For Sjef with many thanks
5.12.97

FINAL REPORT

Contract Number TS3 - CT94-0314 (DG 12 HSMU)

TITLE	**An integrated study of land properties, their floristic indications and appropriate farming systems in an acknowledged biodiversity center in amazonian Peru**
PROJECT LEADER	Risto Kalliola
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ASSOCIATED COUNTRIES /INSTITUTIONS:	- The Netherlands: International Soil Reference and Information Centre (ISRIC). - Germany: Forshungsinstitut Senckenberg. - Perú: Instituto Nacional de Recursos Naturales (INRENA). - Perú: Universidad Nacional de la Amazonia Peruana (UNAP).
KEY WORDS:	Landuse planning; Rain forests; Tropical soils; Sustainable development; Tropical agriculture
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SUMMARY

The EU/STD3 funded project An integrated study of land properties and their floristic indications in an acknowledged biodiversity center in northern Peruvian amazonia (1994-97) attempted to combine geographical, geological, pedological and biological knowledges to gain new understanding of the ecological constrains of agricultural production in the Amazonian lowlands in the vicinities of the city of Iquitos, Peru.

The general objectives were to find realistic alternatives to migratory farming by (1) determining the geological background for the existence of site types with different production potentialities, (2) developing a model for the identification of edaphic differences utilizing ecological knowledge of indicator plant species and (3) promoting the development of appropriate land use systems for the different site types.

Study methods varied according to the scientific disciplines involved. Substantial work was based on the use of digitally enhanced satellite images and aerial photographs, and field work was carried out extensively in different parts of the study area.

The results indicate that the geological structures and soils near Iquitos are highly heterogeneus, causing differenciation in edaphic site properties. The majority of the soils are very poor and strongly weathered while a minor portion of them have close to neutral soil reaction and are only slightly weathered. The natural vegetation and land use potentials vary according to differences in soil properties.

Early phases of deforestation in the region preferred productive soils, but recent road construction has introduced colonisation pressure into areas with low agronomical potential. The secondary vegetation in abandoned lands contain several economically valuable species. With appropriate agroforestry technologies selected, even poor soils can support longer term agricultural production than has been customary until now.

The research followed very closely the original work plan and the main results of this work have got positive response from both the scientific community and national land use authorities. Several scientific articles and a book based on this research will be published still in the year of 1998.

OBJECTIVES OF RESEARCH

Colonization activities in humid tropical lowlands can easily become destructive for both the environment and the local economy if they are a planned without basic knowledge of the local conditions. Especially food production by practicing swidden fallow agriculture is often ephemeral in nature, and gradually the availability of unburnt land becomes an acute problem. In order to make the best possible use of the natural resources with minimal destruction it is imperative that reliable knowledge about the distribution and qualities of different soils are made available to the appropriate decision makers.

Our research aimed to examine this problem in vicinities of the city of Iquitos which is located in the Amazonian lowlands of eastern Peru. The humid tropical forests of this region are internationally celebrated as being among the most species-rich forests known on our planet. However, these forests are currently threatened by road construction and accelerating deforestation pressure.

Our project formed a coherent network of interactions among fundamental research and applied research and it attempted to combine views from different scientific disciplines to gain new understanding of the ecological constrains of agricultural production. Its general objectives were defined in the application formula as follows:

1. To find the geological background for the existence of soil types with different production potentials in Peruvian Amazonia.
2. To develop a generally applicable model for the assessment of soil production potential in Amazonia.
3. To evaluate the applicability of alternative land use options on different soil types by measuring agronomical success in edaphically different sites.
4. Through 1-3 to find realistic alternatives to migratory farming in Amazonia.

ADMINISTRATION

The project started in 1 of November 1994 and it lasted until 31 of October 1997. The work was co-ordinated by Dr. Risto Kalliola from the University of Turku in Finland, and in addition four other research institutions participated representing the countries of The Netherlands (ISRIC from Wageningen), Germany (Forschungsinstitut Senckenberg from Wilhelmshaven) and Peru (INRENA from Lima, UNAP from Iquitos). Different participants are from hereon referred to according to their home cities.

Economy

The Operative Commencement Date of 1 of November 1994 was not reached in budgetary terms because the first advance payment was only received in March of 1995. Due to this delay certain activities began later than expected, yet the participating institutions were very flexible and lounched some of their work prior to receiving research funds.

Economical resources were distributed among participants following very carefully the original research plan. Each time when a new prepayment was received from the Commission, the sum was divided among participants according to their respective percentage shares (Table 1). Although the prepayments were delivered in ECUs they were changed fo FIMs before to their depositon to the bank account of the University of Turku. Thereafter respective economical resources were transferred to subcontractors using FIMs in the case of Wageningen and Wilhelmshaven and USDs for Lima and Iquitos.

Only the third prepayment was distributed somewhat differently since the co-ordinating institute decided to loan funds for making it possible to distribute up to full 100 % prepayments for the subcontractors. The economical gap that was created by this means in Turku will be recovered by the receipt of the remaining 10% of the project's total value after the Final Report has been approved. This policy was taken in oder to ensure appropriate working conditions in other institutions and also for the sake of rationalising the task of overall economical administration.

TABLE 1. Division of economical resources among partners in ECUs. Fourth payment refers to the funds that will become available only after final reporting of this project has been accepted.

	budgeted	*% share*	1. payment	2. payment	3. payment	4. payment	total
Turku	151084,00	*49,54*	60433,60	46670,33	12111,17	31868,90	151084,00
Wageningen	39996,00	*13,11*	15998,40	12354,89	11642,71	0,00	39996,00
Wilhelmshaven	7920,00	*2,60*	3168,00	2446,51	2305,49	0,00	7920,00
Lima	46500,00	*15,25*	18600,00	14364,00	13536,00	0,00	46500,00
Iquitos	59500,00	*19,51*	23800,00	18379,74	17320,26	0,00	59500,00
TOTAL	**305000,00**	***100,00***	**122000,00**	**94215,47**	**56915,63**	**31868,90**	**305000,00**

Substantial additional funding from three sources contributed to our research. First, in Wageningen and Wilhelmshaven the marginal cost principle was applied which means that these institutions allocated at least an equal amount of their own resources for running of this work. Likewise in the case of Turku, the Academy of Finland supported activities of the Finnish research team on an equal basis (contract SA30228 and others). Finally, many institutions used more human resources for this research than was originally planned. This support will also continue until the book based on this research will be ready for printing.

Unfortunately printing of this book could not be covered by funds from this project. Due to this reason the co-ordinator has contacted the STD3 secretariat in order to see possibilities for obtaining additional support for this purpose. According to preliminary offers from printing houses, 25 000 ECUs should ensure appropriate printing quality and also linguistic revision.

It was discussed between Dr. T. Hall and the undersigned in Brussels on 10th of October 1997 that there might be a possibility to consider arranging of a scientific symposium in Peru and to include printing costs into its budget. This possibility would not only give to scientist's of this project a possibility to present their findings to an interested audience of researchers and responsible authorities, but it would also give significant visibility for EU:s scientific activities within the Amazon Basin area. The symposium should take place in the city of Iquitos and its arrangements would require some additional funding to cover organisational costs and national and international travelling.

In an optimal situation the final book could be printed in early 1998 and the symposium would take place in March or April. Whether this possibility can materialise is open and dependent on especially economical resources.

Administration and co-ordination

An effective integration of information from several different disciplines and institutions was one of the main objectives of the project. This endeavour was approached by arranging altogether six coordination meetings (twise a year on the average), three of them in Europe and three in Peru (Table 2). During these meetings, common research goals and methodologies were set up and also the lengthy discussions about various research questions helped us to define the most relevant measures for this work. Also a number of minor workshops have been held at various stages among different groups of participants.

TABLE 2. List of co-ordination meetings and the most important issues dealt in them.

Place and date	*number of participants*	*Main items discussed*
1. Iquitos 28.11.-9.12.1994	13	Getting organized; establishment of detailed work plans for each institution; calibration of working methodologies.
2. Turku 23. - 27.8. 1995	14	Progress reports of work already done; preparation of preliminary draft of the Geoecological map; definition of general lines for the final book.
3. Iquitos 8. - 16.1. 1996	13	Reporting of work already done; preliminary plan for chapters for the final book; extensive field work with a multidisciplinary team.
4. Iquitos 19.10.1996	13	Reporting of work already done; scientific discussions with special emphasis to geology and land use; extensive geological and pedological field work.
5. Wilhelmshaven 3.-5.3.1997	15	Reporting of work already done; compilation and presentation of the first version of the book; preparation of the geoecological map.
6. Turku, 15. - 18.7.1997	11	Reporting of work already done; scientific discussions with special emphasis on geology and pedology; further processing of chapters for the final book.

The general protocol in the coordination meetings comprised four distinctive components. All meetings started with presentation of the project's current administrative situation including aspects of both economy and technical reporting. Considerable effort was put on that all participants would share the same common idea about this project's structure and objectives, and that they would appreciate the need to follow carefully the original work plan and its schedule.

The second part of these meetings was made of scientific reports by different subcontractors and individual scientists. A very good working atmosphere characterised these discussions since people were livingly interested about each others work. Consequently the discussions were enthusiastic and innovative and resulted into productive interaction among members of different scientific teams and disciplines.

The third part in each coordination meeting was dedicated for time consuming discussions and brainstorms on selected topics of current priority, like calibration of working methodologies, preparation of the geoecological map or choosing sites for future field inventories. The work advanced partially in multi-institutional subteams that were formed around common research interests. In those meetings that were held in Peru also extensive field excursions were linked with these activities.

Finally, all coordination meetings ended up with general discussions where concrete plans were put forward for further research activities.

Soon after each co-ordination meeting minutes were written by the co-ordinator and folded together with a collection of relevant appendices. This package was delivered to all participants in order to guarantee an effective dissemination of information among researchers representing various disciplines and institutions. The booklets *"Resumen del ## taller"* also served for a regular follow-up of the project's versatile activities.

Scientific reporting was done each six month period as defined in the contract signed for this project. Annual Periodic Progress Reports (altogether three) were presented to the Commission along with annual Cost Statement Reports in 1995, 1996 and 1997, compiled by the co-ordinator on the basis of institute-specific reports that had been submitted to him by subcontractors. Semi-annual short reports were presented in the month of April of the respective years, written by the co-ordinator on the basis of information gathered during the latest co-ordination meetings.

Research personnel

Most of the personnel who participated in the application for this project could also participate in active research (Table 3). This situation made it possible to carry out long term and goal oriented work. Nearly fifteen scientists were active all through this project, and additional researchers contributed in some parts of it - either as consulting specialists, field assistants or students working with their master's thesis projects.

TABLE 3. List of key research personnel in different institutions.

City and country of institution	*Researchers*
Turku, Finland	Risto Kalliola, Ari Linna, Hanna Tuomisto, Kalle Ruokolainen, Matti Räsänen, Jukka Salo, Sanna Mäki, Frank Wesselingh, five MSc students
Wageningen, The Netherlands	Sjef Kauffman, several technicians
Wilhelmshaven, Germany	Georg Irion, technicians
Lima, Peru	Elva Gómez, Tula Tamariz, Ruben Marquina, Roque Vargas, Francisco Reátegui, Walter Danjoy, technicians
Iquitos, Peru	Gobert Paredes, Salvador Flores, Tedi Pacheco, José Torres Vásquez, Ronald Burga, field assistants and technicians

The only major changes in research personnel took place in the institution INRENA (Lima) where the scientist in charge (project leader) changed twice. The first project year was lead by Ing. *Walter Danjoy* who changed to another job in July of 1995 and was followed by Ing. *Francisco Reátegui.* After his nomination to another position within INRENA's organisation, the final period was lead by Ing. *Elva Gómez.* All these changes were notified to the STD secretary in their due course and they did not cause any need to re-evaluate the tasks of INRENA within this project. However, frequent changes of course caused a major endeavour for familiarising each time the new researchers with the objectives of this project - as well as with members of other teams within this research consortium.

Also in UNAP the situation changed somewhat because the original scientist in charge, Ing. *José Torres Vásquez* became the Rector this university. Due to this reason Dr. *Gobert Paredes* acted as the main researcher of this team and Ing. *Tedi Pacheco* took the task of leading the forestry section and also compiling the final year's reporting at UNAP.

Phases of implementation

The work was spread over a 3-year period with the most active research taking place during the second year. The four phases of implementation were:

**Preparatory phase* (1994). First coordination meeting with preparation of the field work protocols. Preliminary field work in sites of high interest. Acquisition of background data, remote sensing imagery and miscellaneous equipment.

* *Main field activities* (1995-96). Most field studies were be executed although the agroforestry experiment will continue for a longer time period. Several field trips by larger and smaller teams of researchers.

* *Data analysis* (1996-97). Laboratory work started immediately when material from the field became available. Geochemical analyses were made, soil profile samples prepared and plant specimens identified. Preparation of GIS databases.

* *Concluding phase and reporting* (1997-98). Writing of articles for the final book and for scientific journals, preparation of the environment map. A one-week intensive course was held for advanced university students at UNAP. National and regional land use planning authorities were contacted and informed about this research. Writing of scientific articles.

MATERIAL AND METHODS

Study area

The study area is located in the western periphery of the Amazon Basin (c. 100 m a.s.l.) near to the confluence of river Ucayali and river Marañon to form the mighty river Amazonas. The region has a moist tropical climate with an annual precipitation of approximately 3 metres and it is characterised by tropical lowland rain forests on both annually inundating (floodplain) terrain and uplands (tierra firme) (Fig. 1).

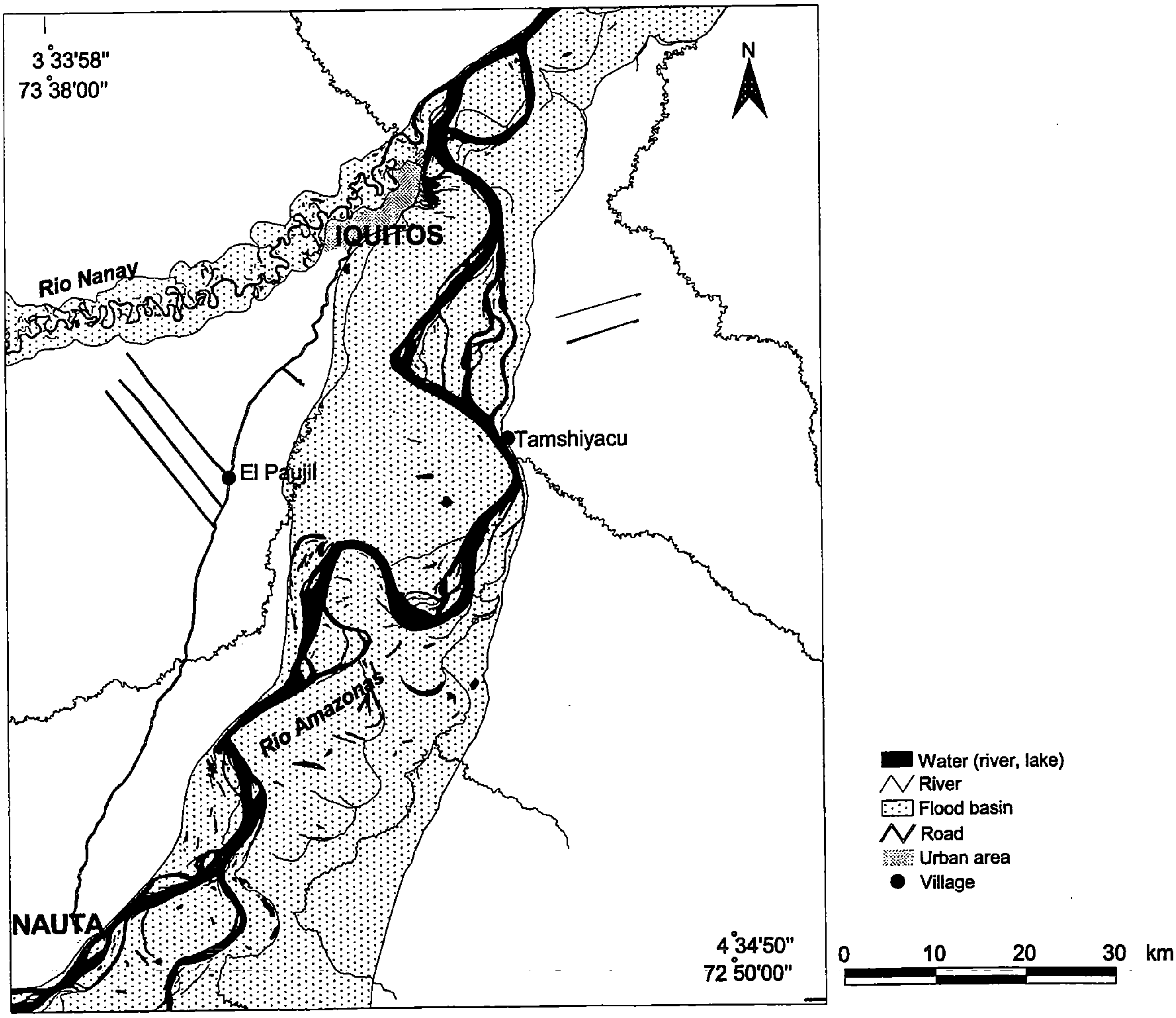

FIGURE 1. General map of the study area.

The region is only accessible by river and air since there is no road connection to any other area. The city of Iquitos has a population of quarter of a million and it is the administrative and commercial centre of the region of Loreto which has an area of 370 000 km^2. Other towns in the region (Tamshiyacu and Nauta) are like villages in relation to Iquitos which is also the most important foreign trade river port in eastern Peru.

The economical history of the region has been shaped by cycles of economical prosperity and recession. For example Iquitos was only a small village until the shift for the 20th century when wild rubber extraction grew to a booming industry and the city grew fast. After demand for wild rubber dropped, natural resource use shifted to minor products (timber, animal skins, vegetable ivory) until in 1970s when large oil resources were detected in Loreto.

General working philosophy

Multidisciplinary approach

The present research consortium was built to form a coherent network of interactions among fundamental scientists, applied researchers and national authorities. The former studies attempted to gain understanding of the variation in site edaphic conditions combining aspects of geography, geology and biology. The applied studies tried to examine new agronomical and forestry systems in the study area.

The research aimed to form a sequence of five phases: (1) mapping of different site types using satellite imagery and vegetation data, (2) assessing the soil production potential in each site type using geological and pedological field documentation, (3) monitoring deforestation and colonization history using multitemporal remote sensing data, (4) evaluating the usefullness of different landuse practices in different site types using experimental and inventory data, and (5) a synthesis of the above to refine a practical method for assessing soil production potential in pristine areas.

Prior to this study the natural rain forest area near Iquitos had not been studied using a multidisciplinary approach. For example due to the extreme species diversity of these forests it was considered to be quite impossible to measure floristic differences among sites. Now for the first time in Amazonia this problem was circumvented by inventoring only a fraction of the total flora. This made it possible to cover exceptionally large areas by effective field work. Also the strong weight that was given to geoscientific field documentation was new in land surveys in Amazonia.

Multi-institutional collaboration

The work was carried out by a research consortium of five institutions from four countries. The division of tasks between different institutions was quite alike defined in the original study plan (Table 4).

TABLE 4. Division of tasks between different research institutions.

Institution	Role of participant	Further description
Turku	Coordination, environment and site-type survey (geology, floristics)	Geohistory and edaphic properties; the use of natural vegetation as indicator of site edaphic conditions, geoecological mapping
Wageningen	Description and classification of soils	Chemical and physical characterization of soils, soil databases
Wilhelmshaven	Clay mineralogy	Rate of weathering and depositional history of soils
Lima	Monitoring of landuse	Monitoring of colonization using satellite data and GIS; linkage to national authorities
Iquitos	Soil description, landuse methods	Validation of secondary vegetation, experiments for permanent agriculture, soil sampling

Because of this project's multidisciplinary nature, research methodologies can in this connection be presented only in a very general manner. Each scientific discipline had its own methods to be applied, and the general methodology of the total project was in integration of results from different studies. The following gives a general overview of this aspect.

Remote sensing and GIS

The use of remote sensing imageries played a central role throughout this research project. One of the first activities of the institution INRENA (Lima) was to purchase a new Landsat TM (Thematic Mapper) image from the study area and to produce different multi-channel colour composites out of it. Two informative colour composites were processed to hardcopies at the scales of 1: 250 000 and 1: 100 000 and these were distributed among all participants. In later stages of research, digital image processing was continued in collaboration with Turku and Lima.

Digitally enhanced Landsat TM imageries served as the basis for much of the recoinnaissance level interpretation of landscape properties. Further, they served as the principal information source to distinguish naturally separable units in the tropical lowlands under examination, and to plan in a maximally cost-beneficial way for future field research. Satellite imageries were frequently consulted during co-ordination meetings and they also served as an excellent source of inspiration for all scientists of this project (Fig 2).

The other remote sensing materials used in this study include older Landsat MSS and TM imageries which were available in Lima, and SLAR (Side Looking Airborne Radar) imageries and aerial photographs. In the very beginning of this project we made a detailed survey of the availabile airborne photographs from our study area, and a maximally complete coverage of them was purchased for the use of this work. Remote sensing imageries were also used in determination of river channel changes in the floodplain area of river Amazonas.

The features that are distinguishable in remotely sensed imageries represent a combination of features of geomorphology, vegetation and landuse. Some of these features are rather easy to interpret visually by an experienced analyst who has enough field experience from the region. For example deforestation usually appear as clearly separable patches, though they can sometimes be mixed with features of the natural landscape especially in river floodplain areas. In areas of natural vegetation image interpretation is less straightforward because much of the spatial variation that is presented by these imageries have never been documented in the field. As an example the non-inundating lands in different sides of river Amazonas appeared to have different spectral reflectances in the near infrared wavelength of the electromagnetic radiation, yet the ultimate reason for this phenomenon is not known.

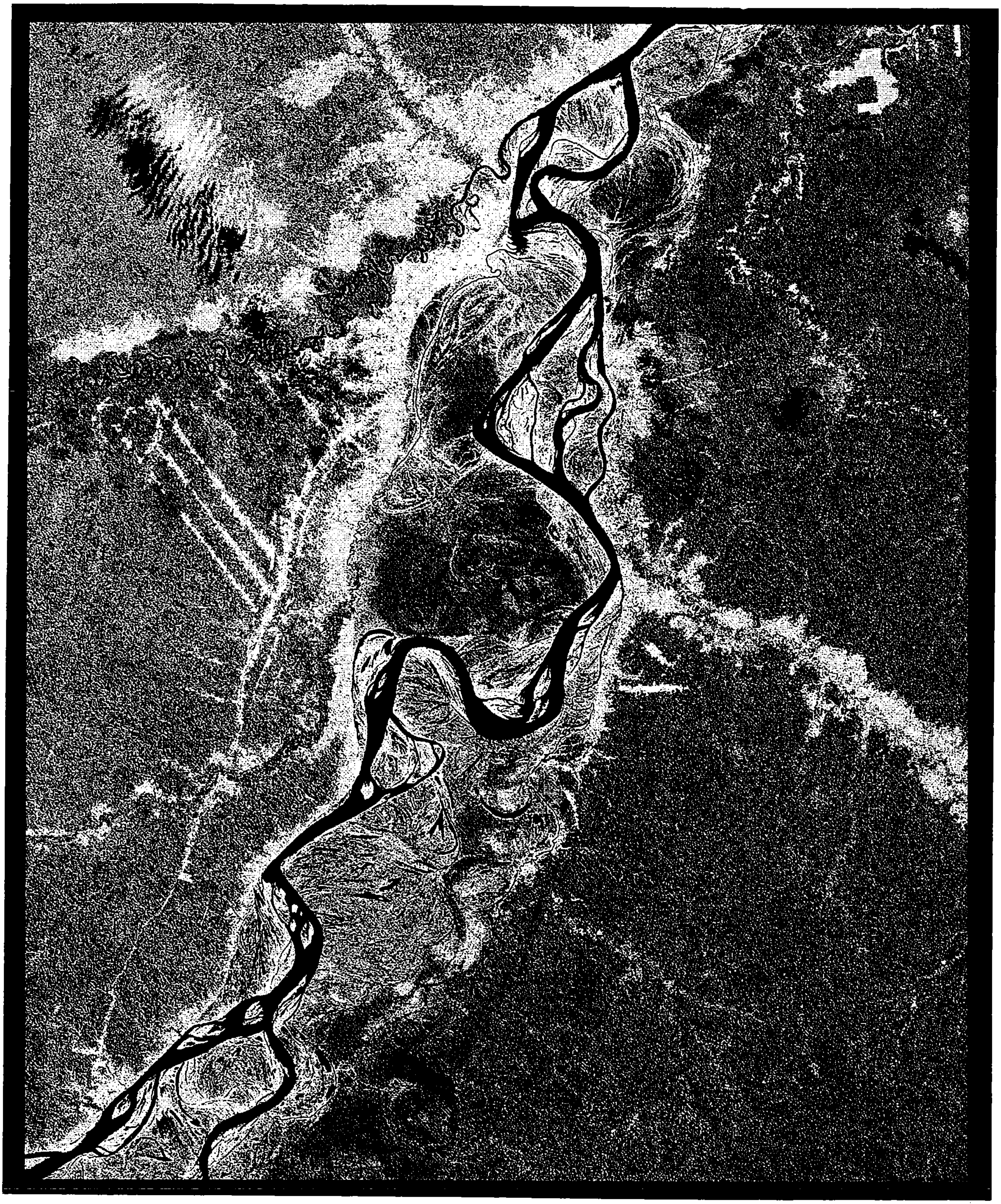

FIGURE 2. Landsat TM image of the study area.

The use of GIS technologies (Geographical Information Systems) intensified toward the latter phases of this research. Most of these analyses were done using the program Arcview-3 for especially the following purposes: preparation of the geoecological map, creating spatial database of field study sites and analytical results obtained from them, and to carry out an analysis of deforestation. This work was done in Lima and Turku, and also Wageningen made a considerable effort in this field.

Field inventories

Geology and pedology

Soils were studied intensively by several scientific teams throughout this research. An intense attention to geological and pedological soil surveys was considered necessary because it was known already prior to this study that the soils of the Iquitos region are highly diverse and unsufficiently understood. Special soil augering equipments were purchased for the use of this project's field research teams.

Scientists from Turku and also Lima described in field conditions the geological structures in order to determine the depositional origins and ages of the parent material. These surveys were usually made in sites where topsoil stratigraphy was clearly visible for at least a few meters deep, either at river margins or along the road Iquitos - Nauta where minor hills had been dug for road construction.

In each site where a detailed stratigraphic survey was carried out, different sediment layers were described in field and samples were collected for standard chemical, physical and mineralogical analyses in Turku and Wageningen. Analyses of clay mineralogy using the X-ray diffraction method were principally made in Wilhelmshaven. In areas where macroscopic fossils were present they were collected for later determination of their species composition.

Pedological soil surveys were carried out using different levels of precision. In Soil Reference sites, soils were opened until two meters deep, and undisturbed soil monoliths were collected for the soil museum at Iquitos (CRISAP, *Centro de Réferencia y Información de Suelos de la Amazonía Peruana*). Also represantative soil samples were collected from different horizons for determination of their physical and chemical composition. Furthermore each site of detailed soil survey were also described in terms of their vegetation and landuse. Soil samples were collected predominantly by scientists from Iquitos and Wageningen, and laboratory analyses were made in Wageningen. The data from these sites were included in national and international soil survey databases.

Additional soil surveys were carried out by doing soil augerings until 1-6 metres deep. Different soil layers were described verbally, and samples were collected from several different layers for laboratory analyses. Most of these surveys were carried out by the team of botanists from Turku as part of their transect studies in areas covered by natural vegetation. The number of sites studied by this means exceeds that of the reference soil surveys described above but their level of presicion is less comprehensive.

Floristics

The floristic (and soil) sampling in areas covered by pristine tropical rain forests were done along 5-m-wide transects by scientists from Turku together with botanists from UNAP. The sites for these transect analyses were chosen to represent the most distinctive natural landscape types in non-inundated areas of this region, as based on surveys of remotely sensed imageries and other relevant information sources.

Within each transect, the preselected indicator plant groups (terrestrial and low epiphytic pteridophytes and Melastomataceae) were recorded for the registration of floristic differences. Both groups are easy to identify and their distribution patterns strongly correlate with those of trees. The two groups are common within the study area and they are diverse enough to show a sufficient array of ecological responses to the different site conditions.

Along the transects, four sample plots 20 m by 20 m in size were established in order to document tree species composition at the site. Soil samples taken within each tree plot down to the depth of at least 1 m to document geological and pedological differences in the substrate. In these plots, all trees with a diameter exceeding 2,5 cm were recorded and measured. In total, 17 inventory transects and 24 tree plots were established between 1994 and 1997 (Table 5).

Table 5. Floristic inventories and soil sampling carried out with EU funding.

Locality	Transect lentgh in metres	no. of 20x20m tree plots	no. of soil samples
Panguana 1	500	4	4
Panguana 2	500	-	4
Puerto Almendras	500	-	3
Treze de Febrero	500	4	4
Ex Petroleros	1300	4	16
San Gerardo	500	-	3
San Antonio 1	1300	4	16
San Antonio 2	500	-	5
Palo Seco 1	500	-	3
Palo Seco 2	500	-	3
Santa Ana	1300	4	9
Libertad Agraria km 8	500	-	3
Libertad Agraria km 3	500	-	3
Tarapoto	1300	4	14
Carbajal	12000	-	12
San Pedro	500	-	3
Siete de Julio	500	-	3
Total	**23200**	**24**	**108**

The botanical voucher specimens were deposited in the herbaria of *Universidad Nacional de la Amazonia Peruana* (Iquitos, Peru), *Universidad Nacional Mayor de San Marcos* (Lima, Peru) and the University of Turku (Turku, Finland). The specimens were identified by comparing them with existing collections at these three herbaria and at several other herbaria in Europe and in the USA. Also many specialists of different taxa gave invaluable help in the identifications.

Monitoring of colonization

The advancement of deforestation was studied using satellite imageries between the years of 1983 and 1995, and by examining air photographs from after 1948. The work was predominantly carried out by Lima.

The interpretation of deforestation was rather clear especially in non-inundated areas because the reflectance of ground cover changes dramatically when forest cover is removed. In areas inundated by river Amazonas image interpretation was more problematic because many natural forms that are created by river channel movements and flood disturbance are often hard to distinguish from man-made forest clearings. In order to avoid errors in interpretation, three small plane flights were made over the region, covering all the major types of deforested landscape.

The interpreted units of deforestation were drawn on plastic at the scale of 1:250 000 and they were later digitized to form a database in Arcview GIS software. As far as possible the type of the original natural vegetation was identified in colonized areas. An attempt was also maid to determine the length of the time that deforested land was used for agriculture - but unfortunately it turned out that this type of survey could not be done well enough due to insufficient spatial resolution of the satellite imageries.

Quantitative assessment of the economical potential of unmanaged fallows

This research was carried out by a rather big team of scientists and field assistants from Iquitos and it included analyses of an array of different sites and also fallows of different ages. The study produced information on the differences among the secondary growths in different site types, and the possibilities to use economically such vegetation that is usually considered to indicate wasteland.

The study plots were 400 m^2 in area and data were recorded from subplots of 5 x 5 metres. In each plot all trees and lianas were identified and their heights and DBH were measured. The possibilities of using these species as producers of timber or non-timber products were investigated, and the realistic commercial value of the standing crop was evaluated.

Experiments of permanent agricultural/agroforestry production

The agroforestry experiment that was founded and monitored with funds from this study was established in an area called San Gerardo (19 km from Iquitos). Only one experimental area was established although originally we thought to make several of them. This was due to insufficient economical resources and also because it was seen that it is more valuable to do one experiment well rather than to divide resources between several unsufficiently studied experiments. On the other hand our data was extended by experiences obtained from agricultural experiments funded by the Caritas organisation, where similar type of agroforestry plots were established in several villages, supervised by Ing. Salvador Flores Paitán who was also in charge of our experiment.

The experimental area in San Gerardo is characterized by nutrient-poor white sand soils, in other words the least possible sites for agriculture in the region of Iquitos. The site was deforested for the first time over ten years before this experiment started and a low-growing secondary forest covered the site at the beginning of this this experiment.

The special innovation of this work was to imitate natural succession by planting such useful plant species that can fill the ecological niches of natural successional species. Also the crop plants were planted differently than what is common, because "seed soil" was put on the bottom of each planting hole by mixing mineral soil with ash and unburned organic material. Also during later phases of work, leaf litter of especially leguminous trees (agroforestry components of the same experimental field), rich in nitrogen, were composted and distributed around the crop plant individuals.

Scientific data were collected by periodic length measurements and by weighting the harvested crop. The experiment will last for at least twenty years, and for this reason only preliminary results can be presented in the present connection. The ultimate goal of this experiment is to enhance the application and acceptance of permanent cultivation methods to replace the common habit of migratory slash and burn agriculture.

RESULTS

Generally, the results obtained from this study confirm the hypothesis that the tropical lowland plains around the city of Iquitos constitute a mosaic of differing landscape units with contrasting site qualities. The following descriptions will give a general overview of these observations, while further information on these aspects can be found from the accompanying manuscript for the book based on this project.

Geoecological map

The preparation of the geoecological map (*Mapa Geoecologico de la Zona de Iquitos, Perú*) was one of the most challenging general objectives of this study. Although the final map has not yet been printed its general contents and layout are finished, and desicions have been made on the use of some new cartographical solutions which are considered to be of interest also in other areas.

Traditional methods of vegetation mapping are difficult to apply in tropical rainforest areas because of the high number of species and poor accessibility of the sites. Many published maps include no subdivisions of this unit or the distinguished classes are debatable. Sometimes several separate thematic maps are produced of the same region; geology, soils, vegetation, hydrology, and so forth. This tradition has been widely applied also in Peruvian nature resource inventories.

A major problem from map user's point of view is that interpreted thematic maps may appear far more finished than is the mapping effort behind them. This is especially so if cartographic tools are chosen misleadingly. For example contrasting colours between different map units suggest major differences between them, and homogeneous map symbols are suggestive of rather even land cover. In the case of the Amazonian lowlands both of these aspects may be problematic: the borders between different land cover units may not be clear in the real world and the units to be separated are not likely to be internally homogeneous.

We chose to use digitally enhanced Landsat TM satellite images as an important tool not only in map production but also in its presentation. Image enhancement is a process that involves the use of colours to visualise maximum amount of the spectral information recorded by the satellite. Various techniques of data manipulation are available; by choice of bands, band ratios and processing parameters this method can be fitted to various purposes. Powerful stretching procedures are needed to distinguish even minor variation in reflectance values because the green canopy layer of a tropical rain forest can be rather monotonous also structurally.

Many types of landscape unit became recognizable from our study area using this method. The colour patches in our enhanced satellite image represent features of natural vegetation, land use, local moisture or any other variation in ground cover. Also the structural image contents such as the shapes, textures and dimensions of differing land units are left unbroken. This feature is especially valuable because it makes it possible to detect previously unknown variation in vegetation within poorly studied areas. Therefore these images can be used directly as image maps by experienced users but they are less useful for those who do not have adequate basic knowledge about the area and may not be familiar with scientific image interpretation.

Our solution was to include both the enhanced satellite image and an interpreted map on the very same map sheet (Appendix 2). We hope to come across three benefits by this means: (1) for inexperienced map user an interpreted map will be available; (2) specialists are given unprocessed information to give them the chance to disagree with our interpretations; and (3) all map users will easily notice that those landscape units we distinguished are not internally homogeneous nor separated by undisputable limits. Our aim thus is to make map making as transparent as possible and at the same time we want to experiment new ways to disseminate scientific information.

The printed map will include more than one dozen clearly different land cover types which are recognizable from both satellite imagery and due to the distinctive floristic composition of their natural vegetation. Moreover the soils of these terrain types are very distinctive, though they may be locally heterogeneous. None of the mapped units is internally homogeneous. In order to provide map users with enough tools to evaluate the representativeness of our field surveys all study sites are marked at their exact locations.

By presentig a cartographic product that is based on three years long research by an international scientific team, and by the use of methodologically transparent cartographic solutions we hope to draw attention to the unsufficient amount of scientific field data from this region even after this study effort has been completed. It is necessary to realize that within the Amazonian lowlands, we are dealing with the most complicated ecosystems on Earth, and far more scientific surveys are needed prior to an adequate understanding on overall environmental gradients and their biological consequences has been obtained. Not to speak about those unknown implications that future land inventories may have on evaluation of sustainability among alternative landuse options.

Geology and soils

Although it is commonly generalised that highly weathered nutrient-poor soils characterise most of Amazonia, at least in the vicinities of Iquitos the spatial variation in soil properties is remarkable. Not only the seasonally flooded soils along rivers are distinctive but also the soils of unflooded areas vary considerably in their origin, age, texture and fertility. These differences can be high even locally and it has been shown that the natural rain forest vegetation is sensitive to variations caused by them.

An important part of soil heterogeneity is determined by geological processes and climate. Our study area belongs to the western part of Amazonia where compressional tectonics provoked by the Andean orogeny is the major landscape forming force. The city of Iquitos occurs near to an underground structure called the Iquitos arch which is subject to relative uplift. In turn the town of Nauta lies next to vast floodplains of the subsiding Pastaza-Marañon foreland basin. Even though understanding these features is far from farmers direct needs it makes it much easier to realise why soil characteristics can vary so much between even adjacent areas.

All soils in Peruvian Amazonia are sedimentary by origin and they have been deposited in a wide array of environments as determined by changes in geology and climate, ranging from fresh-water fluvial to marine or brackish tidal systems. Different sediment provenances are unique in their mineral composition and thus also soil fertility. Marked mosaicism is generally evident for the properties of especially recent or subrecent surficial sediments. In time, these differences level down as weathering turns originally dissimilar sediments more and more alike — but at the same time other soil forming processes add a new dimension to this heterogeneity. The consequence is that even contrasting soil qualities can occur side by side.

It is estimated that within our study area, more than two thirds of non inundated *Tierra Firme* soils are strongly leached Ferralsols and Acrisols. They are very acid and poor in plant nutrients. The rest of the soils may have substantial reserve of plant nutrients due to the presence of non or slightly leached clay in the shallow subsoil.

Five main soil groups are identified, and these are correlated with landform (slope), soil permeability, soil tillage and soil fertility. (I) Slightly leached smectite-clay containing soils (gleyic and dystric Cambisols); (II) Strongly leached kaolinitic-clay soils (Ferralsols and Acrisols); (III) Strongly leached loamy soils (Ferralsols or ferralic Cambisols); (IV) Strongly leached sands (Arenosols and Podzols); and (V) Poorly drained soils, nearly permanently saturated with water, of various textures situated in valleys and depressions, which include peat soils (Histosols) and mineral soils (Gleysols).

A low base saturation and a strong soil acidity expressed by a low pH and an extremely high exchangeable aluminium content are critical properties of most Tierra Firme soils. In view of the low to very low plant mineral nutrient content of both topsoil and subsoil samples, the decomposing organic material covering the mineral soil (litter layer) is the main source of soil fertility and should be included as a potential key property in future soil studies. It is recommended to strengthen research of the local institutions how to overcome these edaphic constraints. It is obvious that the spatial variation in natural soil fertility is clearly reflected both in the yield of cultivated fields and in the species composition and production potential of fallows.

Different forest types

Distribution patterns of selected plant groups of the natural flora (pteridophytes and the family Melastomataceae) were studied in tierra firme by continuous transect analyses both at the local and landscape levels. At the local scale, habitat differences correlated clearly with topography, with the greatest local diversity generally being found in the valleys. At the landscape level, the observed floristic patterns correlated with the above described topsoil properties. Data were collected also on tree species and they show similar responses as the indicator plant groups. Much of landscape level details within the study area are visible in satellite images and can be correlated with those of vegetation.

The pattern of floristic similarities and differences among the separate localities is significantly predictable on the basis of information about soils. Especially the variation in the sum of exchangable bases and soil texture are well correlated with variation in plant species composition. This result suggest that plant species composition and even Melastomataceae and pteridophyte species composition alone can be used as a rough surrogate for important soil characteristics in Amazonian rain forests. This knowledge could be extremely valuable for the purposes of large-scale surveys of land use options in the area, because useful generalisations of soil characteristics can be made without expensive soil sampling. Naturally, though, at finer spatial scales and for more specific purposes traditional soil sampling procedures will still be unreplaceable.

The floristic pattern was also found to be correlated with the pattern of general environmental similarities and differences as expressed by colours of digitally reproduced Landsat TM images. Wave length bands of near infrared had the strongest correlation with floristic variation. Generally, relatively low reflectance values of near infrared radiation was associated with forests growing on relatively nutrient poor soils. This pattern held remarkably well if one treated the western and eastern sides of the Amazon river separately. However, the forests on relatively nutrient rich soils in the eastern side of the river presented similar reflectance values as the poor soil forests in the west. Thus, it appeared that different regions in the study area present somewhat different sets of colours for the same floristic (and soil) units. Satellite imagery can obviously give important information about floristic and soil variation, but only in association with reliable ground checking.

The floristic similarities and differences among different sampling localities as measured by tree species composition can also be reproduced with a fair accuracy using only the information about Melastomataceae and pteridophyte species composition (Mantel correlations between similarity matrices vary from 0.6 to 0.7). This result implies that a reliable floristic classification of rain forest vegetation can be made without the laborious sampling of trees. For studying a defined area, Melastomataceae and pteridophytes require less than one tenth of the sampling and identification efforts of trees.

Floristic similarities and differences among the inventoried tierra firme localities (Figure 3) form two main gradients that can be interpreted very effectively on the basis of general geological and soil characteristics of the sites. Forests on white sand (Varillal seco and Varillal húmedo) is shown to form floristically as well as pedologically a special kind of environment, confirming thus the results of earlier studies. However, a previously unknown pattern was the floristic variation from sites on clayey relatively more nutrient rich soils in Pebas Formation (Tarapoto, Ex Petroleros and Gengen) to sites on poorer and more loamy to sandy soils on river terraces (Momón 1, Manití, Panguana and Mishana).

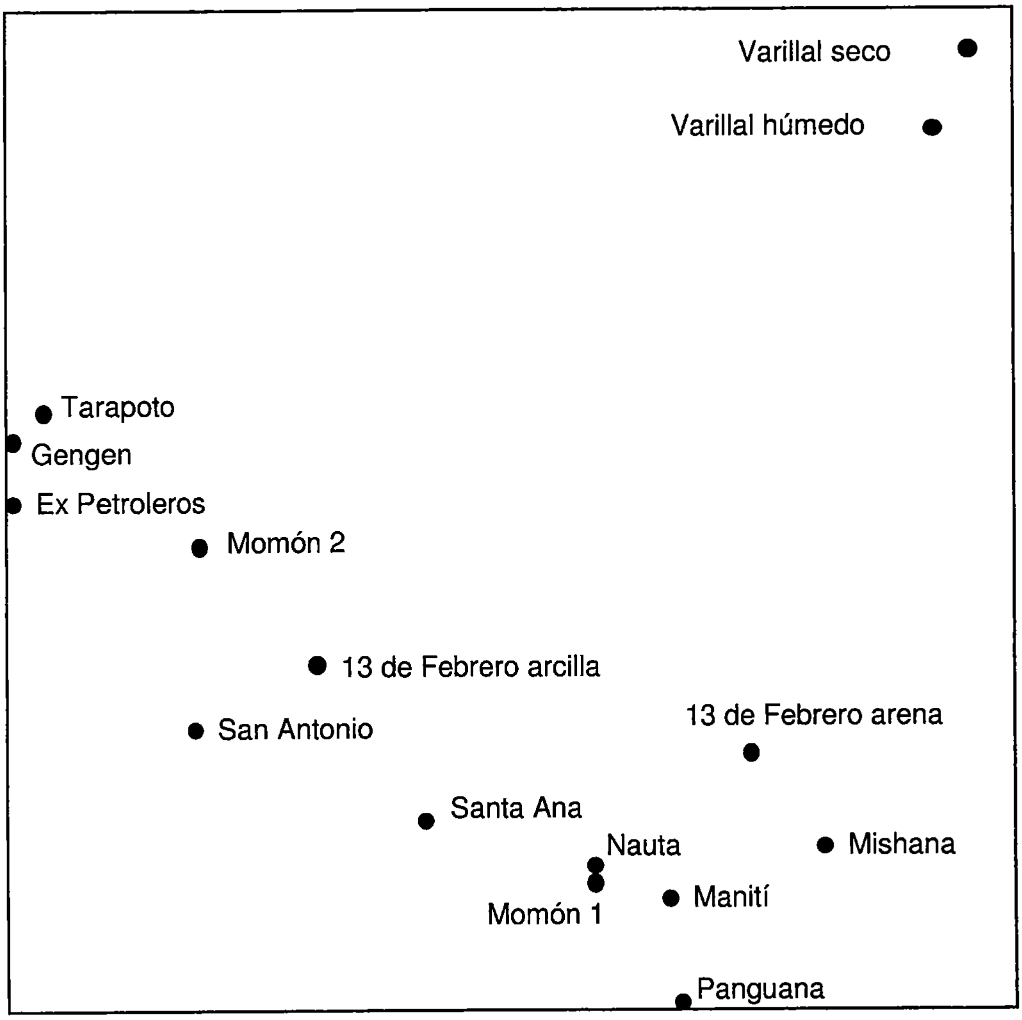

FIGURE 3. Principal coordinates ordination of tree inventory sites in Iquitos area. Site to site floristic similarities measured with Jaccard similarity index.

Together with similar inventories made earlier in the area there are 22 transects and 53 tree plots that will be analysed and discussed for the chapter of vegetation in the Spanish speaking book about Iquitos area. The complete floristic data set includes records of more than 50,000 individuals and ca. 300 species of Melastomataceae and pteridophytes. The number of recorded tree individuals is about 6,000 representing ca. 1,400 species. This data set is probably the largest of its kind in Amazonia, and even though the analyses are not yet fully completed the preliminary results allow many important conclusions.

Land use

Land use monitoring

The first western settlements that lead to the formation of the city of Iquitos were located at lower reaches of river Itaya in the nineteenth century. On the basis of our remote sensing survey, by the year of 1970s only areas close to the city of Iquitos were occupied and deforestation was restricted to the immediate vicinities of riverine villages. This is the early pattern of deforestation in the region. Since that time deforestation has advanced steadily and more systematically from the city of Iquitos to the surrounding areas (Fig 4).

In mid 1970s, a rather curved road was constructed until approximately 20 kms from Iquitos close to such *tierra firme* lands which had already been deforested. By the year of 1983 a new almost parallel road had been opened until approximately 25 km from Iquitos. In Landsat images from the year of 1993 the new road line appears cleared until Nauta, with a rather simply constructed road extending until Ex Petroleros. Also three parallel paths had been made from the main road toward river Nanay. Because of poor quality of roads, cars could enter painlessly only until some 15 kilometres from Iquitos and great difficulties were to be expected in further parts of the road. Most of the peripheral road areas thus remained isolated and poorly populated, although obviously it was hoped that the opening of new terrain for colonisation would secure living of unemployed households.

FIG. 4. Deforestation map of the study area. The gradient of grey values relates to the time of deforestation (from darkest to lighest): 1993-1985, 1985-19889, 1989-1993, 1993-1995.

By far the latest and most decisive period for road construction started in 1995 when a number of new heavy machineries and lorries were introduced for this work. Starting from the city of Iquitos, practically all road sections were built again using quartz sands for their basement, and finally the new road was paved. At the time when our project ended on October 1997, this construction work still continues and it is programmed to be finished by the year of 1999. The bridge over Rio Itaya was constucted in the year of 1996.

Road construction on *tierra firme* clearly started a new era on landuse in the region of Iquitos, because colonisation pressure was introduced to upland forest areas which are especially unsuitable for agriculture. This situation contrasts to the earlier distribution of agricultural lands which had been much more sensitive to local variations in soil production properties. Also large commercial pastures were introduced to the region by road construction.

Currently the new road margins are surrounded by a few kilometres wide deforestation belts at both sides of the road. Land occupation is controlled by regional authorities and therefore deforestation does not advance as freely as an outsider might believe. However, despite of a certain degree of planning, deforestation is likely to accelerate. This is at least the lesson that we learned from our deforestation monitoring effort: land occupation has always increased considerably after new road sections have been constructed.

Economical value of secondary vegetation

The survey made of secondary vegetation on abandoned fields indicates that the secondary successional stands contain trees and lianas with obvious economical potential. Out of the 288 species that were identified in 14 study plots (Table 6), approximately 68% possessed at least some type of use, many of them having several possible uses.

The calculations made for estimating the real economical value of secondary vegetation indicated a considerable potential for especially timber production. However, the authors of this work are well aware that these type of calculations can be problematic because the real market value of any products depend on a number of factors. Detailed calculations should take into account for example the costs of harvesting, transportation and manufacturing.

TABLE 6. Number of families (F), genera (G) and species (S) in different life forms in sites studied for their secondary vegetation in the region of Iquitos.

	Life form																	
Area	Tree			Shrub			Palm			Liana			Herb			Total		
	F	G	S	F	G	S	F	G	S	F	G	S	F	G	S	F	G	S
Magdalena 7	15	20	25	10	15	8	-	-	-	4	4	4	-	-	-	22	39	47
Magdalena 13	12	13	13	3	3	3	1	2	3	2	2	2	1	1	1	17	2	22
Tarapoto 5	14	20	20	5	5	5	1	1	1	2	3	3	-	-	-	19	29	29
Tarapoto 15	17	20	20	7	7	10	1	2	2	2	3	3	-	-	-	23	31	35
Nina Rumi 5	12	13	15	5	5	5	-	-	-	-	-	-	1	1	1	16	17	21
Nina Rumi 13	17	22	23	3	3	3	-	-	-	-	-	-	-	-	-	19	25	26
San Gerardo 7	11	13	14	6	6	6	-	-	-	-	-	-	-	-	-	17	19	20
San Gerardo 14	23	44	50	10	13	15	1	2	2	2	2	2	-	-	-	32	60	68
El Milagro 7	20	31	32	6	7	10	1	1	1	3	3	3	-	-	-	24	41	46
El Milagro 13	17	24	28	11	12	14	-	-	-	3	4	4	-	-	-	27	40	46
Nuevo Horizonte 7	22	26	31	8	11	11	1	1	1	3	3	3	1	1	1	29	41	47
Nuevo Horizonte 13	20	30	32	8	9	11	-	-	-	2	2	2	-	-	-	26	39	45
Nauta 7	10	14	17	8	10	13	-	-	-	-	-	-	-	-	-	14	22	30
Nauta 15	22	28	30	11	14	16	-	-	-	2	2	2	-	-	-	28	42	48

Agroforestry experiment

The agroforestry experiment represents the only experimental study within this project, and due to its special nature it is described in detail separately in appendix 8.

Our experimental area was located on white sand soils where even growth of the native plant species is very slow. Despite poor initial conditions the experiment has shown that through imitating stages of natural sucession by using plants that are different in their growth form, it is possible to have some agronomical production in agroforestry plantations even in this area. However, this area clearly represents a site type that should not be deforested for the sake of agriculture. Pristine white sand areas possess unique floras and faunas but their production potential is very low.

In the area of Iquitos recent road construction has caused that several white sand areas have been deforested and they are to a large extent about turning to only wastelands. The special value of our experiment thus is to show that at least certain production can be obtained even in these conditions by using appropriate agroforestry techniques.

Our experimental field has been visited by a number of local farmers and academic people who have learned to appreciate the value of well planned cultivation activities.

CONCLUSIONS

- The research was made according to the original work plan with most of its activities completed either equally or even more profoundly than originally planned. Several institutions allocated more resources for this work than was foreseen. This became possible through additional funding received from other sources and due to flexible and well motivated attitudes by the participating institutions and researchers.
- Field work in the region was exceptionally extensive and cost beneficial since the selection of sites to be studied was done on the basis of detailed remote sensing surveys. This helped to avoid duplication of work and ensured maximally effective inclusion of different site types in our data.
- The original research hypothesis of abiotic and biotic heterogeneity in the region of Iquitos was confirmed: the soils, the vegetation - and thus also land use options are extremely versatile. Our project was able to determine the mechanisms that have lead into generation of this mosaicism. However, more site-specific studies are needed for any practical efforts of land use planning.
- Our results suggest that it is possible to develop methods for using the same land areas for much longer time periods than what has been customary until now.
- While most of our study concentrated to non-inundating areas, the inundated lands along especially river Amazonas should be addressed in future studies.
- The work has been truly interdisciplinary in nature with intensive interaction among scientits from different institutions and scientific fields. However, because most scientists had also other duties, the living interaction in co-ordination meetings sometimes contrasted with less active correspondence in other times.

PUBLICATIONS

The list of publications includes articles that are direct results of only this project, and those based on very close linkages with also research activities.

The articles that have been written for the final book are not included in this list but are listed in appendix 1.

INRENA 1996. Monitoreo de la deforestación en la Amazonía Peruana. Ministerio de Agricultura, Lima. 35 pp. (partially based on this project)

Jokinen, P., Tuukki, E., Kalliola, R. & Sarmiento, A. 1996: Vegetación en terrenos de diferentes edades en las islas del Alto Río Amazonas, Perú. — Folia Amazonica 8(2): 1-20.

Kalliola, R. & Flores Paitán, S. 1997. Ecological site conditions and landuse options in Amazonian Peru. In: Usó, J.L., C.A. Brebbia & H. Power (eds.) Advances in Ecological Sciences 1. Ecosystems and sustainable development. Computational Mechanics Publications, Southampton, pp. 254-263.

Kalliola, R. 1996. Metsävarojen kestävän käytön mahdollisuudet Amazoniassa. (in Finnish) — Kehitysmaatutkimus — Utvecklingsforkning 5: 53-59.

Kalliola, R., Jokinen, P. & Tuukki, E. (in press). Fluvial dynamics and sustainable development in upper Rio Amazonas, Peru. — Advances in Economic Botany.

Kalliola, R., Tuomisto, H. & Ruokolainen, K. 1996. Areas importantes para la conservación de la selva baja peruana desde el punto de vista geoecológico. In Rodriguez, L. O. (ed.), Diversidad biológica del Peru: Zonas prioritarias para su conservación. GTZ & INRENA, Lima, pp. 127–132.

Linna, A, Ruokolainen, K., and Tuomisto H. 1994. Topsoil properties and plant communities: correlations in closed-canopy rain forest. Abstract book, pp 129-130. 15th World Congress of Soil Science, Acapulco, Mexico 10.-16.Jul.1994.

Linna, A. 1995. Geoecological and sosioeconomic studies in peruvian Amazon. - Geocenter tiedottaa 2: 6-7.

Linna, A., Kroonenberg, S., Räsänen, M. 1997. Are there first cycle quartz-arenites in Amazonia? Manuscript

Poulsen, A. D. & Tuomisto, H. 1995. Small-scale to continental distribution patterns of neotropical pteridophytes: the role of edaphic preferences — Abstracts from the Pteridophyte Symposium "Pteridology in Perspective", Royal Botanical Gardens Kew, July 16-21, 1995.

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Ruokolainen, K. 1995. Corespondence between changes in tree species distribution and satellite image patterns in Peruvian rain forests. — Abstracts from the 6th Symposium on Nordic Botanical Research in the Neotropics, Stockholm, August 1-8, 1995.

Ruokolainen, K. 1995. Floristic and environmental variation in the rain forests of Peruvian Amazonia. Reports from the Department of Biology, University of Turku 50. (PhD Thesis)

Ruokolainen, K. 1996. Ferns and Melastomataceae as indicators of phytogeographic pattern in Amazonia. — Teoksessa Guillaumet, J.-L., Belin, M. & Puig, H. (toim.), Phytogéographie Tropicale: Réalités et Perspectives. Actes du colloque international de Phytogéographie tropicale, Paris, July 6–8, 1993, s. 323-343.

Ruokolainen, K., Linna, A. & Tuomisto, H. 1997. Use of Melastomataceae and pteridophytes for revealing phytogeographic patterns in Amazonian rain forests. — Journal of Tropical Ecology 13: 243–256.

Ruokolainen, K. & Tuomisto, H. 1996. Kasvitieteellinen vaellus: menetelmä Amazonian sademetsäkasviston esiintymispiirteiden selvittämiseksi. — Abstrakti V Kasvitieteen päiviltä (Kuopio, 23–24.5.1996). Kuopion ylioiston Julkaisuja C. Luonnontieteet ja ympäristötieteet 45: 109–110.

Ruokolainen, K. & Tuomisto, H. 1997. Correlation between Melastomataceae and fern species distributions and satellite image patterns in Peruvian Amazonia. — Abstracts from the 7th Meeting on Nordic Botanical Research in the Neotropics, University of Aarhus, 3–8 August 1997.

Ruokolainen, K., Tuomisto, H., Ríos, R., Torres, A. & García, M. 1994. Comparación florística de doce parcelas en bosque de tierra firme en la Amazonia peruana. — Acta Amazonica 24(1/2): 31–48.

Räsänen, M. E., Linna, A. M., Santos, J. C. R. & Negri, F. R. 1995. Late Miocene tidal deposits in the Amazonian foreland basin. - Science 269: 386-390.

Tuomisto, H. 1995. Amazonian rain forests: how studies at different scales help understand a complex whole. — Abstracts from the symposium on The Importance of Spatial and Temporal Perspective for Understanding Vegetation Pattern and Process, Houston, Texas, June 4–9, 1995.

Tuomisto, H. 1996. Habitat diversity and the distribution of species in the rain forests of Peruvian Amazonia. — Teoksessa Guillaumet, J.-L., Belin, M. & Puig, H. (toim.), Phytogéographie Tropicale: Réalités et Perspectives. Actes du colloque international de Phytogéographie tropicale, Paris, July 6–8, 1993, s. 345–352.

Tuomisto, H. 1996. Miten sademetsäekologi päätyy taksonomiksi: *Danaea*-suvun tapaus. — Abstrakti V Kasvitieteen päiviltä (Kuopio, 23–24.5.1996). Kuopion ylioiston Julkaisuja C. Luonnontieteet ja ympäristötieteet 45: 142–143.

Tuomisto, H. 1996. What satellite imagery and large-scale field studies can tell about biodiversity patterns in Amazonian forests. — Abstracts from the 43rd Annual Systematics Symposium, "New tools for investigating biodiversity", Missouri Botanical Garden, October 4–5, 1996.

Tuomisto, H. 1997. How an ecologist gets converted into a taxonomist: the case of Danaea. — Abstracts from the 7th Meeting on Nordic Botanical Research in the Neotropics, University of Aarhus, 3–8 August 1997.

Tuomisto, H. & Groot, A. T. 1995. Identification of the juveniles of some ferns from western Amazonia — American Fern Journal 85: 1–28.

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Tuomisto, H. & Poulsen, A. D. 1996. Influence of edaphic specialization on pteridophyte distribution in neotropical rain forests. — Journal of Biogeography 23(3): 283–293.

Tuomisto, H., Poulsen A.D. & Moran R.C. In press. Edaphic distribution of some species of the fern genus Adiantum in Western Amazonia. — Biotropica.

Tuomisto, H. & Ruokolainen, K. 1994. Distribution of Pteridophyta and Melastomataceae along an edaphic gradient in an Amazonian rain forest. — Journal of Vegetation Science 5: 25–34.

Tuomisto, H. & Ruokolainen, K. 1995. Botanical observations along a long transect across lowland rain forests: a method for verifying large scale vegetation patterns. — Abstracts from the 6th Symposium on Nordic Botanical Research in the Neotropics, Stockholm, August 1-8, 1995.

Tuomisto, H. & Ruokolainen, K. 1997. The role of ecological knowledge in explaining biogeography and biodiversity in Amazonia. — Biodiversity & Conservation 6: 347–357.

Tuomisto, H., Ruokolainen, K., Kalliola, R., Linna, A., Danjoy, W. & Rodriguez, Z. 1995. Dissecting Amazonian biodiversity. — Science 269: 63–66.

Tuukki, E., Jokinen, P. & Kalliola, R. 1996. Migraciónes en el río Amazonas en las últimas décadas. — Folia Amazonica 8(1): 112-131.

ORAL COMMUNICATIONS

Seminars and lectures

During all field research trips to Peru, lectures or seminars have been given by European scientists for different audiences, including at least the following events:

25.11.1994	IV Congreso Nacional de la Ciencia del Suelo, I Congreso Internacional de suelos Huancayo (Linna)
16.12.1994	Universidad Nacional Mayor de San Marcos, Lima (Kalliola)
16.12.1994	Instituto Nacional de Recursos Naturales, Lima (Kalliola, Linna)
19.1.1995	Universidad Nacional de la Amazonia Peruana, Iquitos (Tuomisto)
22.1.1995	Universidad Nacional de la Amazonia Peruana, Iquitos (Ruokolainen)
29.3.1996	Universidad Nacional Mayor de San Marcos, Lima (Tuomisto, Ruokolainen)
18.10.1996	Universidad Nacional de la Amazonia Peruana, Iquitos (Linna)
18.10.1996	Universidad Nacional de la Amazonia Peruana, Iquitos (Kalliola)
26.6.1997	Universidad Nacional Mayor de San Marcos, Lima (Tuomisto, Ruokolainen)
6.10.1997	Instituto Nacional de Recursos Naturales, Lima (Kalliola)

Practically all these presentations have dealt with aspects of geology and soils in the region of Iquitos or in Amazonia in general, and they have pointed out the need to extend scientific field activities to those areas which are poorly covered by currently available data.

As to oral communications in scientific symposia, those congress papers that were mentioned in the above list of publications have usually been associated with an oral presentation.

Education

The project has strengthened the research facilities in all the participating institutions through getting experience of working within an international multidisplinary research consortium. The Peruvian institutions Inrena (Lima) and Unap (Iquitos) have also become familiar with the modern culture of formulating study problems and the use of contemporary research methodologies, while the European scientists have learned from their Peruvian counterparts to appreciate the need to look for practical implications out from their scientific results.

In February of 1996, Risto Kalliola organised a field course in Iquitos for advanced students from the University of Turku, where also scientists from UNAP participated by giving lectures and by proviging field guidance. Another course was held by Hanna Tuomisto and Kalle Ruokolainen for advanced university students of UNAP, with the title of *Curso en Métodos de evaluación e inventario botánico de vegetación Amazónica* (19–23.6.1997).

The STD3 project has also advanced the training of both peruvian and finnish students who have made their master's / engineer's thesis works within this fraimwork. The following works have already been completed:

1995	Eeva Tuukki, Department of Biology, University of Turku
1995	Päivi Jokinen, Department of Biology, University of Joensuu (Finland)
1996	Richer Ríos Zumaeta, Facultad de Ingenería Forestál, Universidad Nacional de la Amazonía Peruana
1996	Alberto Torres Hidalgo, Facultad de Ingenería Forestál, Universidad Nacional de la Amazonía Peruana
1997	Sanna Mäki, Department of Geography, University of Turku
1997	Kai Vuorinen, Department of Geography, University of Turku
1997	Luisa Rebata Hernani, Department of Geology, University of Turku (peruvian student with stipendium to study in Turku)

Two PhD thesis works with clear relation to this STD3 project are currently active in Turku (Ari Linna, Sanna Mäki), while one doctoral dissertation, partially based on this research, has been completed:

Ruokolainen, K. 1995. Floristic and environmental variation in the rain forests of Peruvian Amazonia. Reports from the Department of Biology, University of Turku 50. (PhD Thesis)

Other forms of disseminating information

In addition to academic training, information has also been distributed to a wide array of national and local desicion makers and even local farmers. The project has had inbuilt contacts with the Peruvian natural resource authorities through participation of the institution INRENA, i.e. Peru's national nature resource institution. This linkage has assured a direct and extensive flow of information of this project's findings to such national level processes as preparation of *Mapa Forestal del Perú* (1996), *Monitoreo de la deforestación en la Amazonía Peruana* (1996), and definition of national priorities for nature conservation and biodiversity management.

In the regional level, discussions have been held with a number of local authorities in Iquitos, including the *Gobierno Regional de Loreto* and IIAP (*Instituto de Investigación de la Amazonía Peruana*). Also the participation of the Rector of UNAP in this project has made it easy to communicate directly with local authorities.

In all contacts with responsible desicion makers, our major message has been to stress the need for an improved knowledge of the spatial variation of site properties and production potentials. By this way it will be possible to direct food production and silviculture to those areas where these activities are most productive and least destructive, and to choose the appropriate management practices for each site type. When recommendations are given for the management of the different site types attention should also be paid to the conservation value of the land areas either because of their outstanding biological richness or because of their environmental fragility.

In the local level, a number of farmers and village board members have been informed about the management techniques available to increase the productivity of fallows. This goal is reached through their involvement in experiments of permanent farming systems as described earlier on in this Final Report. These contacts aimed to enhance the acceptance of new agricultural technologies that will extend the time period in which once cleared agricultural land can remain productive.

All the questions treated in this research are relevant not only in the Iquitos region but also elsewhere in the Amazon Basin area. A major dissemination of information for other Amazonian countries is planned to take place through publishing a book in Spanish language in 1998, and possibly also through arranging a symposium along with its presentation.

FINAL STATEMENT

On the basis of all the above information, I have the pleasure to conclude that this research project has progressed according to the original work plan. The project was also characterized by a good and interactive working atmosphere.

The book for Spanish speaking audience, based on this research, is programmed to be published in early 1998, so as the new results of this study will reach Peruvian and international scientists and decision makers, and thus contribute the development of a solid scientific basis for sustainable land use in Amazonia.

In name of the co-ordinator of these activities, I would also like to use this opportunity to acknowledge all the participating researchers and institutions of this project for their valuable contributions during different phases of work. It has been for the most time a great pleasure for me to run this project. Also I would like to acknowledge the EU:s STD3 programme for making this research possible, as well as The Academy of Finland and other additional financiators who supported in a very valuable manner different activities of this research.

In Turku, 1. Of December of 1997

Dr. Risto Kalliola

Co-ordinator

APPENDICES

Folded appendices:

1. List of contents of the book based on this research
2. General layout of *Mapa Geoecológico de la zona de Iquitos, Perú* (with locations of the field inventory sites)
3. Final Report by Turku
4. Final Report by Wageningen
5. Final Report by Wilhelmshaven
6. Final Report by Lima
7. Final Report by Iquitos
8. Detailed report of the agroforestry experiment

Separate appendices:

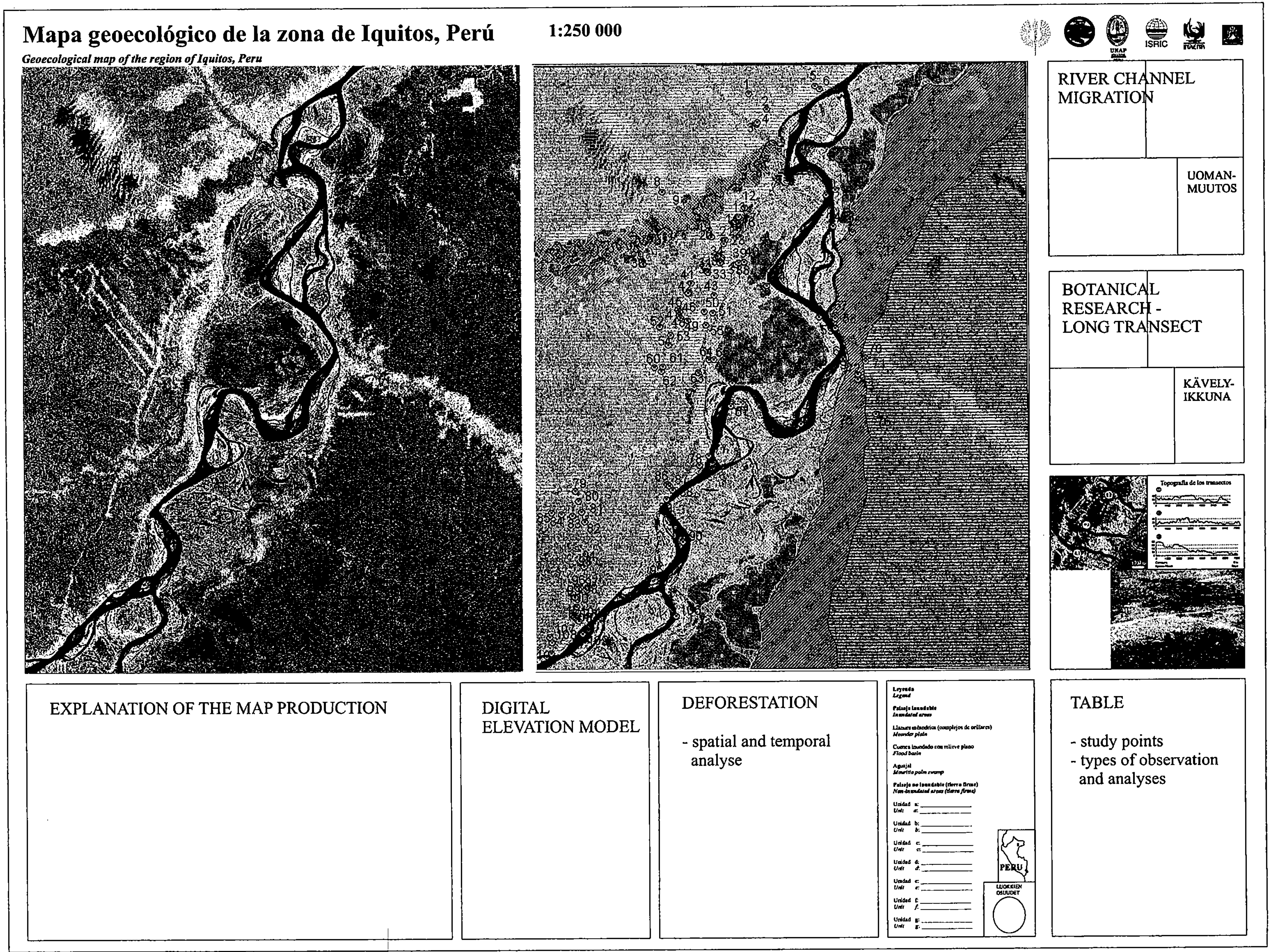
- Manuscript of the book based on this research
- Copies of publications based on / related to on this research

APPENDICES

GEOECOLOGÍA Y DESARROLLO DE LA ZONA DE IQUITOS, PERÚ

Editores: Risto Kalliola y Salvador Flores

General layout of *Mapa Geoecológico de la zona de Iquitos, Perú* / **APPENDIX 2**
(with locations of the field inventory sites)



Final Report / University of Turku

AN INTEGRATED STUDY OF LAND PROPERTIES, THEIR FLORISTIC INDICATIONS AND APPROPRIATE FARMING SYSTEMS IN AN ACKNOWLEDGED BIODIVERSITY CENTER IN AMAZONIAN PERU (TS3 - CT94-0314 (DG 12 HSMU)

The study team in the University of Turku was formed by members of the Amazon project which has activities in the departments of Biology, Geology and Geography. One part of its researchers are university staff members (professors, assistants) while others work with project based financiation as full time researchers. Also graduate and undergraduate students participated.

Generally, the financial basis for activities of the Amazon Project come from different sources (university budget, projects) and several studies are active simultaneously. This situation has lead to an intense interaction among different disciplines.

This STD3 project benefited from the above described situation for several different reasons. All activities of this research were backed by an extensive experience of research in Peruvian Amazonia including field research materials, literature, maps and remotely sensed imageries. The present study also received economical support from other sources. Especially valuable contributions in this connection were funds received from the Academy of Finland, which made it possible that the Hanna Tuomisto and Kalle Ruokolainen have been able to work for three years as full time researchers, with most of their activities related to this study. Also the University of Turku allocated considerable financiation for this study through especially salaries of the key personnel, including that of the co-ordinator.

Approximately half of the economical resources received for of this study were linked to the University of Turku. The most important cost types were due to salaries of one full time researcher (Ari Linna) and those relatiing to the long and frequent field work periods. During field trips, considerable funds were spent to support participation of Peruvian scientists and field assistants. Funds from Turku were also used to cover all arrangement costs of the co-ordination meetings including in several cases international travelling by also other than Turku based participants. Moreover, Turku stood for the costs of some additional work elements also in other institutions.

The three major activities of the University of Turku in this project were Administration, Botany and Geology, yet also remote sensing and GIS analyses as well as other types of geographical and land use surveys were carried out in Turku. While Administration was presented in detail in the Final Report of the total project, the following presents a summary of the other two other main activities, compiled by the responsible scientists Kalle Ruokolainen, Hanna Tuomisto and Ari Linna.

In Turku, 30 of November of 1997

Risto Kalliola
Co-ordinator

Botany

The floristic and soil sampling was done along 5-m-wide transects. Within each transect, the preselected indicator plant groups (terrestrial and low epiphytic pteridophytes and Melastomataceae) were recorded for the registration of floristic differences, and surficial soil samples were taken so as to gain representative coverage of local topographic variation. Along six transects, four sample plots 20 m by 20 m in size were established in order to document tree species composition at the site. Soil samples taken within each tree plot reached down to the depth of at least 1 m to document geological differences in the substrate. In these plots, all trees with a diameter exceeding 2.5 cm were recorded and measured. In total, 18 inventory transects and 24 tree plots were established between 1994 and 1997 (Table 1.). Descriptions of the inventory localities follow.

- Two 500-m-long transects were established in Panguana, on the eastern shore of the Amazon river. The distance between the transects is about 10 km, and they represent the surface between the rivers Amazon and Maniti. In the area there are farms that follow an experimental agroforestry cultivation system supervised by S. Flores Paitán. Tree plots were established in only one of the transects.

- One 500-m-long transect was established at the beginning of the Iquitos-Nauta road, in Puerto Almendras which is the experimental station of the Faculty of Forestry. This transect represents sandy soils, and is situated at a site where all trees have already been inventoried. Therefore, no tree plots were established.

- One 500-m-long transect was established at San Gerardo, km 13 of the Iquitos-Nauta road. This transect represents sandy soils, and is situated in the same area where the agroforestry experiment and inventories of the secondary vegetation will take place. No tree plots were established.

- One 500-m-long transect was established along the road Iquitos-Nauta at 38 km from Iquitos, close to the village of 13 de Febrero. This transect represents the transition area between two topographically different landscapes: towards Iquitos, the landscae is distinctly hilly, and towards Nauta, it becomes very flat and is in general at a lower elevation. The transect represents the slope one of the last hills, and there was a distinct change in soil texture corresponding to topographic position: in the lower parts, the soil was clayey, while in the higher parts, the soil consisted of sandy material.

- One 1300-m-long transect was established at km 48 of the Iquitos-nauta road, close to the village of Ex Petroleros, in an area that represents the low-lying flat surface with clay soils. Detailed soil descriptions were made at the same site, and a monolith was taken.

- One 1300-m-long transect and one 500-m-long transect were established in San Antonio, about 10 km west of the town Nauta. The site represents an area with topography varying from flat to undulating. Detailed soil descriptions, as well as tree plots, were made at the 1300-m transect. The distance between the two transects was about 5 km. In the area there are farms that follow an experimental agroforestry cultivation system supervised by Salvador Flores Paitán.

- One 1300-m-long transect was established in Santa Ana, about 10 km southeast of the confluence of the river Tahuayo with the Amazon. The site represents an area with gently undulating topography and is the closest primary forest to the tree plots established in secondary forests in Magdalena by the team of Tedi Pacheco.

- Two 500-m-long transects were established in Libertad Agraria, about 10 km south of the transect in Santa Ana. The distance between the two transects is 5 km, and the first represents a terrace of the Amazon river, while the second represents gently undulating terrain behind the terrace. Soil samples were collected, but no tree plots were established.

- One 500-m-long transect was established at km 20 of the Iquitos-Nauta road, in Allpahuayo which is the experimental station of IIAP. This transect represents a mixture of sandy and clayey soils, and is situated at a site where all trees have already been inventoried. Therefore, no tree plots were established.

- Two 500-m-long transect were established between km 25 of the Iquitos-Nauta road and the village of Palo Seco at the River Itaya. One of the transect represents loamy soils, and the other one clayey soils. No tree plots were established.

- One 1300-m-long transect was established 5 km north of the village Tarapoto at the Nanay river in an area that represents the low-lying flat surface with clay soils.

- One 23-km-long transect was established in the upper reaches of the Itaya river. Being so long, the transect sampled several kinds of soils and topographies. No tree plots were made, but soil samples were taken every 2 km.

- Two transects were established along Quebrada blanco, a tributary of Tahuayo River. One of them situated close to the village of San Pedro on an old flat sandy terrace of Amazon river. The other transect was established in the vicinity of 7 de Julio, on slightly undulating clayey terrain.

More details on studies of vegetation are presented in the Final Repoprt of the complete project.

Geology

The task has been to coordinate the geology studies and the geology related integrated studies so that common targets could be achieved by combined work and assessments in the field, laboratory methods, working meetings and in developing the informative and scientific interpretations on Iquitos case. The other task has been to introduce a petrographic subdata by studying the mineralogic and geochemical composition of geologic formations in the study area, and to apply this data in description of the original compositional variety and it´s later changes caused by post depositional processes of the surficial sediments in the study area. Ecologically relevant soil parameters have been viewed in the light of the geologic interpretation of the area, and a set of compositional factors have served as a base for vegetation diversification studies in other subpart of Turku run research .

The geologic and soil survey has been actively in common interchange during the project. The surveys have been done in collaboration with Senckenberg. ISRIC, UNAP, INRENA, Leiden University and Turku University Quaternary geology department. The personnel involved have been correspondenly Georg Irion (geology, clay weathering), Sjef Kauffman (soils), Gobert Paredes Arce (soils), Ruben Marquina Pozo and Roque Vargas (soils and geomorphology), Frank Wesselingh (geology, paleontology, outside the officional personnel of the project), Matti Räsänen (geologic processes, outside the officional personnel of the project). The strenghtening of the geology team by interconnecting scientific themes of of Leiden and Turku University Quaternary Geology scientists with the STD-project original themes has been fruitfull by all means, and the Geology sector will form a solid basis for other targets in the project.

To start the project, the Geology part of the proposal was negociated and formulated in the Netherlands and Germany by Ari Linna during his period of WAU stipendiate in Wageningen, the Netherlands 15.9.93-15.3.94 (ISRIC/Wilhelmshaven). General negociations with UNAM and INRENA, the becoming subcontractors in the STD-project, were run by Ari Linna in Peru 25.-30.11.97. Scientific and practical prochedures were adjusted to fullfill interactive approach on Iquitos ecology and ecologic constrains. After approval of the application first work-meeting was held with all participants in Iquitos. Before that the STD-project was introduced to internacional and peruvian scientists in a couple of congresses by Ari Linna. The general procedure in the geologic sector of the project has been:

- First Coordination meeting and field work period in Iquitos 28.11.-9.12.94. Determining the objects of the project with all participants but Wilhelmshaven. Common field work geology-pedology together with the other scientists involved as well to estimate the role of geologic and soil processes around Iquitos and on northern side of river Nanay. Discussions on how to combine different study items to most relevant sites. Primary geologic sampling from the revieved sites, road cuttings, Auger drillings to 2-3 meter depth, Nanay floodplain.

- Second Coordination meeting in Turku 23.-27.8.1995. Representation of preliminary results, and planning the next in closing up field work in 1996. All participants but from Lima. Dr. Matti Räsänen from Turku University Geology Department took part, and the geologic final objects were determined. Prof. Georg Irion from Wilhelmshaven, Germany, had prepared 53 clay and granulometric analyses plus five clay compositional analyses from the Iquitos material collected by Ari Linna and Turku University botany team. These gave promising views in the future use of clay mineralogy to interprete geologic and soil environment by separate weathering evolution on diffrent geoilogic formations. The status of prof. Georg Irion was practically changed from consulting scientist to one of conducting practical works due to his scientific interest in the project. A common field work prochedure was planned with Georg Irion, and a mach of geologic expedition of Matti Räsänen and PhD student Frank Wesselingh from Leiden/Turku Universities to these STD-field inventories was agreed. Participation of UNAP/INRENA scientists was agreed. Location of a geology Master of Thesis field work of Luis Rebata Hernani was agreed to cover areas within the STD-study area around the city of Nauta. The work would start simultaneously with the 1996 Nauta-oriented STD-fieldworks. Matti Räsänen is supervising the Master of Science study of Luisa Rebata Hernani.

- Fourth coordination meeting in Iquitos and field work in the Nauta, Tamshiyacu and Iquitos region. A geology oriented section of work. Description of the sedimentary sequences by Matti Räsänen, collection of the fossils for paleoenvironmental reconstruction by Frank Wesseling and collection of mineral clay and sand samples for description of the weathering sequences in each of the separated geologic formations and units by Ari Linna and Georg Irion. Summarizing the results and stage of work with Risto Kalliola and Flores Paitan. The INRENA team also participated to the meeting event. Profound discussions on the structure in the final book to be published were conducted. A former structure was evaluated and reshaped.

- Preparation of the next coordination meeting to be held at Wilhelmshaven by travelling to the Netherlands and to Wilhelmshaven 17.2.-12.3.97. Gobert Paredes Arce was invited from Belgium to represent the present stage of the work at Wageningen. The resources ISRIC is substituting to the project in the form of man labour by Sjef Kauffman were readjusted in the negociations with the head of ISRIC, Dr. Oldeman. The contribution of soil science to Wilhemshaven was practically not relevant as the data analysing had not been performed to appropriate level. In Wilhelmshaven the weathering related results were treated in the discussions with prof. Georg Irion, and the practical matters related to coordination of a becoming meeting were handled.

- Representation and discussions over STD soil themes in a international conference on podzol soils in the Geologic Survey of Finland, Kuopio 25.3.-26.3.97. E.g. Dr. Dominique Righi from Poitiers University, France, was present.

- Fifth Coordination meeting in Wilhelmshaven in April 1997. Representation of the results and different chapters in their present stage. Analysis of the rest of clay minerals (Georg Irion, ISRIC) available, as well the modal counts of the separated sand fractions by Ari Linna. Both results were included in the geology chapter in the form of interpretation of geologic variety and weathering. The results from the works of Matti Räsänen, Frank Wesselingh, Luisa Rebata Hernani, and Roque Vargas and Ruben Merquiza Pozo had been also incorporated to formulate a synthesis on Geology. Matti Räsänen, in responce of the geologic processes, had worked since the field work period in 1996 as a first author for geology chapter. A new chapter to represent intermixed relations in geology and soils was planned to be made still in the book.

- Turku University Geology laboratory clay analysing facilities were activated by conducting M.Sc Marjaana Stedt to work on clay separation and preparate manufacturing during 5.5.-1.9.97. A visit to Senckenberg laboratory was arranged, and Marjaana Stedt visited Wilhelmshaven during 9.-15.6.97. A total mach with Senckenberg analyses was not achieved due to lower intensities in Turku laboratory XRD-analyses.

- Sixth Coordination meeting in Turku 15.-20.7.97. Main focus on geology and soil chapters, and how to proceed in finalizing them. Gobert Paredes Arce, not present at last meeting in Wilhelmshaven, took part. Geology chapter was most advanced, and about75% was ready. The character of interdisciplinary chapter on geology and soils to was discussed, and the chapter was decided to be prepared by Ari Linna et al. Prof. Georg Irion brough a silica standard for XRD, and besides a cross-analysed kaolinite sample was used to evaluate the functionalism of Turku XRD. Analyses were seen to be worthless untill the intensity of the peaks has been lifted. In the end of the year the decision of service for the machinery has been done. The availability of clay analyses from ISRIC and Senckenberg for STD-project has however covered the basic need, even surpassed the original plan.

Sampling and analyses:

Geologic sampling was partly based on old collections performed in context on earlier work in the area, but the major part of data was got from the sampling planned and done in this project. Satellite images and common field work periods were used to determine different geologic formations, and sampling was focused to cover those. Not all the surface area could be covered by sampling - this was a time and resource related question, and it had been expressed as such as one of the study aspects. The aim was to interprete the area by using a rationally selected set of study sites, and extrapolate the interdiscliprinary interpretation to remote and logistically difficult sites. The major question, can the ecologic patterns follow geologic and soil patterns, was involved by making vegetation studies equally on different geologic formations - to a certain degree at the same study plots.

For full geologic history, and studies on weathering of the different geologic formations, geologic sampling was extended from the soil reference sampling and botany study sampling sites to locations, where deep cuttings (profiles) crossing the sedimentary layers were accessible. Artificial cuttings were met along the road under construction between Iquitos and Nauta, specially towards Nauta, and along the river in the riverbanks when the river eroded Tierra Firme at either edge of it´s floodplain area.

Altogether about 150 clay analyses (Senckenberg, ISRIC) and 119 modal counts on sand mineralogy were done. Modal counts were made from a wet sieved 63-500 micron sand fraction to avoid the major effects of fluvial sorting on mineralogy, and to be able to make areal comparisons. 102 samples were stusied from Tierra Firme sediments and 17 from the floodplains in the region, and surroundings (floodplains for Amazon, Marañon, Nanay, Tigre, Pastaza and Napo rivers). The samples were prepared to thin sections which were studied under the polarizing microscope. 600 to 700 grains were calculated for each of the samples to get the mineralogic composition.

Results:

The present study showed some analogous results with the earlier ones from the region. The Iquitos sand unit and Pebas formation were rerecognized, but the depositional environment and characteristics of Pebas formation were fixed in a more accurate way by sedimentologic and paleontologic analyses. The sedimentary structures revealed besides that lacustrine Pebas formation changed via mediatory tidal phases into fluvial systems of "Nauta" type. For most this interpretation made by Matti Räsänen could be verified by paleontologic control (Frank Wesselingh). Petrographic studies showed that this evolution was with harmony of the evolution of the Andean mountain front, and that the source of the sediments had been since Pebas-times from the Andean direction. Sand mineralogy was increasing in maturity (quartz) in the sequence from Pebas towards more recent Tierra Firme deposits, which increase results from tectonic uplift of the Andean foothill areas exposing new parts of the former sedimentary basin to weathering, erosion and recycling prosesses. The primary andean immature material gets increasingly diluted by weathered lowland Tierra Firme material through it´s geologic history (eastward migrating andean tectonism) and the further the site is located in the lowlands (proportionally more weathered surface area involved in material releace). Clay mineralogy (by Georg Irion) revealed two different geologic environments to occur side by side in the area. The anomalously smectitic Pebas formation and the kaolinite rich tidal to fluvial sediments deposited on the top.

The weathering sequences were studied in detail from the deep profiles sampled year 1996. Their evolution was described and interpreted both using sand and clay mineralogy. The homogenization of the primary composition in the weathering, and the different "paths" in the weathering for different geologic formations were documented. Pebas formation, although the oldises formation in the area, was the least weathered one due to various reasons, It lies lowiest in the stratigraphy, and is exposed fromunder the covering sandier deposits just after the tectonic uplift of the crystalline basement and start of erosive processes to work on the sedimentrary sequences. Then it´s fine texture makes permeability low, which slows down or prevents the weathering reactions. In Pebas weathering covers the top meter or the topmost few meters (smectite changing into kaolinite, amount of feldspars reduced). In the coarser tidal to fluvial deposits weathering exceeds even 50 meters depth, and feldspars changed into secondary kaolinite minerals are frequent. Also mica minerals (illite) change into secondary kaolinite and/or Aluminium chlorite, the end products of weathering in most of the Iquitos and nauta study areas. Gibbsite clay is locally met in the Iquitos white sand unit, but it´s occurrence develops just in the case of excellent drainage in the lack of fluvial overbank facieses.

The ecologic relevance of the sands is in the primary heritage of different elements which can serve as nutrients (or be toxic) for flora. Different minerals bear varied elements in varied proportions, and weathering is reducing these reserves by substituting them through ion exchange reactions (e.g. change with H^+ from water) to the use of flora. This release of nutrients happens mostly however via the surfaces of the clays, and their quality tells more directly of the actual nutritative stage of each site. The amount of available nutrients was seen to be fixed to the quality in clay, the amount of Aluminium (toxic in great amounts) was following the acidity in the formation. Pebas, and related clays had the primary composition even close to the Andean lithologies, and the Iquitos quartz sands had extractable nutrient reserves just a fifth part in comparison to andean values. The amount of extractable bases, the ions of Na, K, Ca and Mg could be 100 times of thet in the sandier deposits of other formations in the Iquitos region, and quite commonly ten times higher. A formation with kaolinite and Aluminium-chlorite could show even a nil value for extractable bases.

EU/STD3 PROJECT No. TS3*CT-940314

An integrated study of land properties, their floristic indicators and appropriate farming systems in an acknowledged biodiversity centre in Amazonian Peru

FINAL REPORT

International Soil Reference and Information Centre (ISRIC)
Period: 1 November 1994 - 31 October 1997

The final report of ISRIC includes an account of the following:

1. ISRIC tasks
2. Logistic support by ISRIC
3. Soil analyses by ISRIC
4. Participation in four Workshops
5. Preparation and analysis of the dataset
6. Chapter "Soils of the Iquitos region"
7. Conclusions and recommendations

The consolidated Cost Statement, prepared by ISRIC's administration, has been sent to the Turku University.

1. ISRIC TASKS

The following main tasks for ISRIC are indicated in the technical annex of contract EU/STD3 PROJECT NO. TS3*CT-940314. The chemical, physical and mineralogical analyses of 150 soil samples at ISRIC soil laboratory. The involvement of one ISRIC staff member in various project activities: i) participation in four Workshops in Iquitos, Peru and Turku, Finland, ii) advise in the field observations of the soil profiles and in the correlation of these according to international standards, iii) description and classification of soils, and iv) preparation of project publications.

2. LOGISTIC SUPPORT BY ISRIC

Period
January and February 1995.

Objective
Purchase and sending of equipment and manuals on soils description and classification.

Summary
Manually operated soil auger equipment suitable for soil observations in remote areas in the forest was selected, ordered and sent to the project team in Iquitos. Field manuals on soil description and classification were sent to all project parties involved.

3. SOIL ANALYSES BY ISRIC LABORATORY

Period
Main period of soil laboratory work: June - September 1995, September - November 1996 and February - March 1997. Outside this period some additional verification and repetition work of selected samples was carried out.

Objective

Chemical, physical and mineralogical analyses of the 158 soil samples taken by the botany team of the Turku University, the soil scientist of UNAP, and samples taken during the field visits by project members participating in two workshops in Iquitos.

Summary

ISRIC received two series of soil samples which were taken by several project members during fieldwork in 1995 and 1996. The first batch consisted of 60 samples, which were analyzed in 1995 and the second batch comprised over 200 samples of which a selection of 98 samples were analyzed in 1996/1997. In addition, in 1997 some analyses were performed on selected samples of an alluvial soils study of the Amazon river, for which field work was executed in 1991.

The following analyses were carried out with a brief indication of the analytical procedures. For details of these procedures reference is made to ISRIC's laboratory manual (Van Reeuwijk, 1995).

- Soil reaction (pH-H_2O in 1 : 2.5 soil-water solution, and pH-KCl likewise in 1 *M* KCl solution)
- Organic carbon (Walkley-Black procedure)
- Sum of exchangeable bases (percolation with 1 *M* ammonium acetate buffered at pH 7)
- Exchangeable Acidity, calculated from the sum of exchangeable hydrogen and aluminium (extraction with 1 *M* KCl)
- Cation Exchange Capacity (CEC), percolation with 1 *M* ammonium acetate buffered at pH 7
- Calcium carbonate determination according to Piper's rapid titration method
- Iron and Aluminium extractions with dithionite/citrate, acid oxalate, and pyrophosphate respectively.
- Phosphate (Bray I method)

Physical characteristics

- Particle-size analysis. Sand was determined by sieving. The silt and the clay fractions were determined by pipetting from a sedimentation cylinder.
- Soil moisture retention data were obtained from undisturbed core samples equilibrated with water at various tensions. The following parameters were derived: a) Bulk density; b) Potential Rootable Pore Volume, calculated as pF 0 - pF 2.0; and c) Potential Plant Available Moisture, calculated as the amount of water held between pF 2.0 and pF 4.2.

Mineralogical characteristics

Clay mineralogy was analyzed using a diffractometer and results are presented in semi-quantitative classes, from class 0 indicating absence of a specific clay mineral up to class 8 which indicates a very high content. At the request of the Turku team geologist some additional determinations were carried out (free of charge), which included X-ray fluorescence determination of major and trace elements. On the request of the soil scientists clay mineralogy and a few standard determinations were carried out on 10 alluvial soil samples (also free of charge) .

Reports of the analytical results were dispatched to project participants in August 1995, in December 1996 and the remainder in 1997. On several occasions, advise and comments on the interpretation and the accuracy of results were given.

4. PARTICIPATION IN FOUR WORKSHOPS

Period

Six workshops were held during the project period. One ISRIC staff member participated in four workshops: First workshop 27/11 - 10/12/94, Second workshop 24 - 27/8/95, Third workshop 5 - 17/1/96 and the Sixth workshop 15 - 18/7/97. The total time of the ISRIC staff member devoted to these four workshops amounts to two months, which includes preparation time and back-to-office reporting.

Objectives
The workshop objectives included: i) planning and reviewing of the schedule of activities, ii) participation in multi-disciplinary field trips in the Iquitos region, ii) presentation and discussion of intermediate results, iv) discussions on chapters of the book "Geo-ecologia y desarrollo de la zona de Iquitos, Peru", and v) discussion on chapter 5 "Soils of the Iquitos region".

Summary
Here the main activities of ISRIC staff member are summarized. For more information the reader is referred to the Workshop Summaries and ISRIC Travel Reports made for each of these workshops.
The First workshop in Iquitos included the drafting of a detailed workplan and a five days field trip of the project team along the Iquitos - Nauta road and to some sites in the margin areas of the Nanay river. Field observations of soil exposures in road cuts, quarries and some soil augerings revealed a great variation in soil textures. At the end of the workshop the "Centre De Referencia de Suelos de la Amazonia Peruana (CRISAP)" was inaugurated. This centre houses a first collection of specially prepared soils of the Peruvian Amazon. The collection will be expanded with some soils studied by this project.
The Second workshop was held at the Turku University and included a presentation of intermediate results by all participants and the drafting of the contents of the planned edited Spanish book as final product of this project. Printed analytical results of ISRIC's laboratory were distributed and reviewed during the workshop. The majority of the sampled soils is very acid, with a (very) low base content, a medium or high CEC, and a (very) high exchangeable aluminium content. A minor portion of some deeper subsoil samples present a completely different picture. These samples have a neutral soil reaction, a high exchangeable bases content, no exchangeable aluminium and a very high CEC. The latter samples are directly associated with soils formed in Pebas clay (Tertiary brackish water deposits), which is found at depth in large areas in the Amazon region.
In view of these very contrasting pH values, an easy to use field pH meter was handed over to the UNAP team to be tested in field conditions. In case of failure, the use of easy-to-use indicators such as Hellige Truog was recommended.
The Third workshop was held in Iquitos. Three days of the programme included presentations of the progress by all participants, discussion on the second draft of the "Geo-ecological map of the Iquitos region", drafting of a framework for the book in Spanish for a wide group of users. The workshop office sessions were followed by 6 days of field visits. A day's visit was made to the Agro-forestry field experiment in sandy soils near Iquitos and terraces of the Rio Itaya. A wide variety of annual and perennial crops has been planted. Remarkably good growth was observed for nearly all crops in the yellowish sandy soils with low plant nutrient level. Soil of the terraces of the Rio Itaya area are clayey with a sticky consistency and probably with a much higher fertility in comparison to dominant soils of the Tierra Firme land unit. During three days abandoned agricultural fields, locally know as "Purmas", were visited in the area between Iquitos and Nauta. Auger observations till 3 to 4 meter depth were made and soil samples taken. The project area consists predominantly of clayey soils, which varies considerably from light to very heavy clays. In most sites the clay content increases with depth. Most clayey soils are extremely acid with a high exchangeable aluminium content (Ferralsols, Acrisols, and Alisols). However, a part of the soils, especially those with a very high clay content, most probably derived from a Tertiary lacustrine deposits ("Pebas" formation), have still a high plant nutrient content (Cambisols, Luvisols and Gleysols) and show a greater agricultural potential than the poor acid soils. The distribution of the Pebas formation at or near the soil surface is not well known, because this formation is covered by a relatively thin cover of Quaternary alluvial deposits.
The methodological weakness of "Loss on ignition" method to determine organic matter was repeatedly explained. Except for one site, which was not accessible by road, all soil reference profiles which were described by UNAP's pedologist in 1995, were visited and reviewed. Improvements were mainly restricted to the interpretative part of the profile descriptions such as horizon notation, soil classification and land evaluation. Soil samples taken during fieldwork activities were split for analyses at ISRIC and Turku University.

The Sixth workshop included plenary sessions on the chapters of the book "Geo-ecologia y desarrollo de la zona de Iquitos, Peru". A provisional draft text of chapter 5: "Soils of the Iquitos region" was distributed for comments to the workshop participants. The newly developed main soil groupings and the "single value" maps correlated well with the findings of the geologists and the botanists. A number of recommendations were made for the finalization of the english text for soil chapter 5, which included: i) incorporate information of Alluvial Floodplain soils, ii) finalize descriptions of the Tierra Firme main soil groups, iii) make interpretations of the 'single value' maps, and iv) incorporate information of available soil survey reports.
It was decided to make a separate chapter "Geo-ecology and pedology" and to publish the basic data set of field and laboratory work of the botanists, geologists and pedologists. These data will be accommodated in a second volume, because it requires a substantial number of pages. The different uses of units and classes by biologists and soil scientists of exchangeable cations, sum of bases and CEC were discussed.

5. PREPARATION AND ANALYSIS OF THE DATASET

Period
Time spent by ISRIC soil scientist is two months in 1996 and 1997, and about 2 weeks of ISRIC GIS officer.

Objective
Collection and review of available documentation of soil surveys earlier carried out in the Iquitos region. Verification of the database information, and statistical and GIS analysis of this information.

Summary
The collection of available soil studies, executed by various parties, took substantial time because some reports could only be copied from private collections. These soil surveys comprises over 300 soil observations with analytical results. It appeared that a considerable part of these soil observations are without location information of the sampling sites. During the project period a request was made to INRENA for this information, however, so far without result. Analytical information of non-geo-referenced soil observations were put in a spreadsheet for general statistical analysis. The geo-referenced soil observations, specifically made for this project and information from one earlier published study, were stored in the ISRIC Soil Information System database by UNAP's soil scientist. In addition to extensive correspondence, the soil scientists of UNAP and ISRIC had two meetings at ISRIC to verify the location of the soil sites on the GIS prepared basemap, the contents of the database and the classification of the soils according to international systems. Several key soil variables were studied statistically and results were presented in figures and single value maps. ArcInfo was used for the preparation of a location map and these single value maps. ISRIC assisted also the geologists in the preparation of the geology and geomorphological map.

6. CHAPTER "SOILS OF THE IQUITOS REGION"

Period
Time spent by ISRIC soil scientist amounts to 2.5 months in 1997.

Objective
Preparation of chapter 5: "Soils of the Iquitos region".

Summary

The GIS analysis of the dataset presented a series of "single value" maps of key analytical soil characteristics of the two main land units: the Alluvial Floodplain and the non-flooded uplands, further referred to as *Tierra Firme*. An easy-to-use soil grouping system was developed, aiming at a recognition of the main soil types in the field and giving adequate correlation with essential soil and land variables. Classification of the soils of the reference soil profiles were made according to FAO's and USDA's soil taxonomical systems. Basic data were presented in various figures and statistical diagrams. Land evaluation included a qualitative assessment of the soil data and the consultation of recent literature of acid soils, agro-forestry and plant-soil relationships of acid soils in the tropics. A provisional text of chapter 5: "Soils of the Iquitos region" was discussed at the Sixth workshop in Turku, Finland. Recommendations made during this workshop were included in the final version of the english text and the accompanying figures. This text was distributed to project participants in November 1997. It is expected that a spanish translation of chapter 5 will become available in the beginning of 1998. Major findings and recommendations of the soils study include the following.

The soil studies earlier carried out in the Iquitos region contain a wealth of field and analytical information, which is not yet fully exploited. As a follow-up action it is recommended to search for exact location information of the over 300 soil observations made for these soil studies at the Instituto Nacional de Recursos Naturales (INRENA, formerly ONERN) in order to produce a more detailed updated soil map.

Alluvial deposits of various geological periods are the parent materials of the Tierra Firma soils. It is estimated that over 95% of these soils are strongly leached, very acid, and poor in plant nutrients. Less than 5% of the soils have a substantial reserve of plant nutrients, due to the presence of non or slightly leached clay in the shallow subsoil. These soils have a better agricultural production potential, however, land management requires attention because of the high level of toxic aluminium and the imperfectly drainage conditions.

Well drained Ferralsols and Acrisols, the dominant soil group of the Tierra Firme area, have rather similar key characteristics. The separation is based on a gradual non-significant increase in clay content with depth. Soil studies should be based on key soil characteristics, reflecting the bio-physical functioning of the soil, and should not rely only on a soil taxonomic approach. As a first step a practical subdivision of these soils is proposed according to dominant textures and dominant clay mineralogy.

To direct further soil research and land management five main soil groups are proposed for the Tierra Firme land unit, which are correlated with landform (slope), soil permeability, soil tillage and soil fertility. I. Slightly leached smectite-clay containing soils (gleyic and dystric Cambisols); II. Strongly leached kaolinitic-clay soils (Ferralsols and Acrisols); III. Strongly leached loamy soils (Ferralsols or ferralic Cambisols); IV. Strongly leached sands (Arenosols and Podzols); and V. Poorly drained soils, nearly permanently saturated with water, of various textures situated in valleys and depressions, which include peat soils (Histosols) and mineral soils (Gleysols).

A low base saturation, a strong soil acidity expressed by a low pH and an extremely high exchangeable aluminium content are critical properties of most Tierra Firme soils. It is recommended to strengthen research of the local institutions how to overcome these edaphic constraints.

It is concluded from our soil observations that the silt content in Tierra Firme soils is not a good indicator of soil fertility. The silt content is probably a good indicator for physical properties, such as permeability and erodibility.

Major soil group V, the "white" sands, are the most fragile soils from the viewpoint of soil fertility and should be kept as forest reserve. These sands require further research to understand its origin and geographic distribution.

In view of the low to very low plant mineral nutrient content of both topsoil and subsoil in the studied dominant soils, the decomposing organic material covering the mineral soil (litter layer) is the main source of soil fertility and should be included as a potential key property in future soil studies.

From our soil observations it is postulated that humified organic matter in mineral Tierra Firme soils is practically inert in its role of releasing and retaining plant nutrients, which is contrary to generally accepted assumptions. It is recommended to further study the various types and fractions of soil organic matter.

It is recommended to make soil observations in the vast central parts of the Tierra Firme land unit, which lacks at present field observations. Essential information on the presence of non or slightly leached soil parent material should be collected. For this purpose standard soil observations should be made minimally to a depth of 2 meters, and for selected sites, to include deeper subsoil observations. The latter can be made with hand-operated soil augers up to a depth of about 5 meters.

It is recommended to investigate the need for applications of soil micro-nutrients such as sulphur, boron and zinc.

The use of trees in land use systems should be maximized in order to mimic the plant nutrient cycling mechanism of the tropical rain forest.

The small area of relatively fertile soils of the Tierra Firme (clayey Cambisols) and the larger area of fertile soils of the Alluvial Floodplain (Fluvisols) have fewer constraints from soil fertility point of view. Considering the persistent edaphic constraints of the low-fertile soils of the Tierra Firme, these fertile soils covering a smaller area, should attract the attention of the government and farmers for use in highly productive sustainable agricultural systems.

In addition to this soil study, which highlighted soil qualities and edaphic constraints, it is recommended that future land use plan studies should incorporate aspects of land use systems, land tenure legislation, infra-structure and marketing.

7. CONCLUSIONS AND RECOMMENDATIONS

In addition to the technical conclusions and recommendations given in section 6, generally ISRIC experiences its involvement in the project as challenging and interesting. It is trusted that the project outcome will contribute to an ecologically and economically sound management of soils of the Iquitos region.

The activities carried out by ISRIC surpasses the originally planned ones. These includes the free-of-charge additional analytical work by ISRIC laboratory and an extra two and halve months of ISRIC's research staff, which was required in the final stage of the project to prepare the chapter "Soils of the Iquitos region".

ISRIC considers the multi-disciplinary cooperation as very fruitful. Yet, a few recommendations are made for an envisaged future follow-up:

- to emphasize interdisciplinary work by forming multi-disciplinary sub-teams, being responsible for integrated activities (e.g. correlation of floristic composition and soils, geology and soils, etc.).
- to critically review information of earlier studies prior to designing further fieldwork
- the use of standard procedures for the numbering of field sites and soil samples.

ISRIC, Wageningen, 21 November 1997

J.H. Kauffman

Activities in project TS3*-CT94-0314.
Nov. 1994 to Oct. 1997

Forschungsinstitut Senckenberg, Abteilung für Meeresgeologie, 26382 Wilhelmshaven/Germany

Our contribution to the EU-project TS3*CT940314/DG 12 HSMU was, beside the scientific elaboration of the results, primarily marked by laboratory work. We separated from the samples the different grain-sizes ($<2\mu$m, 2-6μm, 6-20μm, 20-63μm, 63-90μm, 90-125μm, 125-500μm). The grain size $<20\mu$m were separated in settling tubes according their different settling velocities. The grain-size >20 was separated by sieves. A total grain-size analyse requires 10 days but it is possible to do 20 grain-size at the same time.

Since, in geological point of view, the most active grain-size is the $<2\mu$m fraction (clay fraction) our further investigation concentrated on this fraction. The $<2\mu$m fraction has been subjected to x-ray diffractometer analyses. With these analyses it is possible to determine the minerals by measuring the lattic distances of their crystal structures. The most important minerals in soils are the clay minerals. Their development along soil profiles shows the intensity of weathering and gives hints of the quality of geological formation from which the soils have been formed from. Most important are the clay minerals, which are generally the dominant compound of the $<2\mu$m fraction. But in lowland tropical soils some less distributed but very specific minerals occur as well in the $<2\mu$m fraction. These is are mainly the titanium minerals rutile and anatase, the iron minerals goethite and hematite and the aluminium mineral gibbsite. Due to the importance of the $<2\mu$m fraction in all samples we have subjected to grain size anlyses, the clay minerals have been determined. Additionally, from many samples x-ray diffraction patterns of the $>2\mu$m fractions have been established. In these fractions most important are quartz and feldspars. Ari Linna has determined as well the quartz and feldspar contents of the samples. But he has done his analyses by means of microscopy which allows the very important alignment of our methods.

To establish the analyses of the clay minerals in the $<2\mu$m fraction requires the following laboratory work: preparation of the specimen, treatment by magnesium-acetate, potassium-acetate and by ethylenglycol. Three specimen have to be subjected to x-ray analyses. For one sample it is necessary at least 2 hours of laboratory work.

Additionally to the x-ray analyses chemical analyses have been run in the $<2\mu$m fraction of some samples. Most of them have been run in the laboratory of the University of Oldenburg. The elements silicon, titanium, aluminium, iron, manganese, magnesium, calcium, sodium, potassium, phosphorous, arsenic, barium, cesium, cobalt, chromium, copper, molybdenum, niobium, nickel, lead, rubidium, strontium, thorium, uranium, vanadium, ytterbium, and zinc have been determined by means of x-ray fluorescence (XRF).

All together there has been analysed about 250 samples by the above mentioned sedimentological methods. XRD-analyses have been established from $< 2\mu m$ fractions of 31 samples.

We have got the first samples for analyses on January 1995: until June 1995 it has been in total 76 samples. Most of the samples were from places along the northern section of the Iquitos-Nauta road; some have been taken from the banks of Nanay River. All samples have originated from intensively developed weathering horizons. The results of the clay mineralogical analyses showed that there is a distinct separation in two directions. One is the result of extreme alteration of the parent rock, only quartz is preserved and predominantly kaolinite is formed. The other is much less altered and the clay mineral smectite is formed.

The results of these first samples have been discussed on a meeting of the group which has taken place from 23 to 27 August 1995. We decided to work with more samples.

Gobert Paredes from University of Iquitos contributed with 18 samples from two "soil reference profiles " from the northern section of the Iquitos-Nauta road. Additional samples were given by Ari Linna. Those samples have been predominantly taken from river terraces.

From comparing the results of Ari Linna with our analyses it arrived to be geat advantage to collect together samples from the new roadcuts along the southern part of the Iquitos Nauta road (near Nauta) and, as well from the northern section and from the banks of Rio Amazon and Rio Nanay. The excursion was undertaken from 8.09. - 19.09.1996 together with Matti Räsänen, Ari Linna, Frank Wesselingh, and Luisa Rebata. The roadcuts of the southern section revealed as extremely good for studying geological structures. We found strong hints that the upper Pebas Formation was formed in an estuarine - tide-influence environment.

In Iquitos a small one day discussion about the progress of the project was organized by Risto Kalliola.

During the fieldtrip 101 samples were collected, from which 85 were collected for analyses. 22 samples we have got later from Ms Rebata, who sampled in more detail the roadcuts near Nauta.

Some chemical analyses have been done in our laboratory, 20 chemical analyses including the elements (XRF) were run in the laboratory of the University of Oldenburg/Germany.

In 1997 main activities of the program was the scientific cooperation with Ari Linna who was on February one week in Wilhelmshaven. Matti Räsänen and I prepared a manuscript for the ENCYCLOPAEDIA OF QUATERNARY SCIENCE in which there are included first results of the results of the project.

During the first week of March 1997 a meeting of the project members was organized to be held in Senckenberg-Institute/Wilhelmshaven. During three days the results were discussed in detail and each participant gave an oral description of his/her contribution. During this meeting a raw draft of the manuscript for the planned book, with the results from the whole project, was prepared.

A further meeting was held in Turku from 16. to 20. June. During this meeting details of the final version of the manuscript were established. Special attention was given to the results of Gobert Paredes Acre and Sjef Kauffman who could not participate in the meeting in Wilhelmshaven.

During the last months the results are summarised in order to establish the final report.

Wilhelmshaven, the 2nd December 1997

Georg Irion

MINISTERIO DE AGRICULTURA

INSTITUTO NACIONAL DE RECURSOS NATURALES
-INRENA-

DIRECCION GENERAL DE MEDIO AMBIENTE RURAL

INFORME FINAL DE ACTIVIDADES

NOVIEMBRE 1994 - OCTUBRE 1997

PROYECTO:

"ESTUDIO INTEGRADO DE LAS PROPIEDADES DE LA TIERRA, SUS INDICADORES FLORISTICOS Y LOS SISTEMAS AGRICOLAS APROPIADOS EN UN CENTRO DE ALTA BIODIVERSIDAD EN LA AMAZONIA PERUANA"

LIMA - PERU

1997

I. ANTECEDENTES

El 25 de noviembre de 1994 se firmó el Convenio Marco de Cooperación Inter institucional Técnico - Científico entre el Instituto Nacional de Recursos Naturales, INRENA y la Universidad de Turku, Finlandia. Bajo este sustento legal se ha desarrollado el proyecto: Estudio Integrado de las propiedades de la tierra, sus indicadores florísticos y los sistemas agrícolas apropiados en un centro de alta biodiversidad en la amazonía peruana, que culmina oficialmente el 31 de octubre del año en curso.

II. DESCRIPCION DE ACTIVIDADES REALIZADAS

Para el desarrollo del proyecto el INRENA, asumió una serie de compromisos, para el cumplimiento de los cuáles se han realizado las siguientes actividades en el período comprendido entre noviembre de 1994 a octubre de 1997:

- El Proyecto se inició en la Dirección General de Estudios y Proyectos, bajo la Coordinación del Ing. Walter Danjoy Arias, constituyendo una primera etapa en la cual se realizaron las siguientes actividades:

  - Se compró una imagen de satélite de la zona de Iquitos, en cinta digital. Se realizó el análisis digital de la cinta, se imprimió la imagen en papel fotográfico para ser distribuida a los miembros participantes del proyecto.

  - Se colectaron fotografías aéreas y se compró un lote de ellas para completar el área del estudio.

  - Se revisaron antecedentes y estudios anteriores realizados en la zona.

  - Participación de los Ings. Walter Danjoy Arias y Luisa Rebata Hernani, en el Primer Taller del Proyecto que se realizó del 28 de noviembre al 9 de diciembre de 1994 en Iquitos.

- Se inicia la segunda etapa del proyecto bajo la coordinación del Ing. Francisco Reátegui, quien asume este encargo debido a que el Ing. Walter Danjoy deja de laborar en el INRENA. Durante esta Gestión el Proyecto pasa a la Dirección General de Medio Ambiente Rural, y se realizan las siguientes actividades:

  - Participación de los Ings. Francisco Reátegui y Rubén Marquina, representantes del INRENA, en el Mini Taller efectuado en la Ciudad de Turku - Finlandia del 12 al 16 de noviembre de 1995, en el cual se definieron claramente los compromisos que la institución debía asumir y la metodología a emplear en la realización de los trabajos técnicos.

- En este último año correspondiente al período noviembre de 1996 a octubre de 1997 se continuaron los trabajos técnicos de las tres disciplinas en las que participa el INRENA, siguiendo los lineamientos y compromisos asumidos en el Cuarto y Quinto Taller del Proyecto los que a continuación se describen:

➢ Geología.- se concluyó con la elaboración del mapa base, el mismo que fue transformado a formato digital, así como se elaboró el texto correspondiente.

➢ Suelos.- se elaboró y digitalizó el mapa y se redactó un texto, con la parte correspondiente al INRENA.

➢ Deforestación y uso de la tierra en la zona de Iquitos.- se realizó el trabajo de campo, que incluyó un sobrevuelo con avioneta en el ámbito del estudio, así mismo se culminó el análisis en un período comprendido entre 1983 - 1995, obteniendo un mapeo multitemporal del avance de la deforestación, el mismo que fue transformado a formato digital que permitió cuantificar el avance de la deforestación en los diferentes períodos analizados y obtener el mapa de deforestación, se culminó la redacción del texto correspondiente al capítulo.

➢ Se realizaron gestiones ante el Instituto de Investigaciones de la Amazonía Peruana - IIAP los que proporcionaron en calidad de préstamo, la imagen de satélite de la zona correspondiente al año 1995, para ampliar los análisis de las diferentes disciplinas hasta ese año. Se reprodujo la imagen en papel fotográfico para ser distribuida a los otros participantes del proyecto.

➢ Participación de los profesionales Elva Gómez Romero, Tula Tamariz Ortiz y Roque en el Quinto Taller del Proyecto realizado del 03 al 06 de marzo de 1997, en la ciudad de Wilhelmshaven, Alemania en el cual se definieron aspectos técnicos y administrativos del proyecto y se trabajó la primera versión del manuscrito para el libro Geoecología y desarrollo de la zona de Iquitos, Perú.

➢ Se realizaron viajes en Comisión de Servicios a Iquitos, para realizar coordinaciones y recopilación de información relacionadas al proyecto; con el Gobierno Regional Loreto, Dirección Regional Agraria y Universidad Nacional de la Amazonía Peruana, Instituto de Investigaciones de la Amazonía Peruana, Centro de Estudios Teológicos de la Amazonía Peruana, entre otros.

- Participación en el Tercer Taller del Proyecto, el mismo que se llevó a cabo en la ciudad de Iquitos, del 06 al 13 de enero de 1996, que contó con la presencia de los profesionales de los distintos países e instituciones que intervienen en el proyecto. Los profesionales asistentes del INRENA fueron Francisco Reátegui, Rubén Marquina Pozo y Roque Vargas Huamán. Se realizó la presentación de los avances logrados por cada uno de los participantes, discutiendose sobre la metodología de trabajo empleada en cada caso. Se confeccionó el índice tentativo del libro que debe publicarse al final del estudio, asignando las responsabilidades en cuanto a la autoría de cada capítulo.

  Se realizó también, trabajo de campo en un tramo de la carretera Iquitos - Nauta y en la quebrada de Tamshiyacu.

○ Lo que denominaremos una tercera etapa del proyecto dentro del INRENA se inicia debido al cambio en la coordinación del mismo, que se realizó por motivos institucionales, habiendo designado como coordinadora, a partir del 10 de junio de 1996, a la Ing. M. Sc. Elva Gómez Romero, Directora General de Medio Ambiente Rural, y como profesional de apoyo a la Ing. Tula Tamariz Ortiz, especialista en ciencias ambientales de la Dirección General de Medio Ambiente Rural, continuando los Ings. Rubén Marquina Pozo, y Roque Vargas Huamán integrando el equipo técnico del INRENA que participa en el proyecto. Las actividades realizadas se resumen a continuación:

- Se elaboró un primer documento de trabajo del capítulo correspondiente a la deforestación y uso de la tierra, cuya segunda versión se adjuntó al informe correspondiente al año 1995 - 1996.

- Participación de los ingenieros Elva Gómez Romero, Tula Tamariz Ortiz, Roque Vargas Huamán y Rubén Marquina Pozo en el Cuarto Taller del Proyecto realizado el 18 de setiembre en la ciudad de Iquitos, en el cual se analizó el desarrollo del proyecto a la fecha, así como se presentaron los avances de cada disciplina de estudio y los resultados de los trabajos de campo realizados. Se definió más claramente el contenido del libro así como se establecieron las tareas a realizar posteriormente para alcanzar los objetivos propuestos.

- Se elaboraron informes con los primeros resultados de los trabajos de campo que realizaron los Ings. Rubén Marquina y Roque Vargas que se incluyeron en el informe 1995 - 1996.

III. COMENTARIOS GENERALES

- ❖ La experiencia adquirida con la participación en este proyecto ha sido muy enriquecedora para los profesionales participantes en ella, dada la importancia del libro y su relación con las actividades que el INRENA realiza. Así también es necesario mencionar que paralelo a este proyecto en la Dirección General de Medio Ambiente Rural se elaboró el estudio: Monitoreo de la deforestación en la Amazonía peruana el mismo que fue publicado en el presente año el día 05 de junio Día Mundial del Medio Ambiente y que contiene por primera vez cifras oficiales de la deforestación en la Amazonía peruana.

- ❖ Así mismo se ha creado gran expectativa por la publicación del libro "Geoecología en la zona de Iquitos" , que se publicará como producto final de este proyecto, puesto que en las diversas presentaciones que han realizado los profesionales del INRENA que participan en el proyecto se ha informado el trabajo que se está realizando en convenio con la Universidad de Turku - Finlandia.

- ❖ Ha resultado muy interesante y didáctico el estilo de trabajo del proyecto en el que han participado profesionales de diversas instituciones y países, hecho que ha permitido un ilustrativo intercambio de experiencias y visión de la situación de la zona de Iquitos desde diferentes perspectivas.

Es cuanto informo en Lima a los 10 días del mes de noviembre de 1997.

Atentamente,

Ing. ELVA GOMEZ ROMERO
Directora General de Medio Ambiente Rural
INRENA
Coordinadora del Proyecto

INFORME FINAL

PROYECTO "ESTUDIO INTEGRADO DE LAS PROPIEDADES DE LA TIERRA, SUS INDICADORES FLORISTICOS Y LOS SISTEMAS AGRICOLAS APROPIADOS EN UN CENTRO DE ALTA BIODIVERSIDAD EN LA AMAZONIA PERUANA

1. INTRODUCCION

La Universidad Nacional de la Amazonía Peruana, participa en el Proyecto en base a la subscripción el 31 de Enero de 1995 del Convenio "An Integraded study of land properties and their floristic indications in an acknowledged biodiversity center in northern peruvian amazonia", entre la Universidad Nacional de la Amazonía Peruana representado por el Rector Ing José Torres Vásquez y la Universidad de Turku de Finlandia, representado por el Rector Profesor Keijo Paunio; aprobada por Resolución Rectoral No 0209-95-UNAP del 22 de Febrero de 1995.

Dentro de es contexto, el presente informe resume las actividades desarrolladas por la Universidad Nacional de la Amazonía Peruana durante los tres años que duró el Proyecto "Estudio Integrado de las Propiedades de la Tierra, sus Indicadores florísticos y los Sistemas Agrícolas Apropiados en un Centro de Alta Biodiversidad en la Amazonía Peruana".

2. ASPECTOS TECNICO-CIENTIFICOS

La Universidad Nacional de la Amazonía Peruana participó en el Proyecto a través de tres subproyectos. En ese sentido, los aspectos técnico-científicos más saltantes son:

- El subproyecto "Caracterización Morfo-Analítica, Clasificación y Evaluación de Algunos Suelos de las Inmediaciones de la Ciudad de Iquitos-Perú", cuyo responsable es el Dr. Gobert Paredes Arce, desarrolló las siguientes actividades:

  - En 1995, se realizó parte de la fase de campo y de laboratorio.

  - En 1996, se completó con la fase de campo y de laboratorio y se ha ordenado parte de la información obtenida en las mismas, con la finalidad de efectuar el procesamiento informático más adecuado.

  - En 1997, se terminó con el ordenamiento de la información obtenida, se realizó el procesamiento informático y se concluyó con la redacción del documento final correspondiente.

2.2. El subproyecto "Manejo de Purmas con Tecnología Agroforestal", cuyo responsable es el Ing Salvador Flores Paitán. Las acciones desarrolladas, son:

- En 1995, se estableció las parcelas agroforestales, y se iniciaron las evaluaciones.

- En 1996, se continuó con las evaluaciones de las parcelas agroforestales.

- En 1997, se continuó con las evaluaciones de las parcelas agroforestales, el procesamiento de la información, y la redacción del documento final correspondiente.

2.3. El subproyecto "Valorización Cuantitativa del Potencial Económico de Purmas de los Alrededores de Iquitos, Perú"; cuyos responsables son Tedi Pacheco Gómez, José Torres Vásquez, Ronald Burga Alvarado y Pedro Angel Angulo Ruiz. Las acciones desarrolladas, son:

- En 1995, se realizó el inventario de purmas en 6 sitios seleccionados; se han colectado muestras botánicas y se han identificado a la mayoría de ellas.

- En 1996, se realizó el inventario de la localidad de Nauta, se recolectó muestras botánicas, se terminó con la identificación y se efectuó la valorización económica de todas las purmas estudiadas, se redactó el primer borrador del informe final que fue presentado en el Cuarto Taller realizado en Iquitos.

- En 1997, se redactó el segundo borrador del documento final que fue presentado en el Quinto Taller realizado en Wilhelmshaven (Alemania). Además, se hizo los ajustes pertinentes al informe final, quedando éste terminado en su tercera aproximación.

3. ASPECTOS ADMINISTRATIVOS

Es importante precisar, que los investigadores de la Universidad Nacional de la Amazonía Peruana, no manejaron directamente los fondos del Proyecto asignados a cada subproyecto. Para la administración de dichos recursos económicos, se designó a una especialista en Técnica Contable, quien oportunamente informa sobre el manejo económico de los tres subproyectos que desarrolla la Universidad Nacional de la Amazonía Peruana.

4. TALLERES

En la Universidad Nacional de la Amazonía Peruana, Iquitos, se realizaron tres Talleres siguientes:

- El Primer Taller, se realizó en Iquitos entre el 28 de Noviembre y el 9 de Diciembre de 1994, cuyo objetivo fue la justificación general del Proyecto, el cual intenta producir nuevos conocimientos científicos para facilitar el planeamiento de un desarrollo más sostenible para esta zona.

- El Tercer Taller, se realizó en Iquitos entre el 8 y 16 de Enero de 1996, con la finalidad de revisar los avances y definir algunos aspectos incompletos; además de desarrollar las líneas generales de los capítulos del Libro.

- El Cuarto Taller, se realizó en Iquitos en Setiembre de 1996, con la finalidad de hacer un análisis los aspectos del Proyecto relacionados con Suelos y Geología.

Los representantes de la UNAP, participaron en los seis Talleres realizados durante el desarrollo del Proyecto, tanto en Europa como en Perú. Es así, que investigadores de la UNAP participaron en el Primer, Tercer y Cuarto Taller realizado en Iquitos; en el Segundo y Sexto realizado en Finlandia; y en el Quinto Taller realizado en Alemania.

5. PARTICIPACION DE LA UNIVERSIDAD NACIONAL DE LA AMAZONIA PERUANA

En los Talleres realizados en Iquitos, la UNAP, ofreció la logística básica como ambientes físicos, apoyo secretarial, movilidad entre otros.

Además, ofreció el apoyo logístico necesario a los científicos de las demás instituciones involucradas en el Proyecto, tanto en los trabajos de campo como en Iquitos.

6. CONCLUSION

Las actividades contempladas en los tres subproyectos fueron desarrolladas completamente por la Universidad Nacional de la Amazonía Peruana, estando a la fecha todos los documentos informes terminados, listos para su publicación.

Atentamente

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SUB-PROYECTO
MANEJO DE PURMAS CON TECNOLOGIA AGROFORESTAL

SALVADOR FLORES PAITAN

Iquitos, Noviembre 5 de 1997

PERU

SUB-PROYECTO: MANEJO DE PURMAS CON TECNOLOGIA AGROFORESTAL
AVANCES INVESTIGATIVOS
PERIODO NOV./94-JULIO/97

1. MARCO INSTITUCIONAL

El Sub-Proyecto , **Manejo de Purmas con Tecnología Agroforestal** , es parte integral del Proyecto de investigación multidisciplinaria **"An integrated study of land properties and their floristic indications in an acknowledged biodiversity centre in northern Peruvian Amazonia"**, financiada por la Unión Europea (Programa STD3) y la Academia de Finlandia.

La ejecución del Sub-Proyecto **Manejo de Purmas con Tecnología Agroforestal**, se desarrolla en el marco del Convenio firmado entre la Universidad de Turku, Finlandia y la Universidad Nacional de la Amazonia Peruana , formalizada mediante la Resolución Rectoral N° 000209-95 de fecha 22 de Febrero de 1995.

2. OBJETIVOS DEL SUB-PROYECTO

- Desarrollo de alternativa tecnológica agroforestal para racionalizar el manejo de purmas en la selva baja peruana.
- Validar los avances tecológicos agroforestales generados en el Proyecto Agroforestal de la Universidad Nacional de la Amazonia Peruana en Iquitos.
- Promocionar la investigación-acción, con participación de campesinos, estudiantes y profesionales vinculados con la problemática del uso de la tierra en selva baja; y diseminar la viabilidad de la propuesta en los diversos foros locales, regionales e internacionales.

3. IMPLEMENTACION DEL SUB-PROYECTO

El Sub-Proyecto Manejo de purmas con tecnología agroforestal, se inició en el mes de noviembre de 1994, con la ejecución del diagnóstico exploratorio de campo y la localización del área experimental.

El terreno selecto, está ubicado en el Km 20 de la Carretera Iquitos-Nauta, es representativo de suelos predominantes arenosos improductivos de la colonización Iquitos-Nauta y soporta vegetación secundaria de aproximadamente 13 años de abandono posterior a la deforestación. La superficie del área experimental es de 4,5 Has.

El terreno fue delimitado según tratamientos (Sistemas agroforestales semi-intensivo, semi- extensivo y sistema tradicional del agricultor local) y repeticiones (03), determinados por el diseño experimental de Bloque Completo Randomizado.

En el mes de diciembre de 1994, se inició la preparación del terreno, con la práctica del tradicional "rozo" y "wawancheo" ; "la tumba", el "desarrame" y el "picacheo", fueron ejecutado entre los meses de enero y febrero de 1995.La "quema" fue realizada en el mes de marzo de 1995;por desuniformidad de la "quema", se practicó el "shunteo" y "requema", procesos que demoran hasta el mes de abril de 1995.

En el mes de abril, inmediatamente después de la "requema" , se procedió al "jaloneo" y plantación, según tratamientos de las especies forestales: "tornillo" (Cedrelinga catenaeformis), "palta moena"(Anaueria sp.), "caoba"(Swietenia macrophylla) y "castaña"(Bertholletia excelsa); y de las especies frutales leñosas: "palta"(Persea americana), "carambola"(Averrhoa carambola) y "cítricos" (Citrus sp.). El frutal nativo "pijuayo"(Bactris gasipaes) y la especie mejorante de la fertilidad del suelo "guaba"(Inga edulis), fueron establecidos en los meses de abril y junio de 1995 respectivamente.

Los componentes de ciclo corto: "yuca"(Manihot esculenta),"plátano"(Musa sp.) y "piña"(Ananas comosus),fueron sembradas entre el 02 de mayo y el 09 de junio de 1995.

4. PRINCIPALES ACTIVIDADES

- MANTENIMIENTO: Durante el período Julio/95-Julio/97, fueron ejecutados podas de los árboles según programación y deshierbos trimestralmente (labor con alta demanda de mano de obra para atender el mantenimiento de 4,5 has experimentales).
- EVALUACION: Mensualmente, durante el período Julio/95-Julio/97, fueron registrados datos dasométricos de crecimiento en altura de los diferentes componentes arbóreos forestales y frutales. La producción de cultivos anuales, fue registrada ,según la fenología productiva de las especies.
- MUESTREO DE SUELOS: Antes de quema, después de quema, al finalizar el primer año y al finalizar el segundo año, se colectaron muestras de suelo a profundidades de 0-15 y 15-30 cm.

5. RESULTADOS INICIALES PRELIMINARES

- CRECIMIENTO EN ALTURA DE LOS COMPONENTES LEÑOSOS PERENNES.

En el sistema agroforestal semi-intensivo, el promedio de altura de especies forestales a los 24 meses de edad, fue de 3,02m en "moena"; 5,04m en "tornillo"; 2,89m en "caoba" y 1,61 m en "castaña". El incremento promedio de crecimiento mensual en altura en 24 meses, fue de 18,6cm en "tornillo"; 10,2cm en "moena"; 9,1 cm en"caoba" y 4,6cm en "castaña".

En el sistema agroforestal semi-extensivo, el promedio en altura de las especies forestales a los 24 meses de edad, fueron de 3,0m en "moena"; 5,9m en tornillo; 2,22m en "caoba" y 1,6m en "castaña". El incremento promedio de crecimiento mensual en altura en 24 meses fue de 22,7cm en "tornillo; 10,1cm en "moena";6,3cm en "caoba" y 1,6m en "castaña".

Comparando el crecimiento de los árboles entre ambos sistemas, se manifiesta común la secuencia de comportamiento de las especies, correspondiendo en ambos sistemas el primer lugar al "tornillo", seguidos en importancia por "moena", "caoba" y "castaña". Los datos reportados indican escasa variación en los valores de crecimiento de "moena", "caoba" y "castaña"; excepto "tornillo" que expresa mayor crecimiento bajo sistema semi-extensivo (5,99m) y menor crecimiento bajo sistema semi-intensivo (5,04m).

Las especies frutales leñosas, bajo sistema agroforestal semi-intensivo, alos 24 meses de edad ,fueron de 3,78m en "palta";2,40m en "carambola" y y 1,73m en "cítricos". El incremento de crecimiento promedio mensual en altura, a los 24 meses de edad, fue de 12,7cm en "palta";7,0 cm en "carambola"; y 3,8cm en "cítricos.

Bajo sistema agroforestal semi-extensivo, el promedio de altura de plantas a los 24 meses, fue de 3,83m en "palta";2,21m en "carambola"y 1,72m en "cítricos". El incremento de crecimiento promedio mensual en altura a los 24 meses, fue de 12,5cm en "palta";6,3cm en "carambola" y 3,9 cm en cítricos.

La información preliminar manifiesta igual secuencia de comportamiento de las especies, correspondiendo el primer lugar a "palta", seguidos por "carambola" y "cítricos" respectivamente. Los valores de crecimiento preliminar, indican escasa variación de crecimiento de las especies frutales entre ambos sistemas agroforestales.

- SOBRERVIVENCIA

En el sistema agroforestal semi-intensivo, la sobrevivencia de las especies forestales tuvo el siguiente comportamiento: "tornillo" alcanzó el mayor valor, con 88,9 de sobrevivencia, seguido por "castaña" con 83,3%, "caoba con77,8% y en último lugar "moena" con 66,7% de sobrevivencia.

En el sistema agroforestal semi-extensivo, la mayor sobrevivencia correspondió a las especies forestales "tornillo" y "moena" con 88,3% , y la menor sobrevivencia a "caoba" y "castaña", que alcanzaron 77,8% de sobrevivencia.

Evaluando en general, el total de plantas de las diferentes especies forestales en estudio, en el sistema agroforestal semi-intensivo se alcanza una sobrevivencia de 77,8% y en el sistema semi-extensivo 80,5%. Estos valores preliminares indican un nivel medio de sobrevivencia de las especies forestales

Las especies frutales leñosas bajo sistema agroforestal semi-intensivo y semi-extensivo, tuvieron similar comportamiento. En ambos sistemas la "palta" fue la especie que registró el mayor valor de sobrevivencia, con 97,2% en el sistema semi-intensivo y 91,4% en el sistema semi-extensivo. El segundo lugar correspondió a "carambola",con 62,5% en sistema semi-intensivo y 75,0% en sistema semi-extensivo. La especie que sobrevivió menos, fue "cítricos",con 55,5% en sistema semi-intensivo y 58,3% en sistema semi-extensivo.

Con la información preliminar registrada, tentativamente se puede concluír indicando, que "palta" es la especie frutal con mejor capacidad de adaptación a los suelos arenosos de San Gerardo; y los cítricos, son las especies con menor capacidad de adaptación que tienen los niveles más bajos de sobrevivencia; la "carambola", ocupa un lugar intermedio, con valores regulares de sobrevivencia.

6. AVANCES INVESTIGATIVOS

En la fase inicial de funcionamiento de los sistemas agroforestales semi-intensivo y semi-extensivo, resultan favorables respecto al sistema tradicional que maneja el pequeño agricultor local.

El primer año, los tres sistemas en estudio, contribuyeron con la producción de yuca, con rendimientos de 10,6 TM/Ha en el sistema semi-extensivo; 12,2 TM/Ha en el sistema semi-intensivo ; y 11,5 TM/Ha en el sistema tradicional. El valor comercial de la producción fue de S/. 2 126 en el sistema semi-intensivo; S/: 2 450 enn el sistema semi-extensivo; y S/. 2 310 en el sistema tradicional.

El segundo año, la producción de yuca no prosperó en ninguno de los sistemas estudiados, debido a condiciones ambientales desfavoraables inusuales. En el sistema tradicional, la regeneración natural invadió el terreno y se produjo el abandono de la parcela, corroborando el patrón predominante de la agricultura migratoria. Contrariamente, en ambos sistemas agroforestales, se inició la fructificación de piña, con una producción promedio de 1 471 frutos comerciales /Ha, valorizados en S/.1 177.

En los años siguientes, la dinámica de los sistemas agroforestales aportarán diferentes productos, según la fenología productiva de las especies. El cultivo de piña, continuará produciendo hasta el año-6; el pijuayo, iniciará la fructificación el año-4 y continuará hasta el año-8; carambola, fructificará el año-6 y continuará hasta el año-10; palta, fructificará el año-6 y castaña el año-12, ambos extenderán su ciclo productivo hasta el año-30, coincidente con el turno de aprovechamiento de la madera de las especies forestales.

La sostenibilidad productiva de los sistemas agroforestales, está fundamentada en el manejo de la biomasa de la especie mejorante de la fertilidad del suelo Inga edulis ,complementada con roca fosfórica de Bayovar en la preparación de compost; también contribuirá con el mantenimiento de la fertilidad del suelo, la cobertura de leguminosa herbácea programada para su inclusión en los sistemas agroforestales,en el año-5.

La capitalización de la tierra con los componentes perennes de valor económico y la utilización de plantas mejorantes de la fertilidad, leñosas y herbáceas, constituyen el fundamento económico, ecológico y social de los sistemas agroforestales en estudio.

7. LIMITACIONES

Las principales restricciones en la marcha del Sub-Proyecto, fueron abióticos y bióticos.

El factor climático alterado, con períodos inusuales secos acompañados con elevadas temperaturas, afectaron en diverso grado, el establecimiento, crecimiento y producción de los diferentes componentes del sistema. Contribuyeron a intensificar el problema, la gran variabilidad de los suelos en cortas distancias; y el predominio de la fracción arena en los suelos, con sus efectos negativos de pobreza en nutrientes , baja capacidad de retención de humedad y de nutrimentos, y alta capacidad de absorción de energía calórica que favorece rápida evapotranspiración y también afecta el sistema radicular de las plantas.

Los principales factores bóticos restrictivos fueron: la fuerte incidencia de hormigas arriera Atta sp., que defoliaron completamente las plantas, ocasionando la muerte en muchas de ellas, incluyendo las especies más rústicas como yuca, guaba y pijuayo; y el ataque del barrenador del brote Hypsiphylla grandela, que alteró el crecimiento de la caoba.

El tamaño del área experimental, por su gran extensión , demandó mano de obra no disponible para su mantenimiento y manejo.

8. PROYECCION

La evaluación cabal de los sistemas agroforestales, sólo será posible en el mediano y largo plazo.

Es de importancia capital, la continuación del monitoreo experimental, para el registro de la dinámica y de la cuantificación del nivel de sostenibilidad productiva de los sistemas agroforestales.

Es también recomendable, la validación de los modelos experimentales, en diferentes tipos de suelos, para el ajuste metodológico y determinar el nivel de inferencia en los diferentes ambientes ecológicos de la selva baja.

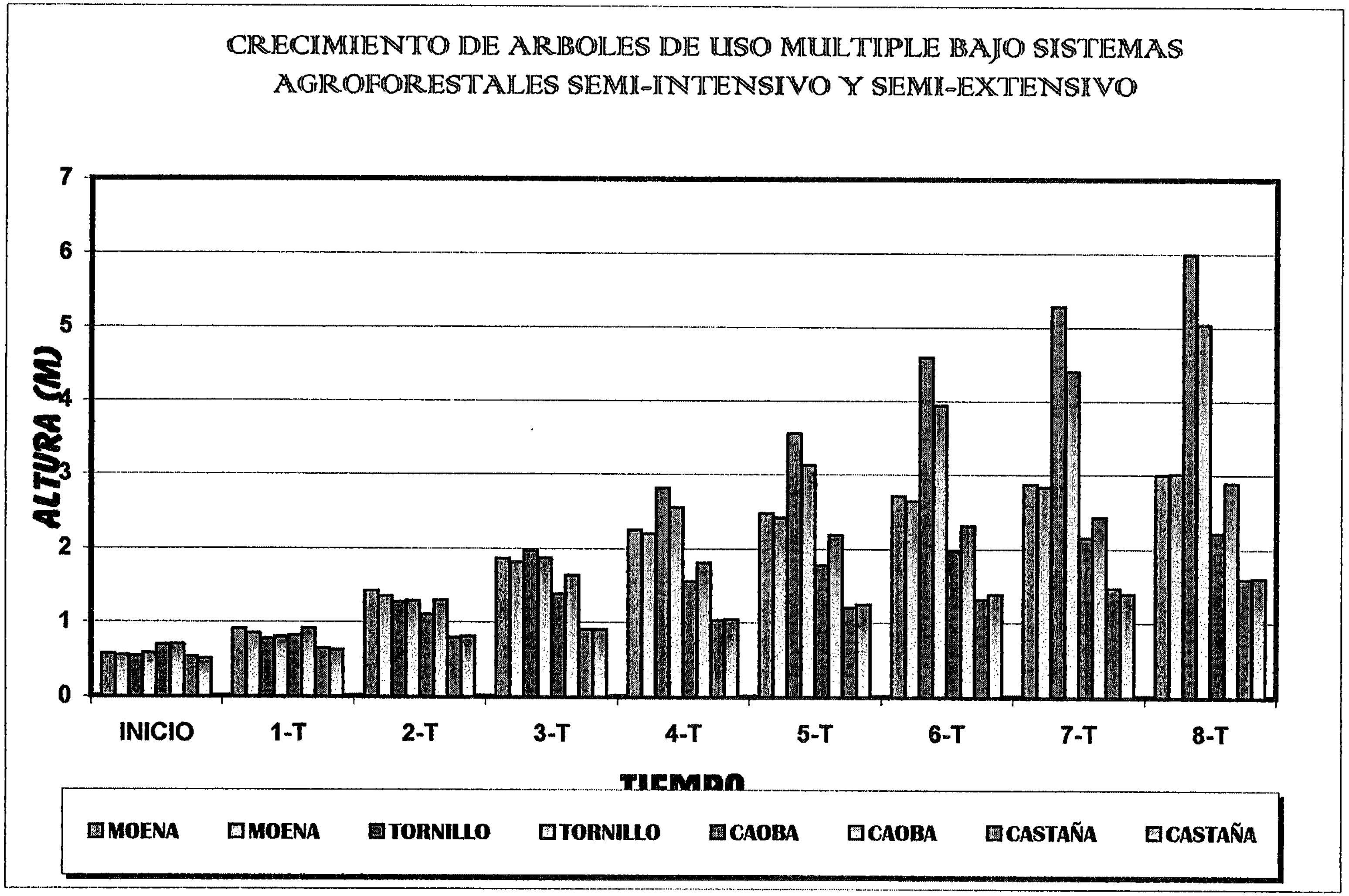
En la práctica, las parcelas experimentales son de gran utilidad, en la capacitación de campesinos, estudiantes y profesionales vinculados a la problemática del uso de la tierra en el ámbito amazónico de selva baja. Los resultados generados por la investigación, son también instrumentos de gran valor, en la promoción de una opción tecnológica racionalizada en el uso de la tierra, con ventajas socioeconómicas y ambientales cuantificables en el tiempo.

CUADRO 21

CRECIMIENTO DE ARBOLES DE USO MULTIPLE BAJO SISTEMAS AGROFORESTALES SEMI-INTENSIVO Y SEMI-EXTENSIVO

ESPECIE : FORESTALES

PERIODO : JULIO/95-JULIO/96

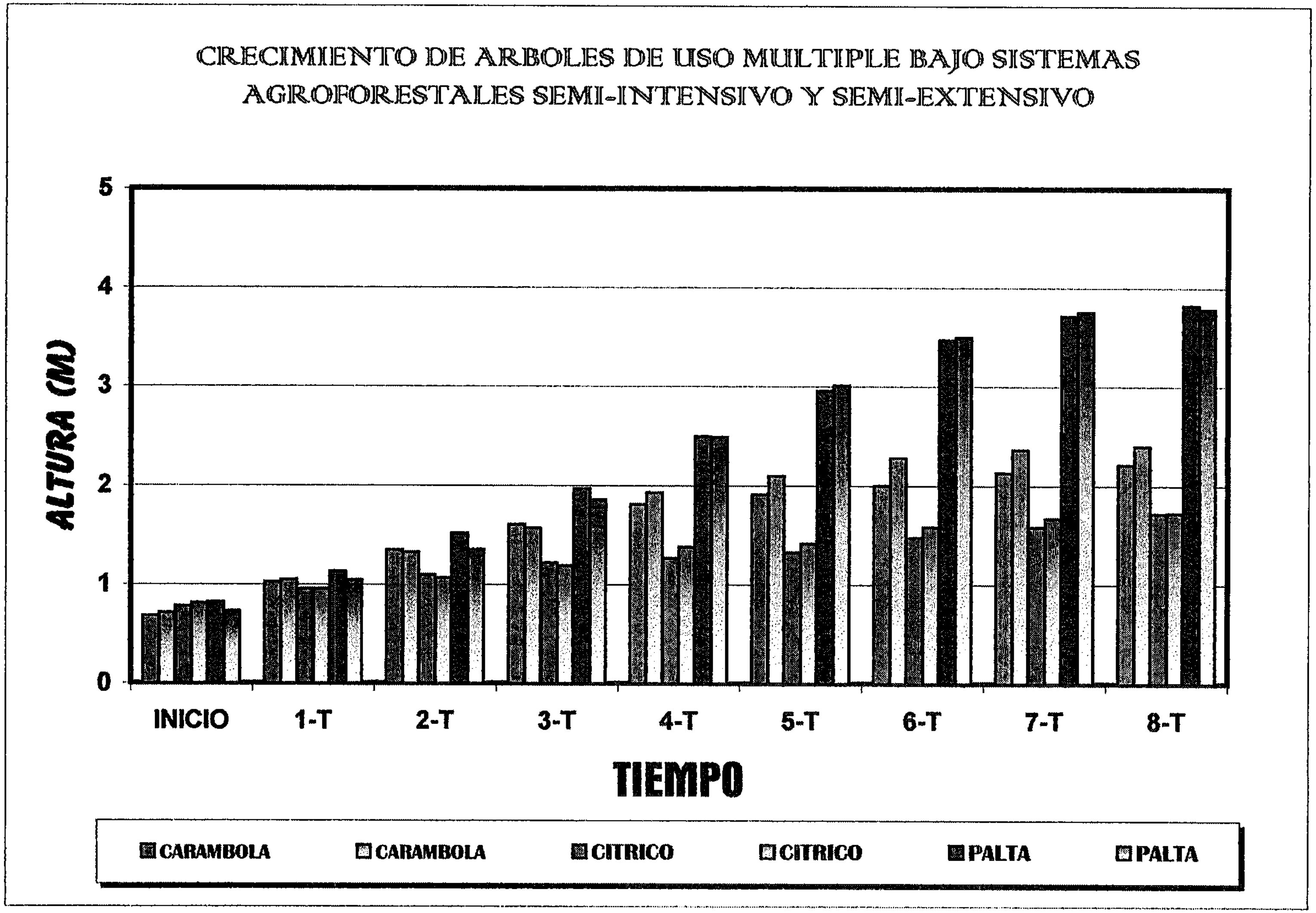


CUADRO 22

CRECIMIENTO DE ARBOLES DE USO MULTIPLE BAJO SISTEMAS AGROFORESTALES SEMI-INTENSIVO Y SEMI-EXTENSIVO

ESPECIE : FRUTALES LEÑOSAS

PERIODO : JULIO/95-JULIO/97



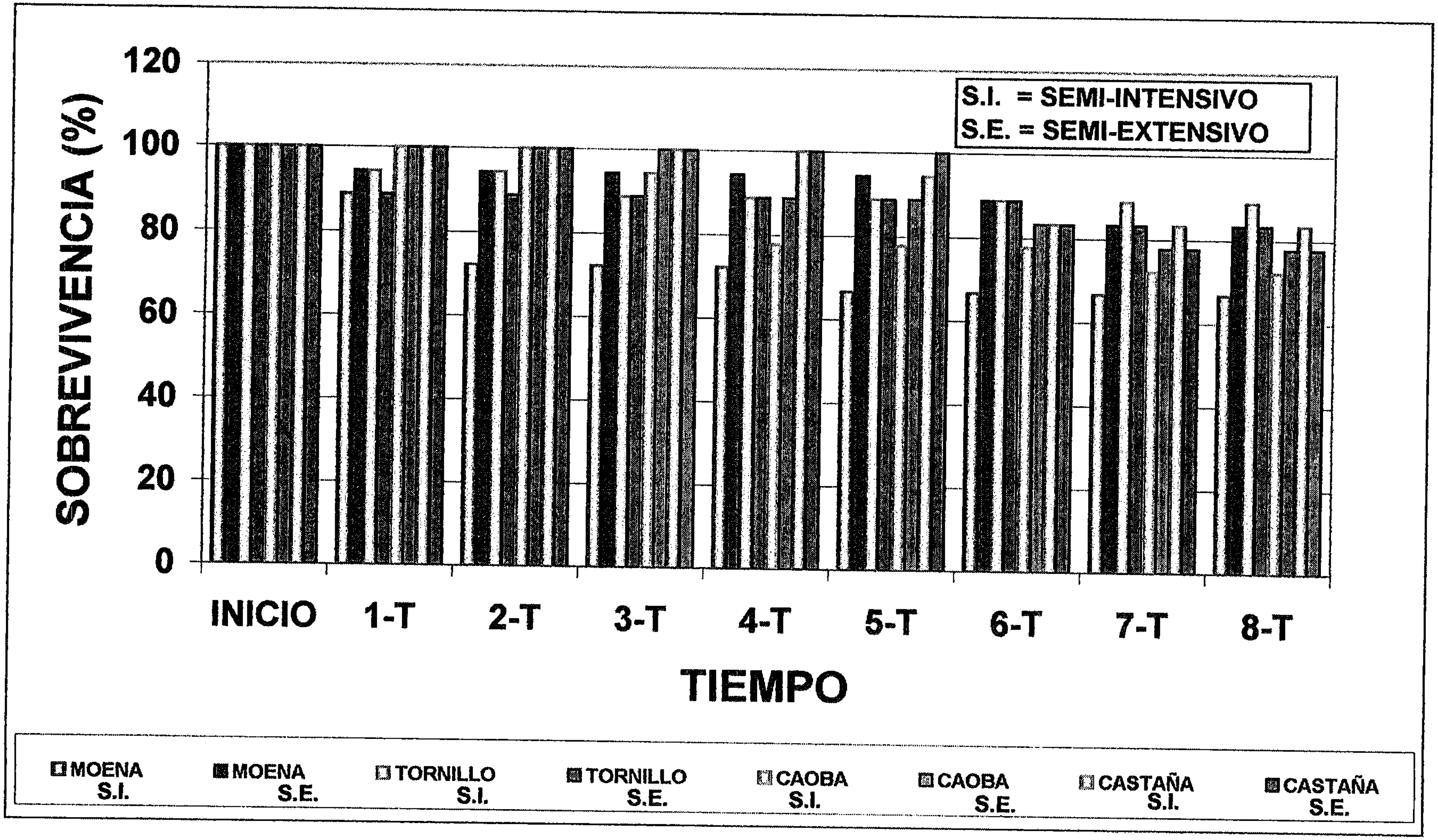
CUADRO 29

SOBREVIVENCIA DE ARBOLES DE USO MULTIPLE BAJO SISTEMA AGROFORESTAL

SEMI-EXTENSIVO Y SEMI-INTENSIVO, SAN GERARDO (IQUITOS)

ESPECIES FORESTALES

PERIODO JULIO/95 - JULIO/97



CUADRO 30

SOBREVIVENCIA DE ARBOLES DE USO MULTIPLE BAJO SISTEMA AGROFORESTAL SEMI-EXTENSIVO Y SEMI-INTENSIVO, SAN GERARDO (IQUITOS)

ESPECIES FRUTALES

PERIODO JULIO/95 - JULIO/97