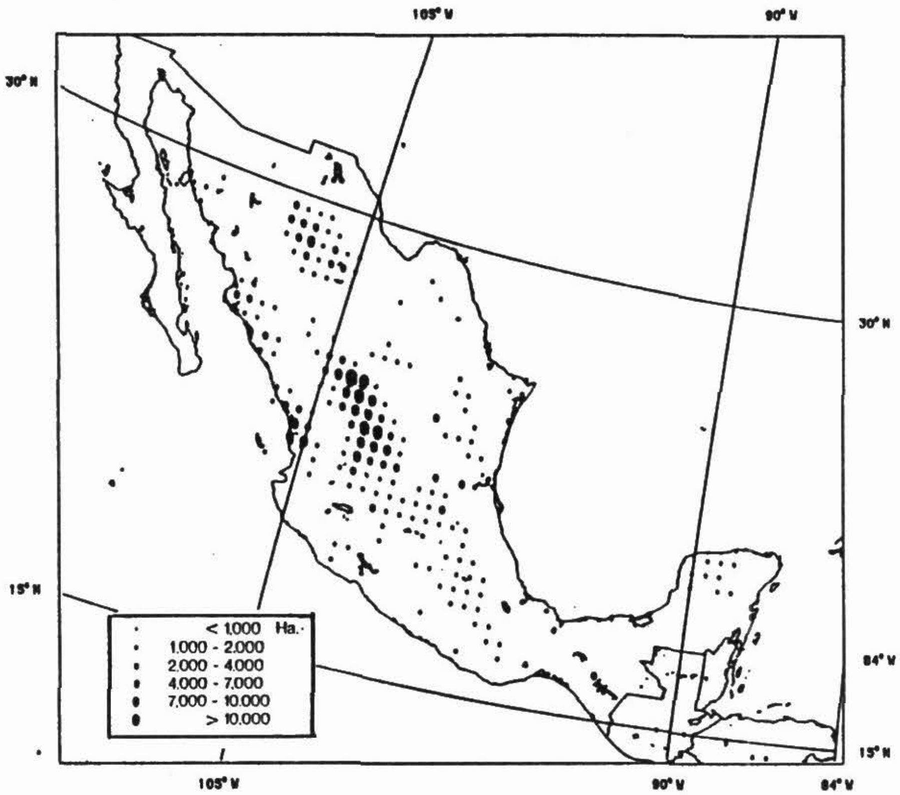


Fig. 12. Mexican Bean Areas at Risk of Drought.

bean soils, where potential rooting depth is estimated at less than 35 cm. Due to the high spatial variability of soil depth, this estimation should be followed up by more detailed studies from large scale soil maps for chosen regions.

TABLE 6. Bean areas at risk from soil nutrient deficiencies and other soils and climatic problems. -

	K		P		pH		CEC		Mn Tox.		Depth		Drought		Total Bean Area
		'000		'000		'000		'000		'000		'000		'000	'000
	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	Ha
BRASIL	30	93	51	1579	61	1889	33	1021		NA*	12	372	NA		3096
MEXICO	1	31	55	1053	2	38	5	96		NA	5	96	76	1465	1915
CENTRAL AMERICA	10	45	62	281	19	86	20	91		NA	7	32	NA		454
SOUTHERN CONE	9	32	22	79	13	46	8	29		NA	1	4	NA		358
ANDEAN REGION	17	45	66	174	26	68	10	26		NA	5	13	NA		263
LATIN AMERICA	4	246	52	3166	35	2127	21	1263	12	725	8	517	-		6086

*NA: Not assessed.

Bean Survey in Mexico

A rapid survey was conducted on farms in Durango, an important Mexican bean growing area. The objectives were to collect agronomic, soils and socio-economic data, to assess constraints to the small bean farmer, and to assess effects of current practices on the environment. The information gathered will be used to assess the ability of small, medium and large scale information in prediction of the main constraints to farmers.

Survey Area Selection

The continental bean distribution map (Figure 6) showed up two main bean growing areas of obvious importance: large concentrations in Brasil, and in the Mexican highlands in the states of Zacatecas, Durango and Aguascalientes.

Two main soil units within the Mexican bean growing region were chosen from the FAO Soils Map (FAO/UNESCO 1974). Within these, the area was reduced by choosing 4 soil units from the SPP-INEGI Mexican Soils Map (1:1,000,000). Finally, within these, 5 soil units were chosen from the SPP-INEGI Mexican Soils Map (1:50,000), coinciding with the main concentration of beans in Durango. Soil units were used as the basic survey sampling units, within which random surveys were carried out. This will facilitate data handling in the comparison of map information to survey information.

The results of an informal survey were used in the construction of a formal survey asking questions about crops and varieties, tenancy and credits, farm size, sowing dates, land preparation and cultivation practices, fertilization, weed control, disease and insect control, yields, labour, perceived production problems, perceived soil types, soil erosion, risks, and was carried out on 60 farmers.

The 104 soil samples taken will attempt to :

- 'Ground-truth' the 1:50,000 map
- Carry out analyses of variance to quantify variability within and between soil units.
- Correlate soils data and agronomic variables from the survey.

The survey has just been completed and detailed analysis is presently underway, however some conclusions can be drawn, and some important considerations are clarified.

Crops

Agricultural statistics for Durango quoted beans and maize as making up 93% of the harvested area for all rainfed crops in Durango (1980-1984). Of these two crops beans make up between 59% and 74%, depending on the year. In the survey, for this year, 81% of farmers interviewed were growing only beans or beans as the main crop with a small proportion of maize for home consumption. The other 19% were also growing beans, but also one or more of maize, oats, barley, wheat and in rare cases sunflower or sorghum.

The trend is away from diversification due to bank loans, crop preferences, crop prices and recommendations from the "Secretaria de Agricultura y Recursos Hidraulicos" (SARH). The Mexican highlands are becoming increasingly a zone of bean monocropping, which has serious implications for soil conservation and sustainability of the system.

The high risks presented by the physical environment are accentuated by the socioeconomic restrictions which affect the small farmers' decisions.

Tenancy, Credits and Farm Size

The two main tenure types are "ejido" and private property. 34% of farmers had "ejido" only, 43% had private property only. The remainder had 2 or more tenure types, including share cropping. Farmers with ejidal land may receive loans from the rural bank for land preparation, sowing, first weeding, second weeding, fertilizers, pesticides and harvest. However most farmers described themselves as "drugged" by debts to the bank. 78% of farmers work with the rural bank. Crop insurance favors monocrop bean production, by discouraging traditional mixed cropping.

Only 3% of farmers interviewed had less than 8 hectares of land, 40% had between 8-10 hectares, 29% had between 11-50 hectares and 28% had more than 50 ha.

Problem priorities

Figure 13 summarizes the problems perceived by bean farmers in Durango, in order of importance.

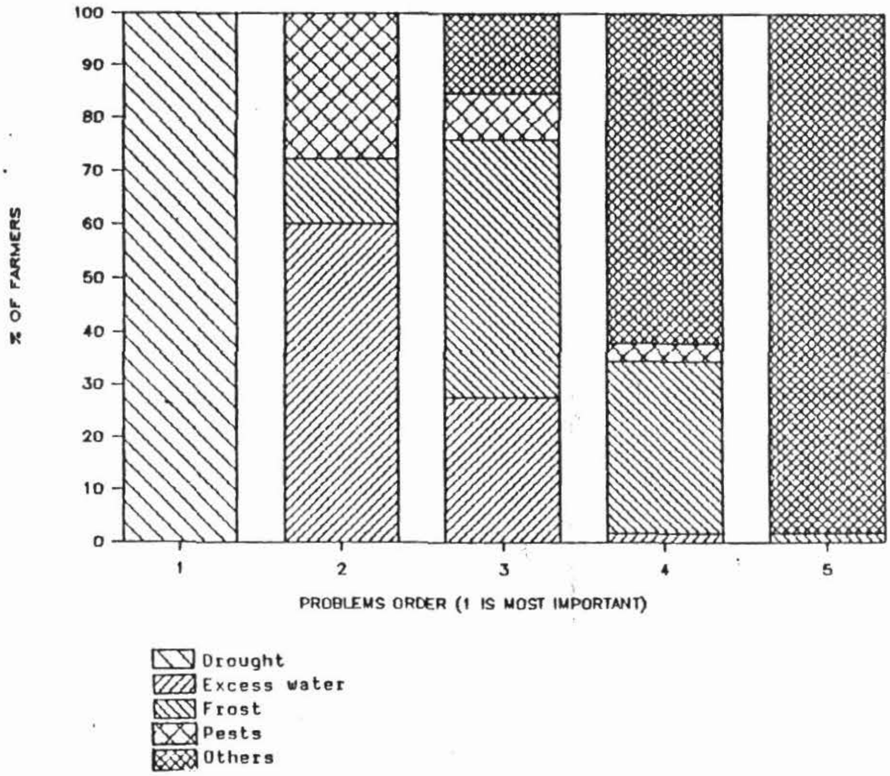


Fig. 13. Principal Problems for Bean Farmers in Durango, Mexico.

The instability of physical conditions the bean farmer is exposed to is highlighted. Although drought is the most important production problem to bean farmers, excess soil moisture is the secondary problem. The latter results in the inability to remove weeds when soils are untrafficable and may result in heavy losses (eg. 1988). Frost was perceived as the next most dangerous risk, ahead of pest damage.

Varieties

Figure 14 summarizes current varieties and changes in variety use. The reasons for these changes are to be investigated.

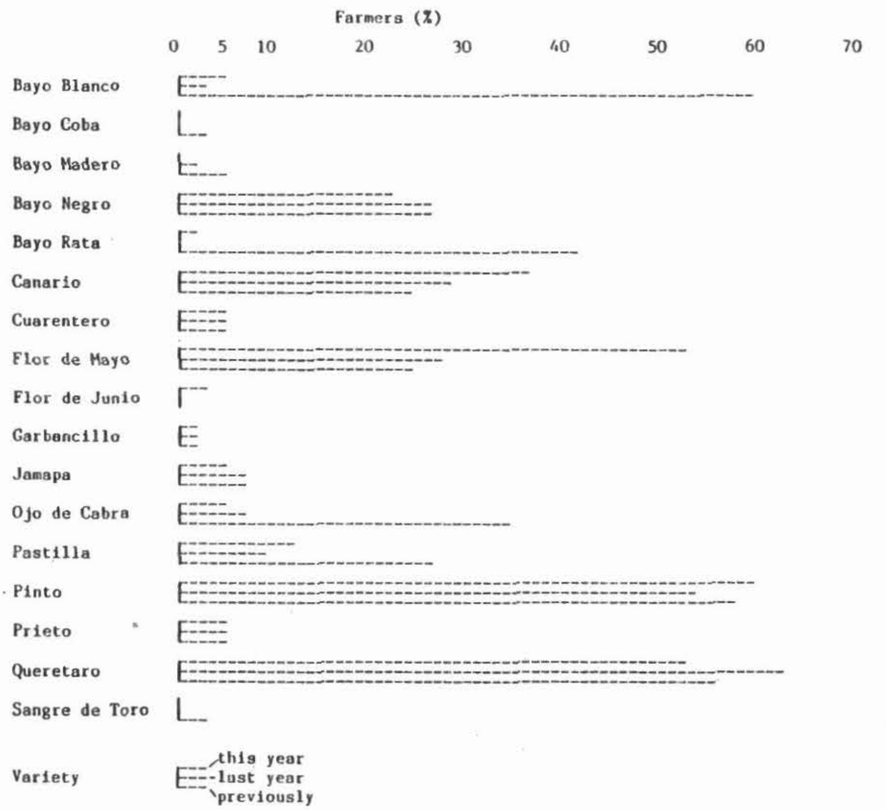


Fig. 14. Varieties of Beans Grown by Farmers in Durango, Mexico.

Soils

A study is underway to relate soil types and soil conditions to management practices and varieties used. However, some simple relationships of soil type as classified by farmes and agronomic factors area briefly described.

"Tierras negras", (corresponding to pellic and chromic vertisols in the FAO system) are fertile, less inclined to require fertilisers, relatively easy to cultivate, and retain enough water to allow rainfed maize to be produced. This is planted with the early May rains. However they are also slower to wet, and later sowing increases frost damage risk at the end of the growing season. Short cycle varieties are thus preferred to reduce risks. In years of excess rainfall these soils also remain untrafficable for longer periods, encouraging weed invasion.

"Sartenejo" (corresponding to very clayey pellic vertisols) the extremely clayey dark soils are sticky when wet, hard when dry. Cracking appears not to interfere with production, although hardness in dry years affects depth of soil preparation.

"Caliche" (corresponding to shallow rendzinas in the FAO system) has high natural fertility but depth restrictions. Use of machinary is thus limited.

"Tierras coloradas" (corresponding to phaeosems and xerosols in the FAO system) are largely favoured for bean production as they reduce risks to a minimum, even though they are not the most fertile soils in the area. They moisten easily and beans are thus planted earlier, which minimises the risk of frost damage. After storms these soils become workable more quickly so that weeding is not interrupted. They require more fertilisation than the dark soils to produce good yields, and are more susceptible to erosion, (particularly the Xerosols).

Erosion, Soil Conservation and Environmental Considerations

Part of the instability of the farming system is highlighted in Table 7.

TABLE 7. Bean yields in Durango. 1987 and 1988.

Kg/ha	% of farmers 1988	1987
0	20.7	-
< 50	12.1	-
51 - 300	43.1	1.7
301 - 500	15.5	3.4
501 - 1000	8.6	69.0
1001 - 1500	-	17.2
1501 - 2000	-	6.9
> 2000	-	1.7

Yield variation from year to year highlights the difficulty farmers have in predicting arrival and intensity of rainfall. In 1988 rains arrived early and were continuous rather than sporadic as is normal. Soils became untrafficable after sowing and yields were low due to weed invasion. 1987 was a year with moderate rainfall, the start of the rains arriving as preferred by farmers in order to produce good yields and avoid frost damage at the end of the growing season.

There was only an extremely weak positive correlation between amount of fertiliser applied and yields. 55% of farmers apply > 100 kg/ha of fertiliser (recommended region-wide by SARH), 21% of farmers apply 30 - 100 kg/ha, and 24% apply no fertiliser. Fertiliser recommendations by soil type would greatly improve efficiency, and reduce reliance on the rural bank.

Additionally, erosion plays an important role. The natural pastures of Durango have supported man's activities from the third interglacial period of the Quaternary up until the 1920's and 1930's. Then these lands were initially opened up to crops, resulting in land being uncovered for large parts of the year. This has continued for almost 70 years. In our survey, 88% of farmers admitted that topsoil was being removed every year by strong winds in January, February and March, when soil is completely uncovered by vegetation. 90% of farmers admitted to soil being removed by water erosion, which was described by the occurrence of:

- Plant being flattened or removed by rill erosion
- Breaking of rows by rill erosion
- Soils becoming noticeably stonier
- Shallowing of soils.

Most of these farmers' fields showed evidence of erosion in the form of rills or wider washways. Most farmers complained of the occurrence of crusting of the soil surface and the need for resowing after downpours. This has increased due to the removal of soil organic matter and the annual cultivations.

Work by SARH an experimental sites in Francisco I. Madero, Durango, found that up to 90 tonnes of soil per hectare per year is removed by water erosion. Loans and crop security by the Mexican government favours, monocrop bean production in the Mexican Highlands for small farmers. Traditional production of 50% maize and 50% beans in yearly rotation, a more environmentally stable system, has been virtually eliminated due to unfavourable maize prices. Farmers are well aware of the advantages of crop rotation but are unable to continue.

THE CHARACTERIZATION OF RICE ECOSYSTEMS IN LATIN AMERICA

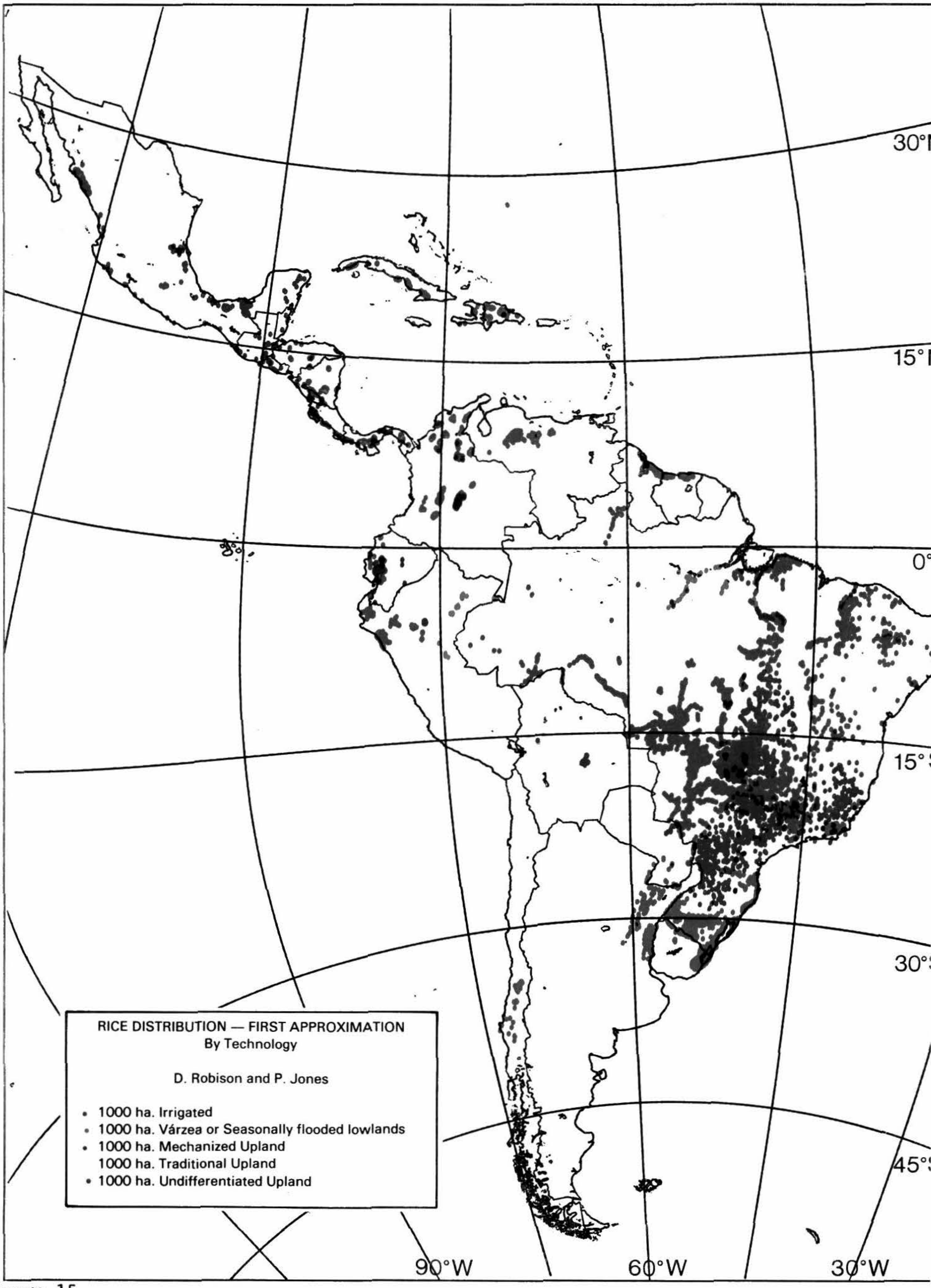
Since August 1988 work has been progressing towards the characterization and location of rice ecosystems in the region within which CIAT's Rice Program works. Though total rice production is estimated yearly for each of the countries, there has not been to date a uniform picture of where rice is grown, how it is grown, on what soils and in what climatic regime. That is to say, there has been no comprehensive system to distinguishing rice grown in Mexico from that grown in Bolivia, or to group ecosystems in different countries that might benefit from a single research thrust.

Approach

There are two common approaches to classifying crop environments. One is to go top down defining all possible environments in terms of parameters important to crop growth. The other is a bottom up approach, which seeks first to find what the actual crop distribution is and then to devise the system which best reflects the ecological and socio-economic environment of the crop. We have used the latter approach, but as with other crops, the quality and resolution of information about rice varies among countries, among years and among groups of technologies. The approach used was to make a first approximation based on the best available secondary data divided by technology group (Figure 15). Once a uniform image was obtained, regional subsets of the data were sent to individuals in each region with the most experience on where the rice is actually grown and what technologies are currently used. Thus the second approximation will be a composite of the best available expertise in each area. Figure 16 indicates the higher classification levels that appear useful to describe the emerging 2nd approximation.

Mid-term Results

The first approximation pointed to some important problems and opportunities: 1. A major problem is the limited information on small-farmer, manual or traditional rice. Recent estimates range between 10,000 ha and 1,000,000 ha in this technology group for Brazil alone. According to the 1980 agricultural census, 93% of the rice growers in Brazil had less than 5 ha of rice and 48% had less than 1 ha. In terms of numbers of people involved and benefitting from rice production, this sector could be very important. 2. Another problem with interpreting the data is the lack of uniform agro-climatic criteria with figure 15


30°N
15°N
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30°S
45°S
90°W
60°W
30°W
RICE DISTRIBUTION — FIRST APPROXIMATION
By Technology
D. Robison and P. Jones
1000 ha. Irrigated
1000 ha. Várzea or Seasonally flooded lowlands
1000 ha. Mechanized Upland
1000 ha. Traditional Upland
1000 ha. Undifferentiated Upland

figure 15

which to classify upland rice ecosystems which represent over 70% of the area under rice in Latin America. 3. A further obstacle to defining rice environments is that crop production information is seldom spatially referenced. This impedes accurate association of the rice with specific soil or climatic conditions.

The first approximation also illustrated an important target ecosystem, principally in Brazil (Table 8). The crop distribution was overlayed with soil and climate information and suggested that there are approximately 2.2 million ha of acid infertile soils already under rice, with sufficient rainfall for upland rice but with low yields. This area could benefit from the acid tolerant rice and the rice/pasture rotation technology currently emerging from CIAT. While the climatic thresholds used in this first approximation are not rigid enough, the final tally of this area may increase, as the area of physically and chemically restricted soil (mainly lateritic) is vastly overemphasized on the small scale soil maps used. The second approximation will benefit from analysis of larger-scale soil maps in the AEU library.

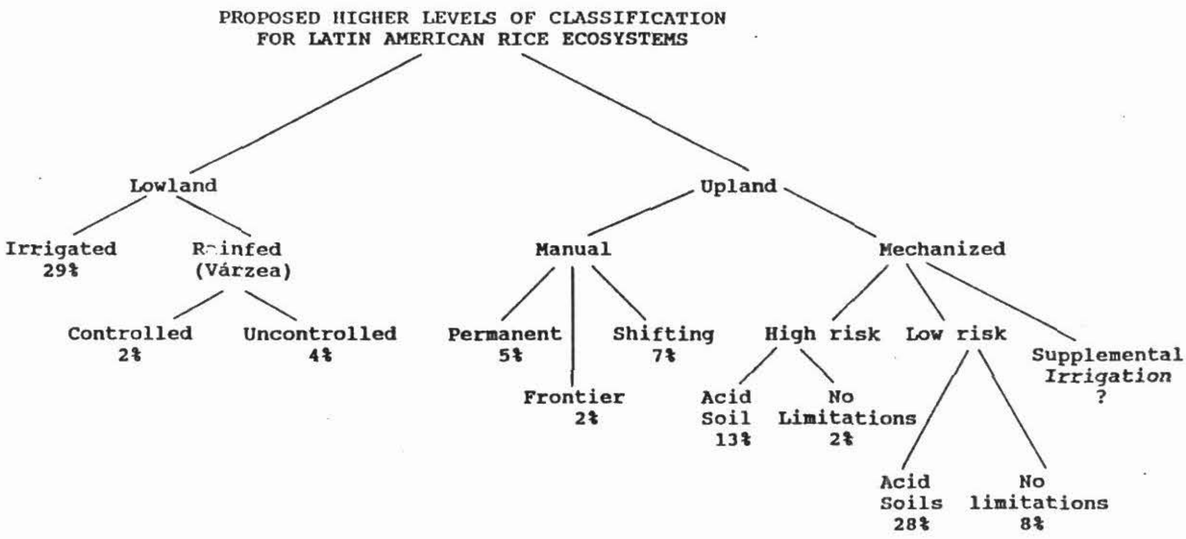
Work with the recent Colombian Census has illustrated another important point. Traditional or manual rice has formerly been discarded as essentially a frontier crop with low potential productivity. However, 48% of Colombian rice growers fall into this group, and half of them are in areas of long-term rice production where edaphic and climatic conditions can be considered suitable for rice. This is a very different ecosystem from frontier slash and burn. It is thought that there may be several significant small farmer/wetland ecosystems with the potential for increasing both yields and the quality of life for traditional rice growers throughout Latin America.

Future Work

Cooperative fieldwork is planned in Northern Brazil where a rapid rural survey is intended to help define the modal small farmer ecosystems. Other cooperative work is planned to take advantage of extensive research in Brazil on drought risk for 80 specific points. This will be used to calibrate and verify climatic stratification using AEU climatic data base with over 7000 stations for the region. When the 2nd approximation of rice distribution is finished, it will form the basis of an environmental classification system along with parameters such as soils, climate, farm-size, access and distance to market. This will enable a better identification and spatial location of target ecosystems and allow for a rational stratification based on socio-economic and agro-ecological parameters.

TABLE 8. Table of soil quality by technology for rice in Latin America. (In thousands of hectares)

	TECHNOLOGY				
Limitations	Irrigated	Varzea (Lowland)	Upland Mechanized	Upland Manual	Upland Undifferentiated
NONE	1607	112	386	463	451
CHEMICAL	485	51	1724	353	708
PHYSICAL	0	0	0	0	7
CHEMICAL AND PHYSICAL	40	0	33	1	813
TOTAL	2132	163	2143	817	1979



(Estimate of percent share of rice area in Latin America)

Fig. 16.

COLLABORATIVE STUDIES

CIAT is not the only CGIAR centre with an interest in agroecology. The Rome meeting of 1986 brought together these interested in the field from other centres and international organisations. This meeting has resulted in a strengthening of the ties between the centres and an increased use of the facilities and data of CIAT for our sister centres needs.

This year the Unit has participated in two major intercentre projects: COSCA with IITA and the CIAT/IFPRI project in the Peruvian Amazon. We have also welcomed scientists from other centres to work with us to develop their own projects using our data and processing capacity.

COLLABORATIVE STUDY OF CASSAVA IN AFRICA (COSCA)

COSCA is a six-country study whose broad aims are to characterize production, processing and marketing systems, present and future demand, and the effect of cassava consumption on nutrition. The first stage is a village-level survey. It is currently underway. Here we describe our contribution to the planning of this phase.

To ensure that the first phase of COSCA provided data from a representative set of producing areas, a spatial stratification system was devised. At the Third Planning Meeting for the project in September 1988 it was agreed that ecological conditions, essentially climate, human population density and physical accessibility should be mapped to define this frame.

We established a database of computer maps, beginning with the climate and cassava maps described above. To create a population density map, we digitized secondary-level administrative boundaries from political maps of the countries involved in the project. To these units we assigned population figures from data obtained from the US Bureau of the Census. Using estimates of national growth rates all population figures were standardised to 1990. We then calculated the area of each Administrative Unit and the corresponding population density figure. Finally we subdivided the map into two areas, high and low density, where population density was greater or less than 50 persons per square kilometre respectively.

All weather roads, railways and navigable rivers were digitized from the Michelin African Road maps for 1987, to provide a measure of accessibility. The IDRISI geographical analysis package was used to overlay climate, population and accessibility maps. To simplify the climatic map we excluded those climates with fewer than 50,000 ha of cassava. These were identified by overlaying the cassava and climate maps within IDRISI. Similarly, once we had defined homogeneous climate-population-accessibility regions, we excluded from individual countries those combinations with less than 10,000 ha of cassava.

We then produced colour maps of the major climate-population-access homologues for the study countries. These comprised grid cells, 12' of latitude high by 12' of longitude wide. Drawing on the field techniques developed in our South American cassava surveys, we proposed that these grid cells should comprise the sampling frame, that cells be selected using a systematic procedure with a degree of randomness, and that after selecting cells, villages or settlements should be chosen at random.

These procedures were utilised by the COSCA project staff, with minor modifications to the areas surveyed, to include some zones which were of special interest despite their unrepresentativeness. We had no control over the number of villages selected; this was determined by the resource and time constraints of the participants. The procedure has ensured a wide spread of survey points across most of the countries involved in COSCA, although in some cases individual homologues have low numbers of survey points. This will have some effect on the types of analysis feasible, and non parametric statistical techniques will be an important analytical tool.

We have recently extended the spatial survey framework to a further five countries, Rwanda, Burundi, Cameroon, Zambia and Malawi. COSCA phase I may be undertaken in each of these if local resources can be mustered. Maps were dispatched to IITA in September.

Our collaboration in COSCA phase I will continue next year, with training and assistance in computer mapping and data analysis to the national and regional level coordinators, and overall mapping and analysis for data generated in phase I.

CIAT-IFPRI PERUVIAN SELVA STUDY

In response to a request to collaborate with the CIAT-IFPRI Peruvian selva study, the Unit provided digital cartographic information and training in the use of IDRISI, to enable environmental conditions in areas of crop production to be characterised.

The CIAT study of land systems in tropical America (Cochrane et al., 1985), provided the basic information necessary to describe soil conditions in the Peruvian Amazon. The land systems are described in CIAT's computer data-base. These data are stored as 5 minute by 4 minute grid cells. A computer image of the land system boundaries was created for use in IDRISI, and descriptive characteristics of each land system were extracted from the data base, in such a form that computer maps could be used to show the attributes of each land system.

To complement the land systems map, all weather roads, first, second and third-order urban centres, provincial boundaries and major rivers were digitized, and computer maps created for each. Finally the major annual or staple food crops grown in the area were mapped as part of the project from recent secondary data. These were digitized, and we created respective computer maps.

The information provided has been used to :

(i) Identify the area in annual/staple food crops grown in the different land systems;

(ii) Identify which land systems are hypothetically most susceptible to erosion and degradation;

(iii) Estimate where pressure on natural resources is likely to be greatest.

IITA

Dr. Karen Dvorak of the IITA sustainable production group has spent two weeks working intensively with us in developing sampling framework maps for a proposed West and Central African survey of fallowing periods.

This called on the techniques used for COSCA but required a complete redefinition of the climate classes to reflect natural vegetation types.

The classification algorithm was developed by Dr. Dvorak in consultation with us and applied to the new Metgrid file for Africa. A project specific redefinition of the soils data was also developed and the two were mapped together to produce the sampling maps for the project. A final map including road access to the sampling cells will be shortly sent to IITA.

CIMMYT

Based on an initiative of CIMMYT dating from the mid 80's the Centre has a valuable inventory of wheat and maize growing regions of the world. This was produced by asking their collaborating scientists in each country to denote the appropriate zones with comments on the environment and characteristics of each zone.

Dr. B. Knapp asked the Unit to check these subjectively estimated regions against the reality of the CIAT databases. The CIMMYT maize regions for the Andes were digitized and overlayed on various digital files available to the Unit.

It became evident that the regions described as homogeneous for maize production could not be so. One in fact included the glaciers of the Nevado de Santa Marta and the lowlands of the Colombian North Coast. In reality, in this region, maize is grown in many different systems depending on altitude.

Using the database of CIAT and the mapping capabilities of the Unit we were able to identify many such inconsistencies. An example of interest was where the Unit could overlay the map of maize production produced by the CIAT/IFPRI Peruvian Selva project with the CIMMYT defined regions. The exercise brought home the conclusions that there is no alternative to exact spatial knowledge of a crop, and that agroecological information is a multicentre commodity.

Further collaboration with CIMMYT is looked forward to within the unit.

NATURAL RESOURCE MANAGEMENT

The Unit has concentrated its efforts in the past on service functions for the commodity program. There is a large overlap of data and techniques already used by the Unit which will assist in any natural resource management initiative of CIAT. Nevertheless there are certain sets of important data which will be needed in addition. The Unit is systematically collecting certain of these in anticipation. An almost complete collection of maps of Latin American forest reserves, national parks and indigenous reserves has been made and digitization is well under way. Also being digitized for the Andean region are the administrative boundaries and infrastructure.

These data along with crop distribution, soils, climate and ancillary data from population or agricultural census can be used to identify areas where the environment is actually or potentially under pressure.

The rapid survey techniques developed by the unit can be used to accurately delineate and quantify real or potential problems.

It is assumed that any initiative in Natural Resource management will consist of a) area selection, b) problem identification, c) technology design and development and d) evaluation and prediction of the long term social and environmental effects of the technology. The Unit is in an ideal position to assist with stages a, b and d in a coordinated plan to produce sustainable technologies.

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Acronyms

CGN	*Centrum* voor Genetische Bronnen
CIA	Central Intelligence Agency
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
COSCA	Collaborative Study of Cassava in Africa
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FAO	Food and Agriculture Organisation
GEMS	Global Environment Monitoring Service
GIS	Geographic Information System
GRID	UNEP/Global Resource Information Database
IBSNAT	International Benchmark Sites Network for Agrotechnology Transfer.
ICARDA	International Centre for Agricultural Research in the Dry Areas.
ICRISAT	International Crops Research Institute for the Semi Arid Tropics.
IDMSR	Integrated Database Management System/Relational
IITA	International Institute for Tropical Agriculture
ILRAD	International Laboratory for Research in Animal Diseases
INEGI	Instituto Nacional de Estadística, Geografía e Informática.
IRRI	International Rice Research Institute
ISRIC	International Soils Reference and Information Centre
NOAA	National Oceanic and Atmospheric Agency
SEARCH	Secretaría de Agricultura y Recursos Hidraúlicos, México.
SPP	Secretaría de Programación y Presupuesto - México.
UNEP	United Nations Environment Program
USDA	United States Department of Agriculture