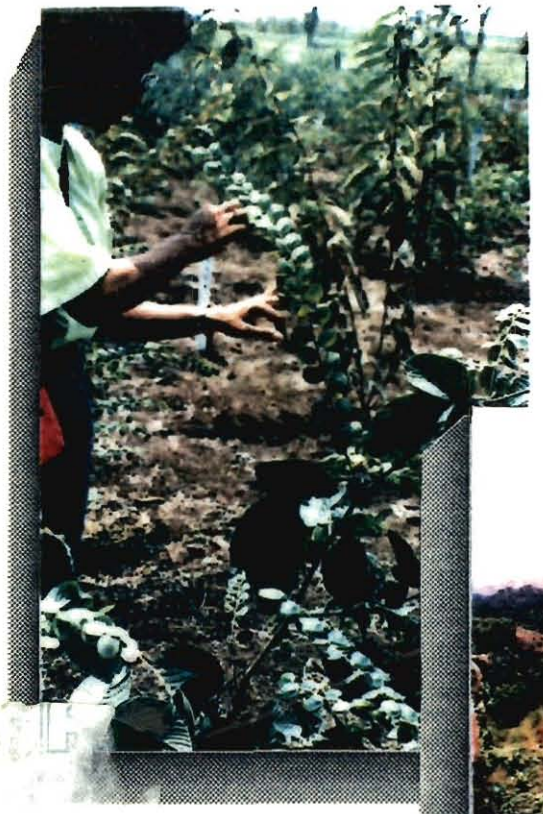
FORAGES FOR SOIL IMPROVEMENT AND ANIMAL FEED SUPPLY



A Proposal for: Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ)

Submitted by:

CIAT

Centro Internacional de Agricultura Tropical
Cali, Colombia

Collaborating Partners:

Centro Internacional de Agricultura Tropical (CIAT): Tropical Forages Program and Hillsides Program.

Department of Tropical Forages, Institute of Plant Production in the Tropics and Sub-tropics, University of Hohenheim, Stuttgart.

Institute for Animal Production, Humboldt University of Berlin.

Institute of Soil Science and Soil Geography, University of Bayreuth.

November 1993

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FORAGES FOR SOIL IMPROVEMENT AND ANIMAL FEED SUPPLY

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USE OF FORAGE LEGUMES IN SMALLHOLDER PRODUCTION SYSTEMS FOR IMPROVING SOIL FERTILITY, CROP YIELDS AND ANIMAL PRODUCTION IN THE ANDEAN HILLSIDES

A Proposal for: Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ)

Special Project Funding

UNIDAD DE INFORMACION Y DOCUMENTACION
12 MAR.

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November 1993

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Acronyms

CIAT	Centro Internacional de Agricultura Tropical, Colombia
CIPASLA	Consorcio Interinstitucional para la Agricultura Sostenible en Laderas
GIS	Geographic Information Systems
GTZ	German Agency for Technical Cooperation
ICA	Instituto Colombiano Agropecuario
MPTS	Multi-Purpose Trees and Shrubs
SFS	Soil Fertility and Sustainability Indicators
SOM	Soil Organic Matter

1.0 Summary

Title of Research Proposal

Use of Forage Legumes in Smallholder Production Systems for Improving Soil Fertility, Crop Yields and Animal Production in the Andean Hillsides

Short Title

Forages for Soil Improvement and Animal Feed Supply

Objective of Research:

To select forage legumes for the environmental conditions and production systems in the mid-altitude Andean hillsides and evaluate their contribution to soil improvement and animal production.

Abstract

Declining soil fertility is a major problem in farming systems of the Andean hillsides. Declining crop yields and impoverished fallow land is good evidence of this occurring. Legume-based forage systems could play a major role in arresting this soil fertility decline in addition to providing feed for animals used for draft purposes or raised for meat and milk production.

The project is based on the **hypothesis** that the **inclusion of forage legume-based systems within the production system is essential to sustainable land use**. This will be achieved through the contribution of legume-based forages towards creating an active soil organic matter (SOM) pool and leading to increased animal and crop productivity.

The focus of the research will be on the improvement of the fallow land which occupies the major proportion of the area. There is good evidence that improving the soil fertility status of such land by the introduction of legumes adapted to the soils and climate will lead to increased crop yields, shorter fallow periods and increased production of animal products.

An integrated approach is necessary to achieve the desired outputs in the study area and to enable the results to be applied more widely. Firstly, it is necessary to select appropriate legumes and demonstrate that they can improve soil productivity. Secondly, it is unlikely that farmers will adopt a new legume technology unless it can be shown to improve income. Increasing milk production through improved nutritive value of the feed will improve their cash flow more rapidly than a gradual increase in soil fertility. Thirdly, it is imperative to develop indicators of soil fertility and sustainability to assess the effect of the new legume technology in the study area and to enable it to be transfered and assessed in other areas.

This is why ***a team of specialists*** from different Programs in CIAT and different Universities in Germany has been put together for this project. Participation in such a team will also give students the experience of a farming systems approach to solution of complex problems.

The Tropical Forages Program in CIAT has access to a large genetic resource of forage materials and experience in evaluating them for crop-livestock systems. The Hillsides Program has expertise in land use strategies and participatory research. Personnel in the University of Hohenheim have experience with tropical forage germplasm, in the Humboldt University of Berlin with tropical animal production systems and in the University of Bayreuth with developing soil fertility and soil sustainability indicators.

Outcomes of the project will include an improved fallow system for the hillsides, new forage systems for animal production and indicators of soil fertility status.

Cooperating Partners:

- Centro Internacional de Agricultura Tropical CIAT: *Tropical Forages Program* and *Hillsides Program.*
- Department of Tropical Forages, Institute of Plant Production in the Tropics and Sub-tropics, University of Hohenheim, Stuttgart.
- Institute for Animal Production, Humboldt University of Berlin.
- Institute of Soil Science and Soil Geography, University of Bayreuth.

Names of Principal Scientists:

CIAT:	Drs. P.C. Kerridge and J. A. Ashby and Senior Scientists in the Tropical Forages and Hillsides Programs
University of Hohenheim:	Prof. Dr. R. Schultze-Kraft
Humboldt University of Berlin:	Prof. Dr. K. J. Peters
University of Bayreuth:	Prof. Dr. W. Zech

Staff to be financed:

German staff:

Three Ph.D. students:	Legumes and fallow improvement
	Legume-based crop-livestock systems
	Soil fertility and SOM dynamics
Nine diploma students:	Related research projects

CIAT staff:	One Research Assistant
	Two Research Technicians

Budget Total and Breakdown by Partners and Year (US$):

Budget in US$	Year 1	Year 2	Year 3	TOTAL
CIAT	171,884	165,330	162,586	499,800
University of Hohenheim	44,700	42,700	45,700	133,100
Humbolt University of Berlin	44,700	42,700	45,700	133,100
University of Bayreuth	57,700	57,700	57,700	173,100
Total Request to BMZ	**318,984**	**308,430**	**311,686**	**939,100**

2.0 Background and Justification

Farm productivity is declining in the Andean hillsides

2.1 Introduction

The Andean hillsides have the highest population density of the rural areas in tropical America. In general, farm productivity is declining due to decreasing soil fertility, increasing soil erosion, and poor retention of water with the result that the socio-economic conditions of the smaller landholders are very poor. Though the welfare of these smallholder farmers depends on many interacting factors there is now an acceptance and concern for the sustainability of the land use system.

Many organisations, both government and non-government, are attempting to promote sustainable land use practices. But in most instances, the technologies for sustainable practices have not been well established or else are not acceptable to farmers. This is the case with the availability of forages, in particular legumes, for hillside farming systems.

The technologies for sustainable practices have not been well established

It is widely recognised that well managed crop-livestock systems contribute to sustainable land use. However, the present use of livestock in the hillsides varies greatly in intensity and purpose and probably does not make a major contribution to sustainability. While cattle are considered a major source of capital or cash flow and provide draft power, pastures and fodder receive little attention because they are not a direct source of income. Many pastures are overgrazed, the use of improved grass pastures being limited to milk or fattening enterprises with a high cash flow. The use of legumes for soil improvement and animal feeding is not part of the farming system at present.

Improved forages offer more than a feed for cattle. Legumes used as a component of fallow land can enhance soil fertility, used as barriers or ground cover they can prevent soil erosion. This latter point has been recognised

in the BMZ funded project 'Soil Degradation in Crop Productivity Research in Andean Hillside Farming Systems' which is evaluating forages for soil cover and as live barriers to control erosion in cassava production systems, among other agronomic practices.

The project aims to make a greater range of forages available for the hillsides

This project aims to make a greater range of forages available to contribute to the establishment of more sustainable farming systems in the hillsides. It will also identify the potential for animals in the region in relation to the available labour and land resources, suggest new legume-based crop-livestocksystems and provide an objective basis for measuring the impact of different crop-livestock systems on soil productivity.

Results of the research will have wide applicability

The target area for this work will be the hillsides in the northeast area of the Department of Cauca, Colombia. Results of research will have wide applicability throughout the mid-altitude hillsides of tropical America and to smallholder hillside systems in Africa and Asia.

2.2 The target area

Sustainable farming systems have not been developed yet in the target area

The focus area, the Rio Ovejas watershed, has been selected by the Hillsides Program as a research area for developing new technologies for the hillsides. It has a population density of 80 persons/km^2 compared with 27 persons/km^2 for Cauca and Colombia as a whole. The region is largely agricultural with a predominance of small farms and with social conflicts over land tenure.

This particular area has only been settled some 50 years and sustainable farming systems have not been developed. This is quite a common phenomonen in other parts of tropical America. However, intense migration to the area has now slowed and there is an increasing degree of local organisation. For example, through a CIAT initiative all on-farm research is coordinated through CIPASLA, a consortium of all organisations working in the area.

The average annual rainfall in northeast Cauca is 2000 mm with two marked dry seasons a year and rainfall maximums occuring in April/May and October/November. The landscape in the study area is strongly sloping and lies between 1200 and 1800 m altitude. Soils are of volcanic origin with pH 3.8-5.0, organic matter 3-8% and soil phosphorus (Bray II) 1.5-2.5 ppm. Al saturation is 60-70% in the surface to 80-95% in the sub-soil. The soils are Inceptisols, similar to Andosols but with a higher bulk density and lower content of volcanic glass and ash (Reining, 1992). Exploitation of the soil and a lack of technological alternatives has led to deterioration of the land resource. This is shown by high indices of erosion (Reining, 1992). Problems are accentuated in the steeper hillside areas.

Exploitation of the soil and a lack of technological alternatives has led to deterioration of the land resource

The farming system is one of family farms with an average size <10 hectares and with seasonal labour shortages. Some farms have dominantly crop systems but the majority have integrated crop-livestock systems (Botero, 1992). Both systems use a fallow phase of 5-8 years between cropping phases of 2-4 years.

Improvement of the fallow land would have a major effect on farm productivity

Arable crops occupy 14% of the area with the principal crops being cassava, beans, maize and tomato. Managed pasture land occupies 24% and unmanaged fallow land another 40% of the agricultural area. Some of the area is planted to coffee. The managed pastures consist of native species such as *Paspalum notatum, P. conjugatum* and *Axonopus compressus*, naturalised species such as *Melinis minutiflora* and *Hyparrhenia rufa,* and recently introduced species such as *Brachiaria decumbens* and *B. dictyoneura.*

Farmers categorise the managed pasture plus the unmanaged fallow as 'crop' fallow land and 'permanent' fallow, the latter land as being too degraded or otherwise not suitable for cropping. Improvement of this 'crop' and 'permanent' fallow land would have a major impact on farm productivity through more fertile soil for cropping; more rapid crop rotation would relieve the pressure on use of the steepest land for cropping.

The average herd size is 3 animal units. The predominant livestock activity is dual-purpose meat and milk production. Livestock contribute to the farm economy through the sale of milk, the sale of weaned calves (which are also an important source of capital) and as draft animals.

In summary, the region faces several problems: (i) the deterioration of the soil resource by soil erosion, nutrient losses through leaching and accelerated SOM mineralisation (ii) the lack of appropriate technologies that would allow more efficient and sustainable use of the land resource and (iii) socio-economic problems arising from insufficient income generation to hold people on the land.

MPTS could play a major role in stabilising the steeper land

2.3 Current state of knowledge

Forage selection

Forages selected in the humid lowlands were evaluated in on-farm studies in the hillsides. The stoloniferous grasses, *Brachiaria humidicola* and *B. dictyoneura,* proved persistent under the high grazing pressures used by the farmers but the introduced legumes, *Stylosanthes guianensis, Desmodium ovalifolium* and *Centrosema macrocarpum*, while they were adapted to the environment, did not persist under this heavy grazing. The grasses form a good ground cover against soil erosion but are not suitable in a pasture-crop rotation system because of difficulty in eradicating them during the cropping phase. There is an interest in multipurpose trees and shrubs (MPTS) for the area but suitable species have not been identified. MPTS could play a major role in stabilising the steeper land and at the same time providing fodder for cattle and timber for fuel.

The prior emphasis on selection of forages in CIAT has been for pasture systems. However, it has been recognised that forages can also play a useful role for other purposes. Examples are the successful use of *Arachis*

Productivity increases under fallow

pintoi as a ground cover in numerous tree crops in tropical America and *Stylosanthes guianensis* CIAT 184 as a cover crop and fodder for feed pellet production in China. In hillside areas of Timor, Indonesia, on high pH soils, *Leucaena leucocephala* has become naturalised and as such is an integral part of the fallow-crop system (Piggin and Parera, 1985). This latter model could well be appropriate for hillsides with low pH soils using acid soil tolerant shrubs such as *Cratylia argentea*.

Soil productivity

It has been shown that the low yield of crops in the area is largely due to low soil fertility. Crops respond strongly to fertilization with chicken manure and chemical fertilizers (ICA, 1988). Crops grown on land fallowed under pasture or secondary forest regrowth are much more productive than those grown on old crop land (CIAT, 1989). This may be due to increased soil organic matter (SOM) but in reality little is known of what happens during the fallow. The use of chemical fertilizer is restricted to crops which have a high gross return such as vegetables.

The use of legumes would increase the value of a fallow

Previous work by the Tropical Pastures Program of CIAT has shown the advantage of intercropping rice and pasture in the savanna areas of eastern Colombia (Sanint et al., 1990). Higher rice yields were obtained following grass-legume pasture than pure grass pasture. An appropriate form of crop-fallow sytem using legumes as a live mulch or as a forage should have similar positive benefits in the hillside farming system. But farmers will be more readily convinced of the value of legumes if they are shown to have a beneficial effect on both livestock and crop productivity.

Legumes could be used as barriers and green covers

A University of Hohenheim-CIAT Project team has been conducting research on measures to reduce soil erosion in cassava-based cropping systems. Soil erosion, itself, is a major cause of reduced soil productivity. They have demonstrated the advantage of using live barriers in

reducing soil loss, and initial studies have been conducted on the use of ground cover legumes to reduce rainfall impact and soil loss. There are suitable grasses, but not legumes, for use in permanent barriers. While the value of cover legumes has been demonstrated more suitable ecotypes with characteristics of rapid establishment but giving low competition with the crop, disease resistance and high seed yields are required. In the outreach phase of the work, farmers have shown an interest in adopting forage plants for multiple end uses. Current experimentation by the team involves the use of erosion control plots to study how different agronomic practices will modify soil loss.

Research has demonstrated the potential of incorporating legumes with grasses for dual-purpose cattle production systems

A review by Leihner (1983) indicates there would be an economic advantage in using a legume intercrop such as cowpea or beans with cassava, but notes that this practice has not been adopted by farmers. He also points out the desirability of developing a green manure crop for the hillsides.

Livestock

Research by the Tropical Forages Program has demonstrated the potential of incorporating legumes with grasses for dual-purpose cattle production systems (Lascano and Avila, 1991). Firstly, the milk production of dual-purpose cattle was increased by 20% per annum but by 40% in the dry season. Secondly, grazing calves on legume-based pastures reduced their need for fresh milk, thus making more saleable milk available, while, at the same time, producing high growth rates in the calves.

The development of dual-purpose cattle systems in the hillsides has been limited by the need to produce a sufficient quantity of milk in a given locality to make pick-up economically feasible. The provision of forages that fit into the farming system to optimise the year round feed supply would help to overcome this limitation.

Introduction of legumes into the fallow land is seen as the key to improving overall productivity

2.4 Research Needs

An integrated research approach is seen as essential to achieve some solution to the problem of declining soil fertility. Introduction of legumes into the fallow land is seen as the key to improving overall productivity. Thus, suitable herbaceous and shrub legumes need to be identified and their contribution towards improving soil fertility assessed. The acceptance of a legume-based fallow system will be much more attractive to farmers if it can be seen to improve cash flow through increased livestock product. That is, the adoption rate will depend on the utility of the legumes. Research needs to be carried out to determine how the improved fallow can be combined with other feeding practices to increase livestock product and thus the income of farmers. Then there is the necessity of identifying indicators of soil sustainability to monitor the impact of introduction of legumes on soil productivity and sustainability.

2.5 Ability of organisations and individuals to undertake the research

CIAT maintains a large genetic resource of tropical forages and also has ready access to germplasm from other Genetic Resources Centers.

The Tropical Forages Program has specialists in relevant areas of Forage Evaluation (Dr. B. Maass), Plant Nutrition (Dr. I. Rao), Forage Quality and Animal Production Systems (Dr. C. Lascano) and Forage Systems for Smallholders (Dr. P. Kerridge).

The Hillsides Program has specialists in Soil Fertility (Dr. B. Knapp) and Participatory Research methodology (Dr. J. Ashby).

These persons will be able to provide adequate local supervision to pre-doctoral and diploma students and themselves will be engaged in research in the area. The

National organizations will participate in the research

Cauca area is close to CIAT Headquarters and thus there is ready access to good laboratory facilities. Both Programs have identified the activities that would be undertaken in this Special Project within their Core Project areas but lack the resources to carry them out at this time.

Prof. Dr. R. Schultze-Kraft at the University of Hohenheim is a Specialist in tropical forage germplasm and has had many years experience in the evaluation of that germplasm on acid, low-fertility soils.

Prof. Dr. K. Peters at the Humboldt University of Berlin is an Animal Production Specialist with tropical experience in Africa and Asia in utilizing various feed resources in crop-livestock systems for smallholder farmers.

Prof. Dr. W. Zech at the University of Bayreuth is a Soil Scientist with experience in soil acidification and in identifying soil attributes that are sensitive to changes in the quality or productivity of a soil.

The research will be facilitated through collaboration with CIPASLA (a consortium of 10 government and local institutions that are actively involved in the watershed) and the Fondo Ganadero del Valle, (see chapter 4.6).

3.0 Project Objectives

Goal

To increase incomes and agricultural sustainability in hillside farming systems by improving crop yields and animal productivity through the introduction of forage legumes.

Project Purpose

To select forage legumes for the environmental conditions and production systems in the mid-altitude Andean hillsides and evaluate their contribution to soil improvement and animal production.

The specific objectives are:

(i) To select forage legumes as components of the farming system, in particular, for the fallow land.

(ii) To evaluate the contribution of improved fallow and legume supplements for increasing livestock production.

(iii) To determine indicators of the soil fertility status and soil sustainability to assess the role of legumes in the farming system.

(iv) To use farmer participation in the evaluation of forages, forage-based systems and in assessing the utility of sustainability indicators.

(v) To provide institutional support through training and dissemination of information.

Specific objectives will lead to discrete outputs

The outputs developed in this project will have wide application

Project Outputs

The expected outputs from the above objectives are:

- Adapted legumes suitable for use in 'crop' fallows and 'permanent' fallows, as supplementary livestock feed, and as green manure, soil covers and erosion barriers for cropped areas in hillside farming systems on acid infertile soils.
- Prototype systems for using improved fallow land for increased milk and beef production.
- Analytical indicators for identifying the soil fertility status and quantification of the influence of land use practices on the dynamics of soil nutrients and SOM with respect to sustainability.
- Criteria for acceptability of forage legumes and sustainable farm practices by farmers.
- Strengthened local institutions, trained scientists and the research well documented.

Project Impact

The outputs will contribute directly to the increased welfare of farmers in Cauca through increased farm productivity. The outputs will also contribute directly to the development of more sustainable land use systems in the hillsides. CIPASLA, a cooperating agency, has the authority to provide guidelines for implementing sustainability land use practices to national and regional government agencies. Further the forage germplasm, new farming practices and soil sustainability indicators identified in the project could also benefit smallholders in similar hillside areas in other regions in Latin America, and in Asia and Africa.

The outputs will strengthen the capacity of national institutions involved in research and development. Students from the National University at Palmira will receive training and CIPASLA will obtain experience in technology development and transfer. More effective linkages between farmers, development agencies and scientists will hasten the process of improving the welfare of less privileged people.

4.0 Workplan

The project has been carefully designated to accomplish the objectives

The major activities and sub-activities required to produce the above outputs are illustrated in Figure 1, the implementation schedule showing the commencement and duration for each main project activity in Figure 2 and the project organization in Figure 3. The project will be located in portion of the Rio Ovejas watershed in the northeast of Cauca, Colombia (Figure 4).

The execution of the project will require at least three years with a possible extension or a new project for undertaking additional activities which arise as a result of outcomes of this project.

The project will be coordinated by Dr. P.C. Kerridge, Leader, Tropical Forages Program, CIAT, with assistance from other scientists from CIAT and staff from the German Research Institutes. CVs of the principal research staff are found in Appendix B. It is planned that a coordination meeting will be held at CIAT each year at the beginning of October.

The research will be carried out by students and staff of the German and Colombian Universities and CIAT scientists. CIPASLA and the Fondo Ganadero del Valle will collaborate in the evaluation and technology transfer process. Farmers will be involved through participatory research.

Figure 1 shows the breakdown of the project structure with descriptions of the activities. Detailed descriptions of the proposed activities follow:

FORAGES FOR SOIL IMPROVEMENT AND ANIMAL FEED SUPPLY

Work Breakdown Structure

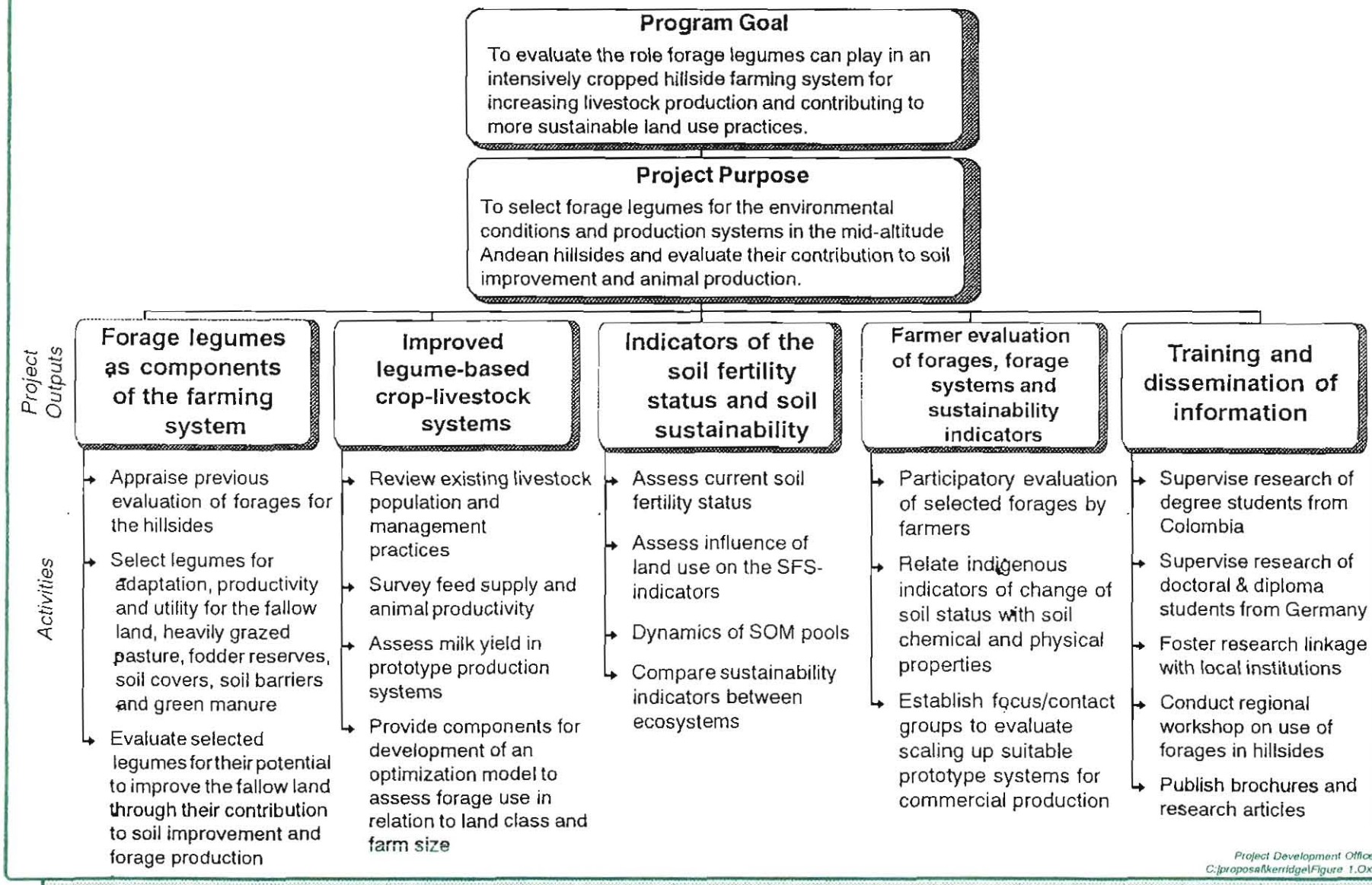
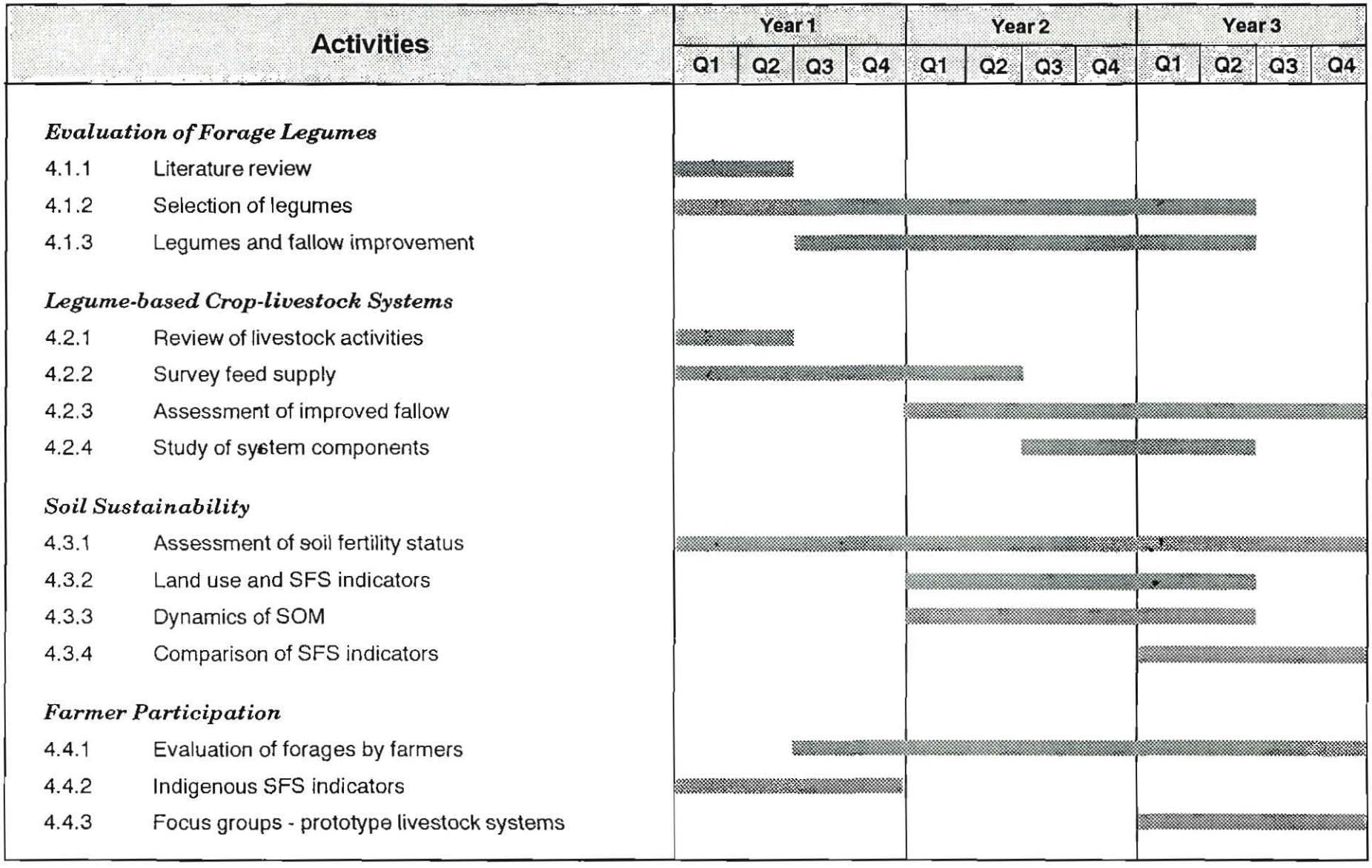


Figure 2

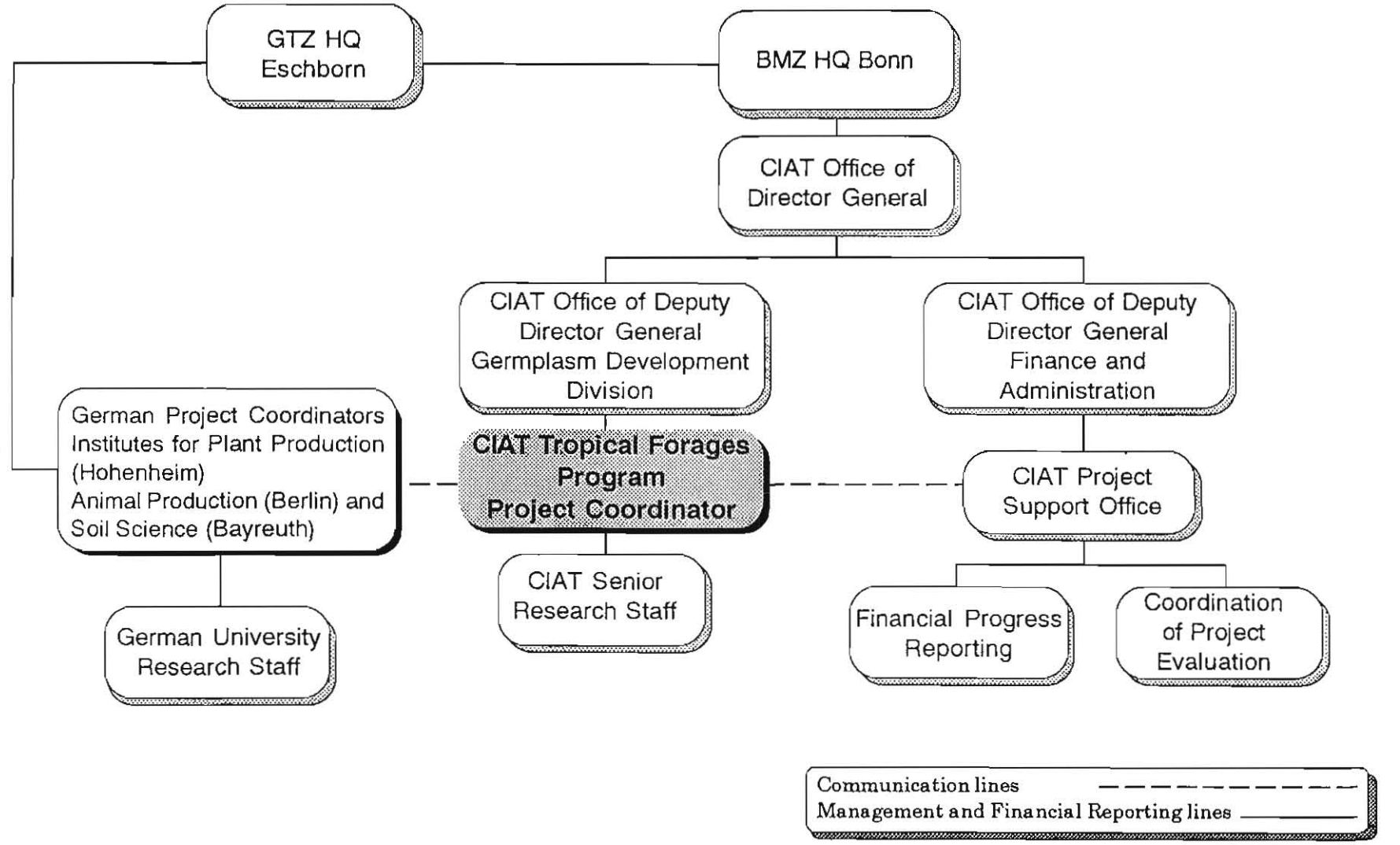
Chronogram of Project Activities by Year



Q = Quarter

Figure 3

Project Organization Chart



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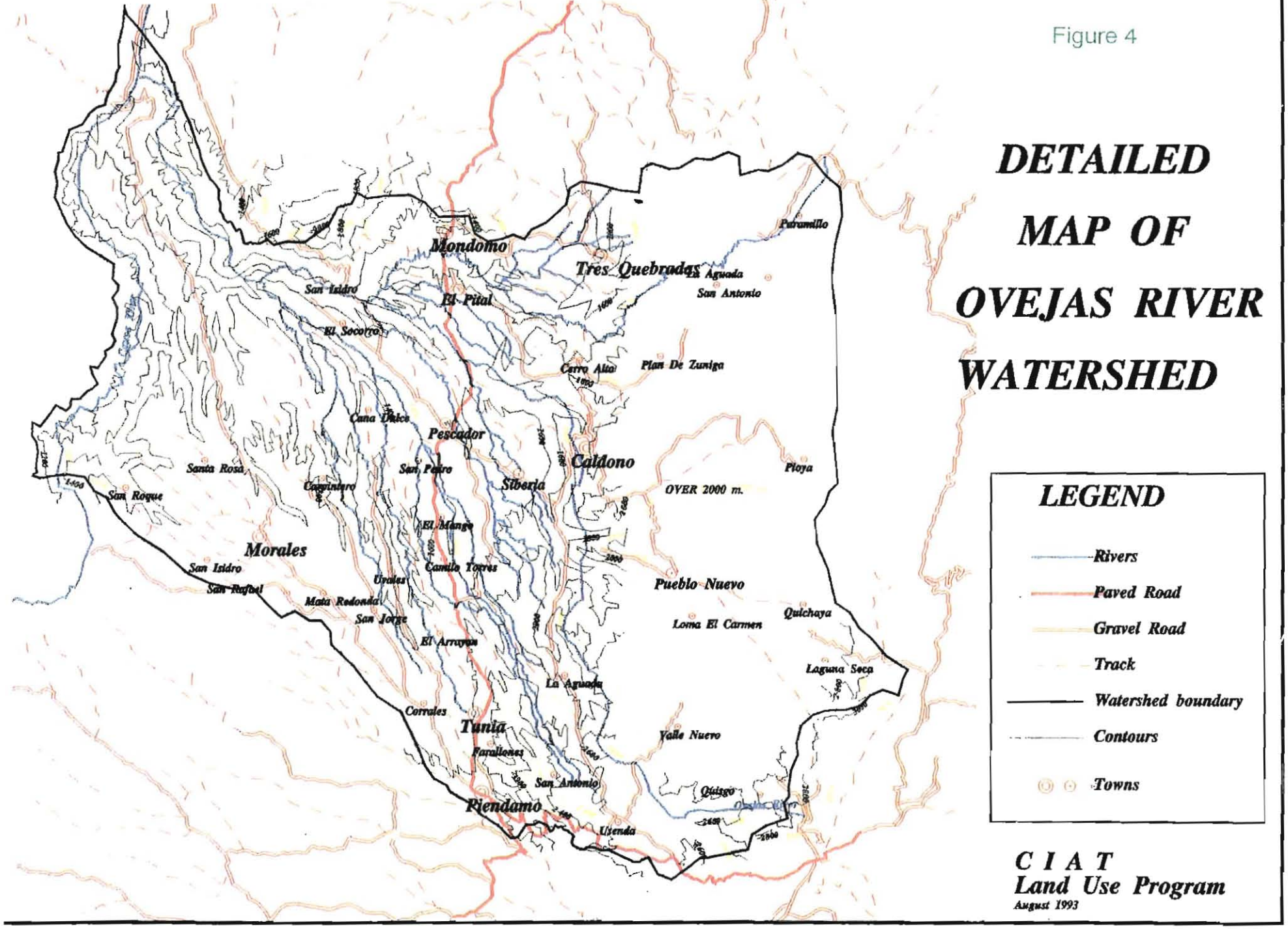
Project Development Office

Figure 4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OVEJAS RIVER
WATERSHED
Mondomo
Tres Quebradas
La Aguada
San Antonio
Putumillo
San Isidro
El Pital
El Socorro
Cerro Alto
Plan De Zuniga
Cana Dulce
Pescador
Caldono
Playa
Santa Rosa
San Pedro
Siberia
Cayantaro
San Roque
OVER 2000 m.
El Mango
Morales
San Isidro
San Rafael
Camilo Torres
Urales
Pueblo Nuevo
Mata Redonda
San Jorge
Quichaya
Loma El Carmen
El Arrayan
Laguna Seca
La Aguada
Corrales
Tunia
Valle Nuevo
Farallones
San Antonio
Quisgo
Piendamo
Usenda
LEGEND
Rivers
Paved Road
Gravel Road
Track
Watershed boundary
Contours
Towns
CIAT
Land Use Program
August 1993

4.1 Evaluation of Forage Legumes

4.1.1 Review previous experience with forage legumes in tropical mid-altitude hillsides

A review will be conducted of previous forage germplasm use in hillsides

A review will be conducted of previous forage germplasm evaluation in the Cauca area. Experience in similar geographical areas will then be reviewed and sources of potentially useful species documented. Attention will be given to the specific climatic and edaphic conditions of the project area, the need for different roles of legumes and whether versatile or specialized germplasm is desirable.

4.1.2 Selection of legumes for adaptation, productivity and utility

Germplasm perfomance can be related to climatic and edaphic variables

Forage legumes are currently being evaluated for environmental adaptation, i.e. to edaphic, climatic and biotic constraints, in pure stands.

Low soil fertility and moisture deficit are major limitations to environmental adaptation in the study area. Atmospheric and soil climate data is being recorded and the available soil water balance determined. In addition, soils will be described, samples taken for chemical and physical analyses, and the soil nutrient status defined in relation to the nutrient requirements of a range of germplasm.

Selected germplasm will then be evaluated for productivity under the management system in which it is anticipated it will be used. Criteria that will be used in this evaluation in addition to productivity and the prospects for propagation by smallholders are shown in Table 1.

Table 1

Evaluation Criteria for Different Management Systems

Management system	Evaluation Criteria
(i) Legumes for fallow	Evaluated in association with natural fallow vegetation with emphasis on ability to establish and produce in competition with the native vegetation.
(ii) Grazed pasture	Evaluated in mixed grass-legume associations under heavy defoliation. Legumes also evaluated for production of soil seed reserves and seedling regeneration.
(iii) Fodder reserve	Species cut at those times of the year when additional fodder is required to supplement other feed supplies. Legumes evaluated for ability to coppice and hold leaf in the dry season.
(iv) Legumes for ground cover	Evaluated in association with crops with which they may be grown e.g., cassava and coffee. Measurements will be made of rapidity of establishment and cover of the soil surface in competition with weeds, contribution to soil N and competition with the crop.
(v) Barrier plants	Evaluated along exposed contour rows. Observations made of ability to prevent soil loss, encourage natural terracing and competition with crops.
(vi) Green manure crops	Evaluated for ability to contribute to available soil N to following crop. Extensive evaluation will only proceed on evidence for soil improvement and acceptance by farmers.

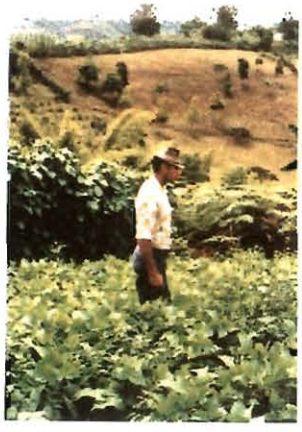
Evaluation of legumes for fallow land would commence immediately with legumes known to have environmental adaptation in the area e.g. *Centrosema macrocarpum, Cratylia argentea, Desmodium ovalifolium, Stylosanthes guianensis* and be extended as other species are identified.

4.1.3 Role of legumes in fallow improvement

Evaluate hypothesis: legume introduction into fallow will increase overall productivity

This activity is to evaluate the hypothesis that fallow vegetation improved with legumes will provide a more high quality forage for cattle and in time restore soil fertility faster than an unimproved fallow.

One experiment will be conducted to evaluate the contribution of 9 best-bet legumes *(Centrosema macrocarpum, Chamaecrista rotundifolia, Cratylia argentea, Desmodium ovalifolium, D. velutinum, Dioclea guianensis, and Zornia glabra),* in comparison with the grass *Brachiaria dictyoneura* and natural fallow vegetation as controls, to soil improvement and fodder production on different parts and aspects of the slope.



The effect of legume introduction will be assessed by measuring soil parameters and growing a test crop

The following measurements will be made:

- **Vegetation**

Establishment vigour, ground cover, total DM yield and botanical composition, leaf: stem ratio, and leaf nutrient composition during the mid-wet and mid-dry seasons. Root yield and composition using ^{13}C will be determined during the second main wet season.

- **Soil**

Once at each site location: chemical: pH, SOM, effective cation exchange capacity, extractable P, exchangeable Ca, Mg, K, Na and Al.

physical: field texture, bulk density, moisture holding capacity, mechanical resistance.

At the conclusion of the second Oct-Feb wet season nitrate NO_3^-, labile N (incubation) and soil respiration on legume and control plots.

Diploma students to undertake short term research

A maize crop will be grown at the commencement of the third wet season in April, to assess the soil fertility status following different legumes and management treatments.

A Ph.D. student from the University of Hohenheim will conduct a study into the improvement of fallow land using forage legumes and be responsible for Activities 4.1.1, 4.1.2 (i), 4.1.3.

German diploma students will complement the improved fallow study by short-term research in the areas of (i) botanical composition of natural-fallow vegetation as influenced by fallow age and degree of soil degradation and (ii) small plot screening of legumes for environmental adaptation and potential for fallow improvement.

Evaluation for 4.1.2 (iv) and (v) will be carried out in association with the BMZ funded CIAT Cassava Program project "Soil Degradation in Crop Productivity Research in Andean Hillside Farming Systems."

Students from the Colombian National University will work with CIAT staff in carrying out activities 4.1.2 (ii), (iii) and (vi).

4.2 Improved Legume-based Crop-livestock Systems

4.2.1 Review of existing livestock population and management practices

A review will be conducted of the existing livestock population and its management in the Rio Ovejas watershed and a similar watershed in Cauca with a greater cattle population. Where necessary further rapid appraisal will be carried out to complete this assessment of the contribution of livestock to overall farm productivity. A review will be conducted of the successful integration of forages into smallholder farming systems in other regions.

Animal productivity will be related to feed supply

4.2.2 Survey feed supply and animal productivity

Milk production, growth rate and reproductive rate of dual purpose cattle will be determined from a representative set of farms in the Rio Ovejas and adjacent watersheds. Studies will also be made of the feed supply situation for livestock so that animal productivity can be related to feed supply. This information on livestock productivity together with that on livestock distribution can then be fed into a GIS land use system which has been developed for the area.

4.2.3 Assessment of milk yield in prototype production systems

Prototype systems will be established to compare milk production from the unimproved fallow with that from the improved fallow, both with and without supplementary fodder (Table 2).

Milk yields in each prototype system will be measured on two selected farms using a cross-over design. Milk yield responses will be related to the quantity and quality of feed resources available in the prototype systems.

Table 2

Prototype systems to compare milk production between unimproved and improved fallow	
(i)	Grazing on grass/natural fallow with supplementation with 'cut and carry' grasses in the dry seasons (traditional system).
(ii)	Grazing on grass/natural fallow with supplementation by 'cut and carry' grass and legumes (Improved system 1).
(iii)	Grazing on grass/natural fallow planted with legumes with supplementation with 'cut and carry' grasses (Improved system 2).
(iv)	Grazing on grass/natural fallow planted with legumes and supplemented with 'cut and carry' grasses and legumes (Improved system 3).

As it will take a year to establish 'best-bet' legumes in the natural fallow, this activity will lag one year behind the other activities. Farmer managed trials of prototype forage systems would naturally follow in a second phase of the Project.

4.2.4 Provision of components for development of a model to allow optimisation of use of forages and crop residues in relation to land class and farm size

German and Colombian students will share research responsibilities

An empirical model will be developed to allow simulation of possible crop-livestock systems in relation to economic benefits to producers and the community. It will be based on information contained in the GIS database of the area (i.e. present livestock numbers and productivity, climatic data, land use, soils and crops). It will assist in planning new prototype systems and extension of results generated in this project.

The review of livestock production and evaluation of prototype systems to evaluate the contribution of an improved fallow to milk production will be undertaken by a Ph.D. student. Some of the initial survey work will be undertaken by graduate students from the Colombian National University. An experienced research assistant could provide the input needed for the livestock productivity measurements and execute the development of the prototype production systems.

4.3 Identification of soil fertility and sustainability (SFS) indicators

Presently, there is limited quantitative data available on soil fertility and sustainability in the Cauca hillsides. Thus it is necessary to develop soil fertility and sustainability indicators as a basis for the evaluation of the effects of selected forages (Activity 4.1) and improved legume-based crop-livestocksystems (Activity 4.2) on soil productivity. The identification of these SFS-indicators will be achieved in two ways:

4.3.1 Assessment of the soil fertility status by correlating maize yields with factors associated with soil, aspect and foliar element concentration

A range of soil and plant variables will be measured to define factors limiting yield

An experiment to allow identification of the factors limiting yield will be carried out at 30 sites. Activities will include:

- Selection of the sites with different conditions of aspect and soil and planted to maize as a test crop.
- Description of the soil at each site for soil color, texture, structure, density, stone content by horizon; and the altitude, inclination, distance off the ridge, shape and exposition.
- Soil sampling and soil analyses for pH, C, N, extractable P and S, effective cation enchange capacity, exchangeable cations and, bulk density, pore volume, size distribution, texture, water holding capacity, infiltration rate, aggregate stability.
- In selected "good", "medium" and "poor" sites, reactive and stabile SOM pools and their characteristics (e.g. C species, CuO lignin polysaccharides, nutrients) will be determined.

- Leaf sampling under standard conditions for analysis of N, S, P, K, Ca, Mg, Al, Fe, Mn, Cu, Zn, B.

- Identification of the main yield restricting factors by correlating (normal distribution, perhaps with transformation, principal component analysis, simple and multiple regression analyses) with:

  Yield (biomass, dm, grains) = f (soil and site factors)

  Yield = f (foliar element contents)

  Foliar elements = f (soil and site factors)

  Yield restricting factors = f (other soil, and site factors)

The Ph.D. student would undertake this study in Year 1 and train national scientists to continue essential measurements for another two years. This will allow a better asssessment of sustainability.

4.3.2 Influence of land use on the SFS-indicators and dynamics of SOM pools

The response of SFS indicators to different land use systems will be determined

After identifying the main yield restricting factors during the first year, the second step will be to examine the influence of different land use practices on the SFS indicators.

This second phase is necessary to determine how the SFS indicators change under the traditional land use systems of secondary forest, newly cleared forests, long-term cropping with a final phase in long-term cassava, coffee, sown grass pasture and the natural fallow in both a qualitative and quantitative sense. This will assist in understanding and evaluating the effects of forages (Activity 4.1) and improved legume-based crop-livestock systems (Activity 4.2) on soil productivity.

The following activities will be carried out:

- Define 10 plots with different land use practices but similar site conditions.
- Description of the soil, aspect and land use description.
- Soil sampling analysis for the SFS-indicators, identified in section 4.3.1.
- Determine soluble cations and anions in the soil solution at the same depths and below the main rooting zone for selected land use units on a monthly basis.
- Statistical evaluation of the data: analysis of variance, regression analyses.

Since it is well known that SFS of tropical sites highly depend on the soil organic compounds, and that the use of legume based forages will influence the type of compounds, special attention will be given to the dynamics of reactive SOM pools.

4.3.3 Dynamics of reactive SOM pools and P as key indicators of SFS

There is a relation between active SOM and soil fertility indicators

Soil organic matter dynamics will be determined by measurements on both the bulk soil samples and soil fractions to identify the reactive SOM pool which in tropical soils are supposed to be significantly correlated with soil fertility and sustainability indicators (Zech et al., 1990). Measurements will include:

- Stabile and labile fractions of SOM using chemical and physical fractionation, ^{13}C and ^{1}H nuclear magnetic resonance, lignin degradation, polysaccharides and lipid content and specific enzymes and microbial biomass.

- Phosphorus dynamics of selected land use units, measuring sorption/desorption, organic fractions using ^{31}P Nuclear Magnetic Resonance spectroscopy and fixation by measuring residual P.

- Calibration of models for hillsides situations.

Results of this study will enable comparisons between ecosystems

4.3.4 Comparison of the SFS-indicators between ecosystems.

Since similar analytical methods and research concepts are used in the BMZ funded project *Soil Indicators of Sustainable Agropastoral Systems*, it will be possible to examine whether the SFS-indicators differ between these ecosystems or not. We consider such a comparison as an important contribution to developing common concepts in soil sustainability in the savannas and hillsides ecosystems being studied by CIAT.

However, it is pointed out that the system components and soils in the Cauca area are quite different to those in the Cerrados and differences in soil processes and thus SFS indicators can be expected.

The work described under 4.3 will be carried out by one German Ph.D. student, one Colombian Master student (M.Sc.), and one German Diploma student.

In a second phase of the Project it is proposed that the sensitivity of the chosen indicators will be evaluated during actual changes in cropping systems. This will be tested in conjunction with other studies in the Project, namely, soil improvement through use of legumes and development of prototype feeding systems. This cannot be achieved within a 3-year time frame.

4.4 Farmer participation in evaluation

It is considered that technology transfer should be conducted concurrently with the research process. This not only allows feedback to the researchers but permits external input into the project.

The beneficiaries of the project, the farmers, will participate in the research process

4.4.1 Evaluation of forages by farmer participation

Two activities will be carried out.

One activity will involve the evaluation of selected forages from Activity 4.1.3 by farmers. Farmers will participate in the choice of forages they will evaluate and in the management of these on their farms. Farmer feedback will be used to review overall evaluation activities.

The second activity will be evaluation of a range of legumes suitable for fallow improvement sown across the total area of a fallow piece of land and managed by the farmer. The choice of legumes will be made in conjunction with Activity 4.1.3 in discussion with the farmer who will be encouraged to consider different legumes for portions of the fallow and different management strategies. Performance of individual species will be monitored along fixed transects. This activity will need to be followed for the whole period of the fallow.

Both activities will be the responsibility of the Ph.D. student from Hohenheim who will be selected on the basis of participatory research experience in latin America.

4.4.2 Relation between indigenous indicators of change of soil status with soil chemical and physical properties

During the conduct of Activity 4.3.1, farmers will be interviewed to obtain some knowledge of their understanding and experience with assessment of soil productivity. This information will be quantified and compared with the results obtained in Activity 4.3.1.

4.4.3 Focus/contact groups to evaluate scaling up suitable prototype systems for commercial production.

This activity will only commence in Year 3 and continue into a planned second phase of the project.

The Research Asistant will be required o assist this process under the direction of Drs. Ashby and Lascano. An economist is available for undertaking an economic assessment.

4.5 Institutional support

4.5.1 Training of Colombian scientists

4.5.2 Training of German scientists

See section 5.0.

4.6 Involvement of local institutions and farming groups

Role for national organizations

The main involvement will be through CIPASLA (Inter-institutional Consortium for developing Sustainable Agriculture in the Hillsides). CIPASLA represents 10 institutions who are active in working with local communities in the Cauca area and has links to ICA and CIAT (Appendix A).

The involvement of CIPASLA will be in identifying collaborating farmers within the site selection guidelines set down by project leaders. More importantly, CIPASLA is responsible for technology transfer which explicitly involves assessing end-user acceptability of the outputs of the proposed research relative to current farmer practices and proposed alternative soil and water sustaining technologies being promoted, e.g. live and dead barriers, reduced tillage, new forage systems. Also CIPASLA has the mandate to suggest to national and regional government agencies guidelines for the execution of policy on sustainable agriculture and resource management. As such, CIPASLA has a vested interest in the outputs of the proposed research.

Cooperation will also be sought from the Fondo Ganadero del Valle - a livestock cooperative that actively supports research for the improvement of livestock production. This group has been active in supporting research undertaken by CIAT. They would be able to assist by providing livestock for proposed research and in obtaining land for the strategic research.

The National University at Palmira will become actively involved through training (see 5.0).

4.7 Complementary Activities

The project will generate activities that cannot be undertaken within the scope of this project or will take longer than three years to complete. These include:

(i) introduction of new germplasm materials which have to be quarantined before release for initial seed increase and evaluation

(ii) incorporation of adapted germplasm into cropping systems

(iii) development of alternative forage systems to those advocated in the present proposal, e.g. agroforestry systems

(iv) assessment of the long term impact of multi-purpose forages on soil improvement, and

(v) development of propogation systems to enable widespread use of newly identified germplasm.

5.0 Training

5.1 Training of Colombian scientists

National University students from Palmira will be given on site training in and be able to undertake B.Sc./ M.Sc. theses in areas of:

- Forage evaluation, livestock production, crop-livestock systems, soil rehabilitation using legume-based systems, evaluation of soil sustainabilitiy using indicator crops in association with soil and plant analysis.

The areas of study for Colombian students have been well defined

Contacts have been established with:

- Professor Edgar Madero, Soils Department
- Professor Eugenio Escobar, Agronomy Department
- Professor, Hugo Sánchez, Livestock Department

who have expressed interest in close collaboration with the Project.

Consideration will also be given to obtain funding from other sources for qualified students to undertake postgraduate studies in Germany.

5.2 Training of German scientists

Doctoral thesis studies will be carried out on the following subjects:

(i) Legumes and fallow improvement

(ii) Improved legume-based crop-livestock systems

(iii) Soil fertility dynamics under different land use systems in hillside farming

German diploma students will work in Colombia for four months during the main growing season assisting in field work. They will be allocated specific studies (e.g., see 4.1.3). They will be allocated specific studies (e.g., see 4.1.3). Data collected during this time will serve towards a Diploma.

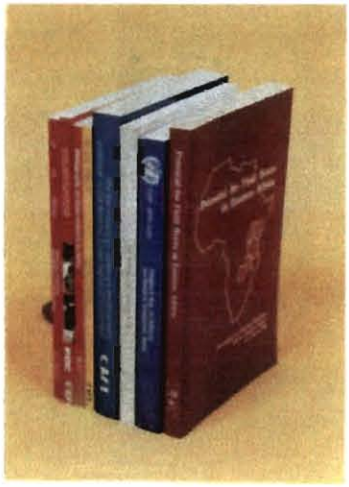
5.3 Training workshop

A training workshop will be held for scientists of collaborating institutions.

6.0 Expected Patentable Research Results

CIAT endorses the principle of free access to research results. It supports this through publication of research findings in international journals and in-house documents.

There are no patentable results anticipated in this project.



7.0 Funding Requirements

The budgets for CIAT, the University of Hohenheim, the Humboldt University of Berlin and Bayreuth University appear in Table 3.

Table 3

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL – CIAT

BMZ – FORAGES FOR SOIL IMPROVEMENT AND ANIMAL FEED SUPPLY

PROPOSED BUDGET
IN US$ DOLLARS

LINE ITEM	Year 1	Year 2	Year 3	TOTAL
CIAT US$				
Personnel				
Research assistant 3 man/yrs	15,000	15,750	16,550	47,300
Research technicians (2) – 6 man/yrs	18,500	18,900	19,800	57,200
Field labourers (6) – 18 man/yrs	36,000	37,800	39,700	113,500
Total personnel	**69,500**	**72,450**	**76,050**	**218,000**
Research and operations				
Supplies and services : Fencing, land preparation, seed, fertilization, water supplies	20,000	16,000	12,000	48,000
Vehicle : hire and maintenance	12,000	12,600	13,200	37,800
Laboratory analysis	8,500	8,000	6,000	22,500
Total research and operations	**40,500**	**36,600**	**31,200**	**108,300**
Travel and coordination				
Local – Cauca – per diems	6,500	7,000	5,000	18,500
Coordination	5,000	6,000	6,000	17,000
Total travel and coordination	**11,500**	**13,000**	**11,000**	**35,500**
Training and inter–Institutional cooperation				
Training undergraduate and graduate students	9,000	9,500	10,000	28,500
Funds for on–farm research	6,000	7,000	8,000	21,000
Total training and inter–Institutional cooperation	**15,000**	**16,500**	**18,000**	**49,500**
Indirect costs	**26,384**	**26,780**	**26,336**	**79,500**
Equipment				
Motorcycles (3)	9,000	–	–	9,000
Total equipment	**9,000**	–	–	**9,000**
TOTAL CIAT	171,884	165,330	162,586	499,800

ABRAHAM E. ESPINO
FINANCIAL CONTROLLER

Table 3

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL – CIAT

BMZ – FORAGES FOR SOIL IMPROVEMENT AND ANIMAL FEED SUPPLY

PROPOSED BUDGET

IN US$ DOLLARS

LINE ITEM	Year 1	Year 2	Year 3	TOTAL
UNIVERSITY OF HOHENHEIM BUDGET				
Personnel				
PhD student (1) (12 mo/yr)	30,000	30,000	30,000	90,000
MSc students (3) (6 mo/yr)	4,000	4,000	4,000	12,000
Total personnel	**34,000**	**34,000**	**34,000**	**102,000**
Materials and operational expenses				
Literature searches, photocopies, telecommunications freight expenses, publications	2,000	3,000	3,000	8,000
Total materials and operational expenses	**2,000**	**3,000**	**3,000**	**8,000**
Travel				
Local – (Germany)	700	700	700	2,100
International : PhD student	3,000	–	3,000	6,000
Supervisor	5,000	5,000	5,000	15,000
Total travel	**8,700**	**5,700**	**8,700**	**23,100**
TOTAL UNIVERSITY OF HOHENHEIM	**44,700**	**42,700**	**45,700**	**133,100**
HUMBOLDT UNIVERSITY OF BERLIN				
Personnel				
PhD student (1) (12 mo/yr)	30,000	30,000	30,000	90,000
MSc students (3) (6 mo/yr)	–	4,000	4,000	8,000
Total personnel	**30,000**	**34,000**	**34,000**	**98,000**
Materials and operational expenses				
Literature searches, photocopies, telecommunications freight expenses, publications	2,000	3,000	3,000	8,000
Portable computer	4,000	–	–	4,000
Total materials and operational expenses	**6,000**	**3,000**	**3,000**	**12,000**
Travel				
Local – (Germany)	700	700	700	2,100
International : PhD student	3,000	–	3,000	6,000
Supervisor	5,000	5,000	5,000	15,000
Total travel	**8,700**	**5,700**	**8,700**	**23,100**
TOTAL HUMBOLDT UNIVERSITY OF BERLIN	**44,700**	**42,700**	**45,700**	**133,100**

Table 3

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL – CIAT

BMZ – FORAGES FOR SOIL IMPROVEMENT AND ANIMAL FEED SUPPLY

PROPOSED BUDGET
IN US$ DOLLARS

LINE ITEM	Year 1	Year 2	Year 3	TOTAL
UNIVERSITY BAYREUTH				
Personnel				
PhD student (1) (12 mo/yr)	30,000	30,000	30,000	90,000
MSc students (3) (6 mo/yr)	4,000	4,000	4,000	12,000
Total personnel	**34,000**	**34,000**	**34,000**	**102,000**
Operational expenses				
Laboratory costs	10,000	10,000	10,000	30,000
Supplies and services (e.g. transport of soils samples to Bayreuth; copies, fax, telephone)	5,000	5,000	5,000	15,000
Total materials and operational costs	**15,000**	**15,000**	**15,000**	**45,000**
Travel				
Local – Germany	700	700	700	2,100
International : *PhD student*	3,000	3,000	3,000	9,000
Supervisor + per diem	5,000	5,000	5,000	15,000
Total travel	**8,700**	**8,700**	**8,700**	**26,100**
TOTAL BAYREUTH UNIVERSITY	57,700	57,700	57,700	173,100
GRAND PROJECT TOTAL : ALL PARTNERS	318,984	308,430	311,686	939,100

BMZ-FORRAJES
03-Dec-93
PROPOSED

Budget Notes

7.1 Personnel

Pre-doctoral students from Germany will undertake the core activities outlined in the work plan, supported by diploma students. Limited activities will also be undertaken by Colombian undergraduate and M.Sc. students.

Research assistant. This person would be employed to coordinate these work activities, purchases, travel of personnel, and in some cases initiate and maintain preliminary or on-going activities. While an experienced local associate with an M.Sc. degree would best fill this role, we have restricted the appointment to a research assistant level (B.Sc. degree).

Research technicians. These persons will assist the Ph.D. students in the preparation, planting, maintenance, and sampling of field experiments and sample preparation for analysis.

Field labourers. These persons are required to carry out basic field operations under supervision of the research technicians.

7.2 Research and operational expenses and capital

The research area is located off station on land rented from farmers one hour's drive from the CIAT experimental station at Quilichao, two hours from CIAT head quarters at Palmira. This will necessitate the purchase of experimental materials, including fencing to protect experimental plots. Two vehicles will be leased from CIAT to transport students and CIAT technical staff. Motorcycles will be located in the area for use of students and technicians.

The laboratory analyses in the CIAT budget are to cover costs of the student from Hohenheim. All analyses for activity 4.2 will be carried out at the University of Bayreuth. Some analyses cannot be carried out at CIAT and there is also presently a long delay on routine analyses because of low staff levels. A computer will be required by Humboldt University for on-farm data collection and data analyses.

7.3 Travel and coordination

Per diem expenses have to be paid to local CIAT staff because they need to travel away from an experiment station. It is planned to hold coordination meetings each year of all CIAT supervisory and technical personnel and cooperating institutions. Some of the coordination funds will be used for printing and distributing progress reports.

7.4 Training and inter-institutional cooperation

Students from the national Universities are paid a small allowance when working on CIAT projects. Funds need to be available to rent land or guarantee farmers incomes do not suffer as a result of cooperation.

8.0 References

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Appendix A

List of Institutions which Participate in CIPASLA

(Consorcio Inter-Institucional para la Agricultura Sostenible en Laderas)

CVC	Corporación Regional del Valle del Cauca, Cali
CVC	Corporación Regional del Valle del Cauca, Piendamó, Cauca
C.R.C.	Corporación para la Reconstrucción y el Desarrollo del Departamento del Cauca, Popayán, Cauca
CORPOTUNIA	Corporación para el Desarrollo de Tunía, Tunía, Cauca
CETEC	Corporación para Estudios Inter-disciplinarios y Asesoría, Técnica
CIAT	Centro Internacional de Agricultura Tropical, Cali
COMITE DE CAFETEROS DEL CAUCA, Popayán	
HIMAT	Instituto Colombiano de Hidrología, Meteorología y Adecuación de Tierras, Popayán
FONDO DRI	Fondo de Desarrollo Rural Integrado, Popayán
FIDAR	Fundación para la Investigación y Desarrollo de la Agricultura Rural, Cali
RENORDE	Red Nacional de Cooperación para el Ordenamiento y Manejo de Cuencas, Cali
UMATA	Unidades Municipales de Asistencia Técnica Agropecuaria, Caldono, Cauca
FUNDACION SOL Y TIERRA, Popayán	
SENA	Servicio Nacional de Aprendizaje, Popayán

Appendix B-1

CIAT C.V.

Centro Internacional de Agricultura Tropical

Name: **Peter C. Kerridge**

Position in Project: Research Scientist, Forage Agronomist.
Project Coordinator

Citizenship: Australian

Country of Residency: Colombia

Education:

B. Agr. Sc., 1958
University of Queensland (Australia)

Ph.D., in Plant Nutrition. 1968
Oregon State University (USA)

Languages:

English	-Native
Spanish	-Conversational, reading
Indonesian	-Conversational, reading

Management Experience:

Centro Internacional de Agricultura Tropical (CIAT)
Cali, Colombia
Leader, Tropical Forages Program
1992-present

Commonwealth Scientific and Industrial Research Organization (CSIRO), Brisbane, Australia
Project Leader: Phosphorus and animal production
1978 - 1990

Australian International Development Assistance Bureau (AIDAB), Australia
Project Leader: Establishment of a grassland research unit.
1973 - 1978

- Stability of native pastures oversown with legumes
  1990 - 1992

Research Experience:

Commonwealth Scientific and Industrial Research Organization (CSIRO), Brisbane, Australia
Division of Tropical Crops and Pastures
Principal Research scientist
1978-1992

- Research on the requirement and supply of phosphorus for growing cattle; adaptation of legumes to nutrient supply; soil fertility and pasture stability.

Seconded to **Australian International Development Assistance Bureau** (AIDAB) to work with the Malaysian Agricultural Research and Development Institute
Senior Research Scientist
1973-1978

- Research on evaluation of grass and legume forage species; nutritional deficiencies of main soil types; nodulation studies; evaluation of fertilizers; productivity of grass legume pastures.

Commonwealth Scientific and Industrial Research Organization (CSIRO), Brisbane, Australia
Division of Tropical Agronomy
Research Scientist
1968-1973

- Research on fertilizer requirements of tropical pastures for dairying on the Atherton Tableland; molybdenum requirement of pasture legumes.

University of Oregon, Corvallis, Oregon, USA
Teaching Assistant
1964-1968

- Research on aluminium tolerance in wheat; *molybdenum* and sulphur nutrition of subterranean clover pastures.

University of Agriculture, Bogor, Indonesia
Lecturer
1961-1964

- Research on evaluation of forage crops; nutrition of forage species; and utilization of corn stover for draft animals.

University of Queensland, Australia
Research Fellow
1958-1961

- Research on pasture improvement and fodder conservation in semi-arid areas of western Queensland; ecological study of *Psoralea erianthia*.

Membership in Scientific Societies:

- Tropical Grassland Society of Australia
- Australian Society of Animal Production
- Australian Society of Soil Science

Consulting Editor:

Plant and Soil 1981-1986.

Editor:

Tropical Grasslands 1989-1991.

Areas of Specialization:

Edaphic adaptation of tropical forages; the relation between soil fertility and animal production; forage systems for smallholders.

Publications:

(Author of 36 articles and 13 book chapters, a representative sample of which appear here)

Kerridge, P.C. 1991. Adaptation of shrub legumes to acid soils. Proceedings of the Second International Symposium of Plant-Soil Interactions at Low pH, West Virginia, 1990. pp. 977-87

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Kerridge, P.C. and McLean, R.W. 1989. Soil fertility and beef production in the semi-arid sub-tropics. XVI International Grassland Congress, Nice, France, 1989. pp. 1191-2

Kerridge, P.C., McLean, R.W. and Jones, R.M. 1992. The impact of soil fertility and legume on the yield and persistence of buffel grass. Proceedings of the Australian Agronomy Conference, Armidale, February, 1992. 4 pp.

Kerridge, P.C., Edwards, D.G. and Sale, P.W.G. 1986. Soli fertility constraints amelioration and plant adaptation. In Forages in Southeast Asian and South Pacific Agriculture. (Eds G.J., Blair, D.A., Ivory and T.R., Evans) pp. 179-187. (Australian Centre for International Agricultural Research: Canberra)

Kerridge, P.C., Gilbert, M.A. and Coates, D.B. 1990. *Phosphorus* and beef production in northern Australia. 8. The status and management of soil phosphorus in relation to beef production. Trop. Grasslds 24, 221-30 pp.

Rao, I.M. and Kerridge, P.C. (1993) Mineral nutrition of forage *Arachis*. In: Kerridge, P.C. and Hardy, B. (eds.). Biology and agronomy of forage *Arachis*. CIAT, Cali, Colombia. (In press.)

Salinas, J. G., P. C. Kerridge, and R. M. Shunke. 1987. Mineral nutrition of Centrosema. 51 p. In: R. Schultze-Kraft and R. J. Clements (eds. Centrosema - Biology, Agronomy and Utilization.

Appendix B-2

CIAT C.V.

Centro Internacional de Agricultura Tropical

Jacqueline Anne Ashby

Position in Project:

Research Scientist, Rural Development Sociologist.
Supervising participatory research.

Citizenship:

USA/United Kingdom

Country of Residency:

Colombia

Education:

Ph.D., Development Sociology, Cornell University
Ithaca, New York, 1980.

Diploma of Education, Cambridge Institute of Education
University of Cambridge, England, 1971.

B.A. Honours, History, University of York
England, 1969.

Languages:

English, Spanish - Fluent
French, Nepali - Basic

International Project and Management Experience:

Centro Internacional de Agricultura Tropical (CIAT)
Hillside AgroEcosystem Program Leader, 1992 to present
Directed several special projects.

Centro Internacional de Agricultura Tropical (CIAT)
Senior Scientist, 1987-1992
Director of the Special Project "Farmer Participation in Technology Design and Transfer", supported by the W.K. Kellogg Foundation: research for development of participatory methodology of technology evaluation; training and training materials development.

International Fertilizer Development Center (IFDC)
Senior Staff Sociologist, 1981-1987
Farming systems team member, adoption studies and gender issues. Directed special project on participatory research.

Rockefeller Foundation
International Postdoctoral Fellow IFDC/CIAT Colombia
1980-1981
Research of farmer decision-making in soil conservation (special project).

Tribhuvan University and **APROSC**
Research Associate, Kathmandu, Nepal.
1975-1978

Areas of Specialization:

Environment, technology, and social organization. Participatory community development. Women in agricultural development. Farming systems research and extension.

Publications:

(Author of 27 journal articles and book chapters, a representative sample of which appears here)

"Adopters and Adapters: The Participation of Farmers in On-Farm Reserach". J.A. Ashby in Planned Change in Farming Systems R. Tripp (ed). Wiley Sayce,1991.

"Targeting New Technology at Consumer Food Preferences in Developing Countries" W. Janssen, J.A. Ashby, M. Carlier and J. Castaño, Food Quality and Preference, 1992.

"Small Farmers' Participation in the Design of Technologies" in Altieri, M. and S. Hecht (eds.) Agro-Ecology and Small Farm Development, Boca Raton, FLA, CRC Press, 1990:245-256.

"Farmer Participation in Technology Development: Work with Crop Varieties". Jacqueline A. Ashby, Carlos A. Quirós and Yolanda M. Rivera. In Robert Chambers, Arnold Pacey and Lori Ann Thrupp (ed.) Farmer First. Farmer Innovation and Agricultural Reserach, Intermediate Technology Publications, Southampton Row, London, 1989. pp. 115-122.

"Agricultural Ecologies in the Mid-hills of Nepal". Jacqueline A. Ashby and Douglas H. Pachico. In Comparative Farming Systems. (ed). (Stephen B. Brush and Turner II, B.L.), Guildford Publications Inc., New York. 1988: 195-222.

"Methodology for the Participation of Small Farmers in the Design of On-Farm Trials". Jacqueline A. Ashby. Agricultural Administration, March/April 1986.

Appendix B-3

CIAT C.V.

Centro Internacional de Agricultura Tropical

Carlos E. Lascano

Position in Project: Animal Research Scientist. Supervising research on prototype feeding systems

Citizenship: Colombian

Country of Residency: Colombia

Education:

Ph.D. Ruminant Nutrition
Texas A&M University, 1979

M.Sc. Animal Science
University of Arizona, 1970

B.Sc. Animal Science
University of Arizona, 1967

Agronómo, Escuela Agrícola Panamericana
Zamorano, Honduras, 1965

Management and Administrative Experience:

Acting Leader of Tropical Forages Program on several occasions

International Research Experience:

Centro Internacional de Agricultura Tropical (CIAT)
Montería, Colombia, 1972-1976
Coordinator of livestock production training course in north coast of Colombia.

Centro Internacional de Agricultura Tropical (CIAT)
Cali, Colombia, 1979-present
Research on pasture management, forage quality and on-farm pasture evaluation.

Teaching and Thesis Supervisory Experience:

Teaching of applied animal nutrition
Universidad Nacional de Colombia, Medellín.

Teaching of forage quality evaluation and pasture management in tropical pastures, yearly training courses at CIAT.

Supervision of Ph.D. Thesis (4), M.Sc. Thesis (8), Diploma thesis (12).

Languages:

English	- Fluent
Spanish	- Fluent
Portuguese	- Reading

Professional Memberships:

- Asociación Latinoamericana de Producción Animal (ALPA)
- Member of Continuing Committee of the International Grassland Congress (1985 to 1993).

Major Publications and Reports in five years:

Editor or co-editor of 3 books on pasture research methodology

1. Recomendaciones para evaluar germoplasma bajo pastoreo (1983)
2. Recomendaciones generales para evaluar pasturas con animales (1986)
3. Establecimiento y renovación de pasturas (1991)

Major Publications and Reports in past five years:

Abaunza, M.A., Lascano, C., Giraldo, H. and Toledo, J.M. 1991. Valor nutritivo y aceptabilidad de gramíneas y leguminosas forrajeras tropicales en suelos ácidos. Pasturas Tropicales, 13:2-9.

Camarao, A.P., Neto, M.S., Serrao, E.A., Rodrigues, I.A. and Lascano, C. 1990. Identificacao e composicao quimica de especies de invasoras consumidas por bovinos em pastagens cultivados em Paragominas, Pará. Boletim de Pesquisa No. 104, EMBRAPA-CPATU, Belem, PA, Brasil. 62 p.

Carulla, J., Lascano, C. and Ward, J.K. 1991. Selectivity of resident and esophageal fistulated steers grazing an association of *Arachis pintoi* and *Brachiaria dictyoneura* in the Llanos of Colombia. Tropical Grassl. (accepted for publication).

Jones, R.J. and Lascano, C. 1992. Oesophageal fistulated cattle can give unreliable estimates of the proportion of legume in the diets of resident animals grazing tropical pastures. Grass and Forage Science 47:128-132.

Lascano, C. and Estrada, J. 1989. Long-term productivity of legume- based and pure grass pastures in the eastern plains of Colombia. XVI Int. Grassl. Cong. Nice, France pp. 1179-1180.

Lascano, C., Estrada, J. and Avila, P. 1989. Animal production of pastures based on *Centrosema* spp. in the Eastern Plains of Colombia. XVI Int. Grassl. Cong., Nice, France, p. 1177-1178.

Lascano, C. 1990. Metodología para medir consumo bajo pastoreo. En: Ruiz Manuel E. y Ruiz Arnoldo (Eds.). Nutrición de rumiantes: Guía metodológica de investigación. ALPA, RISPAL e IICA, San José, Costa Rica. pp. 149-157.

Lascano, C. and Quiroz, R. 1990. Metodología para estimar la dinámica de la digestión en rumiantes. En: Ruiz Manuel E. y Ruiz Arnoldo (Eds.). Nutrición de rumiantes: Guía metodológica de investigación. ALPA, RISPAL e IICA, San José, Costa Rica. pp. 89-104.

Lascano, C. and Plazas, C. 1990. Bancos de proteína y energía en sabanas de los Llanos Orientales de Colombia. Pasturas Tropicales 12:9-15.

Lascano, C., Teitzel, J.K. and Kong, E.P. 1990. Nutritive value of *Centrosema* and animal production. In: Schultze-Kraft, R. and Clements, R.J. (eds.). *Centrosema*: Biology, agronomy and utilization, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. pp. 293-319.

Lascano, C. and Thomas, D. 1990. Quality of *Andropogon gayanus* and animal productivity. In: Toledo, J.M., Vera, R., Lascano C. and Lenné, J.J. (eds.). *Andropogon gayanus* Kunth-A grass for tropical acid soils. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. pp. 247-275.

Lascano, C., Rodríguez, J.C. and Avila, P. 1990. Niveles de úrea en la leche como un *indicativo* del consumo de leguminosas tropicales por animales en pastoreo. Pasturas Tropicales 12:38-40.

Lascano, C. 1991. Managing the grazing resource for animal production in savannas of tropical America (Harry Stobbs Memorial Lecture). Tropical Grasslands 25:66-72.

Lascano, C., Avila, P., Quintero, C.I. and Toledo, J.M. 1991. Atributos de una pasturas de *Brachiaria dictyoneura-Desmodium ovalifolium* y su relación con la producción animal. Pasturas Tropicales 13:10-20.

Lascano, C. and Avila, P. 1991. Potencial de producción de leche en pasturas solas y asociadas con leguminosas adaptadas a suelos ácidos. Pasturas Tropicales 13:2-10.

Lascano, C. and Spain, J.M. (eds.). 1991. Establecimiento y renovación de pasturas. Memorias VI Reunión del Comité Asesor de la RIEPT, Veracruz, México, 1988. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. 425 p.

Lascano, C. and Palacios, E. 1993. Intake and digestibility by sheep of mature grass alone and in combination with two tropical legumes. Tropical Agriculture (in press).

Narváez, N. and Lascano. C. 1989. Digestibilidad *in vitro* de la materia seca de especies forrajeras tropicales. 1. Comparación de métodos de determinación. Pasturas Tropicales 11:13-18.

Narváez, N. and Lascano, C. 1989. Digestibilidad *in vitro* de la materia seca de especies forrajeras tropicales. 2. Factores asociados con su determinación. Pasturas Tropicales 11:19-23.

Reátegui, K., Ruiz, R., Cantera, G. and Lascano, C. 1990. Persistencia de pasturas asociadas con diferentes manejos del pastoreo en un ultisol arcilloso de Puerto Bermúdez, Perú. Pasturas Tropicales 12:16-24.

Rojas, M.E. and Lascano, C. 1991. Competencia entre *Andropogon gayanus* y *Stylosanthes capitata* en pasturas asociadas bajo pastoreo. Pasturas Tropicales 13:2-8.

Schultze-Kraft, R., Lascano, C., Benavides, G. and Gómez, J.M. 1989. Relative palatability of some litte-known tropical forage legumes. XVI Int. Grassl. Cong., Nice, France. p. 785-786.

Toledo, J.M., Vera, R.R., Lascano, C. and Lenné, J.M. 1989. Priorities for research on *Andropogon gayanus*. In: Toledo, J.M., Vera, R.R., Lascano, C. and Lenné, J.M. (eds.). *Andropogon gayanus* Kunth: A grass for tropical acid soils. CIAT, Cali, Colombia. pp. 323-356.

Appendix B-4

CIAT C.V.

Centro Internacional de Agricultura Tropical

Brigitte Lucie Maass

Position in Project: Research Scientist, Germplasm specialist. Supervising research on forage evaluation

Citizenship: German

Country of Residency: Colombia

Education:

Dr. sc. agr. (Doctor in Agricultural Sciences)
Georg-August-University of Göttingen, Germany, 1988

Dipl.-Ing. agr. (Diploma in Agricultural Sciences with specialization in plant production)
University of Stuttgart-Hohenheim, Germany, 1978

Languages:

German	- mother tongue
English, Spanish	- fluent
French	- working knowledge
Portuguese	- basic knowledge

Professional Experience:

Landscape-Planning Office Valentien & Valentien SRL
Stuttgart, Germany
1978-1980

- Landscape-planner Emphasis on agriculture, forestry, and ecology in Southern Germany.

German Agency for Technical Cooperation (GTZ),
Eschborn, Germany

- Pasture expert in the project "Pasture Improvement in the Central Highlands of Peru" 1980-1983. Responsibility in evaluation of native pasture species,

plant introduction of exotic species into native pastures, agrostologic analysis of plant communities, and supervision of undergraduate thesis students. (Huancayo, Peru, Feb. 1981 - May 1983).1983

- **Hendrikson Associierte Consultants GmbH** (HAC), Eschborn, Germany: Ecological and agricultural expert in project identification mission for the Environmental Program of the United Nations (UNEP) in Peru. 1983

- **Georg-August-University Göttingen**, Institute of Crop Science and Plant Breeding, Göttingen, Germany: Visiting Research Associate at the International Center of Tropical Agriculture (CIAT), Cali, Colombia (Feb. 1984 -July 1986); and at the Federal Research Centre of Agriculture (FAL), Braunschweig, Germany (Aug. 1986 - Aug. 1987), responsible for germplasm evaluation of the tropical forage legume *Stylosanthes scabra* Vog.

- **Federal Research Centre of Agriculture** (FAL), Institute of Grassland and Forage Research, Braunschweig, Germany: Visiting Researcher elaborating a doctoral thesis. 1987-1988

- **International Center for Tropical Agriculture** (CIAT), Tropical Pastures Program (TPP), Cali, Colombia: Postdoctoral Fellow in tropical pastures germplasm evaluation, and interim leader of the CIAT TPP Humid Tropics Screening Site at Pucallpa, Peru (Feb. - Oct. 1989).

- **International Center for Tropical Agriculture** (CIAT), Genetic Resources Unit (GRU), Cali, Colombia: Postdoctoral, since Feb. 1992, Senior Research Fellow, Genetic Resources Specialist, responsible for the GRU Tropical Forage Germplasm Section (Cali, Colombia, Nov. 1989 - Aug. 1992).

- **International Center for Tropical Agriculture** (CIAT), Tropical Forages Program (TFP), Cali, Colombia: Senior Staff, Germplasm Specialist, head of the TFP Germplasm Section (Cali, Colombia since Sept. 1992 to present).

International Research Experience:

- Royal Botanic Gardens, Kew, England-CIAT. RBG/ CIAT/ODA.

  Taxonomic revision of species from the genus *Brachiaria* held in the tropical forage germplasm collection at CIAT.

Membership in Scientific Societies:

- Gesellschaft für Pflanzenbauwissenschaften, Germany
- Gesellschaft für Ökologie, Germany
- International Mountain Society, Boulder, Colorado, U.S.A.
- Tropical Grassland Society of Australia

Relevant Publications:

Maass, B. L. 1989. (The tropical forage legume *Stylosanthes scabra* Vog. - variability, performance, and possibilities for improvement through plant breeding). Landbauforschung Völkenrode, Braunschweig, Sonderheft 97, 140 pp. (In German).

Iwanaga, M.; Maass, B. L.; Hidalgo, R. 1991. Plant Genetic Resources: The key to CIAT's mission to help national agricultural systems. Diversity 7(1/ 2):12-14.

Lascano, C. E.; Maass, B. L.; Thomas, R. J. 1992. Multipurpose trees and shrubs at CIAT. Paper presented at the Consultative meeting on ICRAF's proposal for the development of Multipurpose Tree Germplasm Resource Centre, 2-5 June 1992, Nairobi, Kenya.

Maass, B. L. 1992. Research needs and opportunities in CIAT's tropical forage germplasm collection. Abstract of seminar. June 30, 1992, CIAT, Cali, Colombia.

Thomas, R. J.; Lascano, C. E.; Perdomo, P.; Maass, B. L. 1992. Woody forage legumes for the acid soils of tropical America. Abstract, Conference on Tropical Trees: The Potential for Domestication. 23-28 August 1992, Edinburgh, Great Britain.

Maass, B. L.; Schultze-Kraft, R. 1993. Characterisation and preliminary evaluation of a large germplasm collection of the tropical forage legume *Stylosanthes scabra* Vog. Proceedings of the XVII International Grassland Congress. 8-21 February 1993, New Zealand and Queensland, Australia. (In press)

Torres G., A. M.; Belalcázar G., J.; Maass, B. L.; Schultze-Kraft, R. 1993. Inventario de las especies forrajeras tropicales mantenidas en CIAT/Inventory of Tropical forages species at CIAT. Working Document No. 125. CIAT, Cali, Colombia. 36 p.

Appendix B-5

CIAT C.V.

Centro Internacional de Agricultura Tropical

Edwin Bronson (Ron) Knapp

Position in Project: Research Soil Scientist, Cropping Systems Specialist. Supervising research on soil fertility

Citizenship: USA

Country of Residency: Colombia

Education:

Ph.D., Soil Biochemistry/physics, Washington State University, Pullman WA. April 1980

M.S., Soil Biochemistry, Washington State University, Pullman, WA. December 1978

B.A., Economics, Dartmouth College, Hanover, N.H. June 1965

Languages:

English	-Native
Spanish	-Conversational

International Research Experience:

Centro Internacional de Agricultura Tropical, (CIAT)
Cali-Colombia
Nov. 1992 to present

- Research on the sustainability of agricultural systems in Hillside Agro-ecosystems focusing on defining relationships for productivity - degradation, market cost - soil equilibrium

Centro Internacional de Mejoramiento de Maíz y Trigo, (CIMMYT), Cali-Colombia
Jan. 1987 - Nov. 1992

- Developed detailed crop management, climate and soil databases and maize dot density distribution maps; developed stochastic yield gap analyses using OFR results,

crop modelling and GIS analysis; carried out geostatistical spatial analyses to improve selection in abiotic stress breeding nurseries affected by pronounced variability over short distances; studied sustainability mechanisms related to fertility and soil acidification resulting from maize cultivation in one acid soil savanna ecosystem.

Centro Internacional de Mejoramiento de Maíz y Trigo, (CIMMYT), Texcoco (El Batan), Mexico
Oct. 1980 - Jan. 1987

- Designed, managed and taught a seven month field oriented, in-service production training course for university graduate agronomists from LDCs. Supervised graduate students and organized short term, in-country courses. Consulted for the World Bank.

Professional Memberships:

- American Society of Agronomy
- Crop Science Society of America

Publications

Osmanzi, M., S. Rajaram, and E.B. Knapp. (1987). Breeding for Moisture-stressed Areas. In: Drought Tolerance in Winter Cereals. ed. J. P. Stivastava, E. Porceddu, E. Alcevedo, and S. Varma. 1987 ICARDA. John Wiley & Sons Ltd.

Knapp, E.B. and A. Violic. (1989). Manejo de Experimentos en Fincas Bajo el Sistema de Labranza de Consevación. In: XI Seminario. Labranza de Conservación en Maíz. Ed. H. Barreto, R. Raab, A. Tasistro y A. D. Violic. IICA-BID-PROCIANDINO. 1989. Quito, Ecuador. PROCIANDINO. 195p.

Knapp, E.B., O. Urdinola M., O. Carmen C., and A. Ramírez V. (1990). Diagnosticando Prioridades de Investigación y Extensión: Un Estudio de Casos en la Zona de Ladera, Valle del Cauca, Colombia. In: Memorias XIII Reunión de Maiceros Zona Andina. Chiclayo, Peru. 25-30 Sept. 1988. INIPA, Lima Peru. p180-194.

Knapp, E.B., S. Pandey, and H. Ceballos. (1990). El Programa Regional Suramericano de Maíz del CIMMYT 1989-1990. In: Memorias XIV Reunión de Maiceros de la Zona Andina. Maracay, Venezuela. 17-21 Sept. 1990.

Knapp, E.B. (1990). La Formulación de Recomendaciónes a partir de Datos Agronómicos o: Datos son Datos, Información es Poder. In: VII Curso Corto. Sistemas de Producción: Investigación en Campos de Productores (Caso Maíz). IICA-BID PROCIANDINO. 1990. Quito, Ecuador. PROCIANDINO. 191p.

Knapp, E.B., S. Pandey, and H. Ceballos. (1992). The Use of Spatial Analysis in Nutrient Stress Maize Breeding. In: International Symposium on Environmental Stress: Maize in Perspective. Belo Horizonte, MG, Brazil. 8-13 March 1992. EMBRAPA-CIMMYT. in press.

Knapp, E.B. (1992). Uso de Modelos de Simulación en el Diagnóstico de Riesgos y la Formulación de Dominios de Recomendación. In: Memorias XXXVIII Reunión PCCMCA. Managua, Nicaragua. 23-27 March 1992. PCCMCA, Managua, Nicaragua.

Knapp, E.B., H. Ceballos, and S. Pandey. (1992). Uso del Análisis Espacial en Viveros de Mejoramiento de Maíz en Condiciones de Estrés por Nutrimientos. In: Memorias XXXVIII Reunión PCCMCA. Managua, Nicaragua. 23-27 March 1992. PCCMCA, Managua, Nicaragua.

Knapp, E.B. "Diagnosing Factors Limiting Productivity in Wheat Production". Twenty competency-based tutorial instructional modules.

Appendix B-6

CIAT C.V.

Centro Internacional de Agricultura Tropical

Idupulapati M. Rao

Position in Project: Research Scientist, Nutritionist/Physiologist. Supporting research on soil fertility improvement.

Citizenship: Indian

Country of Residency: Colombia

Education:

Ph.D. Plant Physiology, S.V. University, Tirupati, India, 1978

M.S. Botany, Bhopal University, Bhopal, India, 1973

B.S., Botany, Chemistry, Zoology, Andhra University, Waltair, India, 1971

Languages:

English, Telugu: - Fluent.

Hindi, Spanish: - Considerable ability in conversation, reading and writing.

International Research Experience:

Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia
Plant Nutritionist/Physiologist.
1989 - present

University of California, Berkeley, USA
Assistant Specialist
1984 - 1989

University of Illinois, Urbana, USA
Research Associate
1982 - 1983

University of Illinois, Chicago, USA
Research Associate
1981 - 1982

International Crops Research Institute for Semiarid Tropics (ICRISAT), Patancheru, India
Plant Physiologist
1979 - 1981

Supervisory Experience:

Supervision of Ph.D. and Undergraduate degree thesis projects for US, German and Colombian Universities.

Professional Memberships:

- American Society for Plant Physiology
- American Society of Agronomy
- Crop Science Society of America
- Soil Science Society of America

DOCUMENTACION

Major Relevant Publications:

I.M. Rao and P.C. Kerridge 1993. Mineral Nutrition of forage *Arachis.* In P.C. Kerridge and B. Hardy (eds.). Biology and Agronomy of forage *Arachis.* CIAT, Cali, Colombia. (in press).

I.M. Rao, R.S. Zeigler, R. Vera and S. Sarkarung 1993. Selection and breeding for acid-soil tolerance in crops: Upland rice and tropical forages as case studies. BioScience 43: 454-465.

I.M. Rao, M.A. Ayarza, R.J. Thomas, M.J. Fisher, J.I. Sanz, J.M. Spain and C.E. Lascano 1992. Soil-plant factors and processes affecting productivity in ley farming. In: Pastures for the tropical lowlands: CIAT's contribution. pp. 145-175. CIAT, Cali, Colombia.

I.M. Rao, W.M. Roca, M.A. Ayarza, E. Tabares and R. García 1992. Somaclonal variation in plant adaptation to acid soil in the tropical forage legume *Stylosanthes guianensis.* Plant and Soil 146: 21-30.

I.M. Rao, M.A. Ayarza and R.J. Thomas 1993. The use of carbon isotope ratios to evaluate legume contribution to soil enhancement in tropical pastures. Plant and Soil (submitted).

I.M. Rao, V. Borrero, M.A. Ayarza, and R. García 1993. Adaptation of tropical forage species to acid soils: The influence of varying phosphorus supply and soil type on plant growth. In: Proc. Third International Symposium on Plant-Soil Interactions at low pH, Brisbane, Queensland, Australia. (In press).

I.M. Rao, V. Borrero, M.A. Ayarza, and R. García 1993. Adaptation of tropical forage species to acid soils: The influence of varying phosphorus supply and soil type on phosphorus uptake and use. In: N.J. Barrow (ed.) Plant nutrition - from genetic engineering to field practice. pp. 345-348. Kluwer Academic Publishers, Dordrecht. The Netherlands.

I.M. Rao, M.A. Ayarza, R.J. Thomas, M.J. Fisher, C. Lascano and V. Borrero 1993. Adaptation responses of tropical grass-legume associations to acid soils. Proc. XVII International Grassland Congress, New Zealand & Queensland, Australia (in press).

Fisher, M.J., C.E. Lascano, R.J. Thomas, M.A. Ayarza, I.M. Rao, G. Rippstein and J.H.M. Thornley 1993. An integrated approach to understand soil-plant-animal interactions on grazed legume-based pastures on tropical acid soils. Proc. XVII International Grassland Congress, New Zealand & Queensland, Australia (in press).

Thomas, R.J., M. Fisher, C. Lascano, I.M. Rao, M. Ayarza and N. Asakawa 1993. Nutrient cycling via forage litter in tropical grass/legume pastures. Proc. XVII International Grassland Congress, New Zealand & Queensland, Australia (in press).

Ayarza, M.A., I.M. Rao, R.J. Thomas, M.J. Fisher, C.E. Lascano and P. Herrera 1993. Standing root biomass and root distribution in *Brachiaria decumbens/Arachis pintoi* pastures. Proc. XVII International Grassland Congress, New Zealand & Queensland, Australia (in press).

Appendix B-7

CIAT C.V.
Centro Internacional de Agricultura Tropical

Wolfgang Zech

Position in Project:	German Project Coordinator for Bayreuth University
Citizenship:	German
Country of Residency:	Germany
Education:	Habilitation (Dr. habil. for soil science and plant nutrition) Ludwig-Maximilian-University Munich, 1971 Ph.D. degree (summa cum laude), Ludwig-Maximilian-University, Faculty of Natural Sciences Munich, 1968 International Potash Institute for promoting young scientists 1966 M.Sc. Geoscience Ludwig-Maximilian-University Munich, 1962 M.Sc. Chemistry Ludwig-Maximilian-University Munich, 1961 Chemistry, soil science, geology and forest ecology Ludwig-Maximilian-University and Technical University Munich, 1957-1962
Languages:	German, English, French and Spanish (moderate)

Professional Experience:

Professor and Director, Institute of Soil Science
University of Bayreuth, 1976

Professor for Soil Science and Plant Nutrition, Institute of Soil Science, Ludwig-Maximilian-University
Munich, 1973-1975

Scientific Assistant, Institute of Soil Science
Ludwig-Maximilian-University
Munich, 1963-1972

Research Experience:

1) Ecology
2) Soil organic matter research
3) Forest ecology
4) Inorganic and organic pollutants

Appendix B-8

CIAT C.V.

Centro Internacional de Agricultura Tropical

Rainer Schultze-Kraft

Position in Project: German Project Coordinator for University of Hohenheim

Citizenship: German

Country of Residency: Germany

Education:

Field work for doctoral thesis
Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, 1976

Dr. agr. degree
Justus Liebig-University Giessen
Thesis subject: Studies on the suitability of the legume genus *Stylosanthes* for pasture improvement in tropical savannas of South America such as the Colombian Llanos Orientales".
1976

Agronomist degree. Dipl.-Ing. Agr.
Agricultural science studies, majoring in plant production
Justus Liebig-Univesity Giessen, Germany
Diploma Ing. agr.
1972

Languages:

German	- fluent
English	- fluent
Spanish	- fluent
French	- working knowledge
Portuguese	- working knowledge

Research Experience:

University of Hohenheim, Germany
Institute of Plant Production in the Tropics and Subtropics
Professor, Tropical Pastures and Forages
July, 1991 - present

Centro Internacional de Agricultura Tropical (CIAT),
Cali, Colombia
Tropical Pastures Program (TPP)
Germplasm Agronomist.

- Head of the TPP Germplasm section: Collection, introduction, preliminary evaluation and multiplication of tropical forage germplasm. 1976

- Head of the TPP Germplasm Development Unit: Coordination of research activities of seven TPP sections (Germplasm, Breeding, Plant Pathology, Entomology, Regional Trials, Agronomy-Llanos, Agronomy-Cerrados). 1980 - 1985

- Head of the TPP section Pasture Agronomy/RIEPT-Llanos: Species evaluation and selection under cutting and grazing in the Llanos ecosystem, including on-station research at Carimagua and Villavicencio (Meta, Colombia) as well as coordination of RIEPT (Red Internacional de Evaluación de Pastos Tropicales) network trials. 1989 - 1991

Justus Liebig-University, Giessen, Germany
Institute of Plant Production
Scientific Assistant
January, 1973 - April, 1973

Consultant for German Ministry of Economic Cooperation (BMZ), Perú
Agronomist
August, 1972 - September, 1972

Assistant farm manager (bananas, coconuts, citrus, dairy and beef cattle on improved pastures).
Santa Marta, Colombia
May, 1961 - August, 1967

Appendix C

German Partner Confirmation Letter

Prof. Dr. Wolfgang Zech

University of Bayreuth
Institute of Soil Science
and Soil Geography

Prof. Dr. W. Zech , 95440 Bayreuth

95440 Bayreuth
Germany
Phone: +49 - 921 - 552248
Fax: +49 - 921 - 552246

To
Centro Internacional de Agricultura Tropical
CIAT

Cali

Colombia

Letter of commitment

I hereby declare that the Institute of Soil Science at the University of Bayreuth is willing to cooperate with CIAT, and the Universities of Hohenheim and Berlin within the project

"Forages for Soil Improvement and Animal Feed Supply"

to be submitted for financiation to BMZ.

Bayreuth, 30.11.93

Prof. Dr. W. Zech

UNIVERSITÄT HOHENHEIM
INSTITUT FÜR PFLANZENPRODUKTION
IN DEN TROPEN UND SUBTROPEN
Prof. Dr. Rainer Schultze-Kraft

Postanschrift / Mailing address:
Universität Hohenheim (380), D-70593 Stuttgart

Hausadresse:
70599 Stuttgart-Hohenheim
Kirchnerstr. 5
Telefon (07 11) 459-2764
Telefax (07 11) 459-2304
E-Mail: [illegible]

Dr. Peter C. Kerridge
Tropical Forages Program
CIAT
Apartado Aéreo 6713

Cali, Colombia

Via telefax (No. 57-23-647243)

Kaduna, Nigeria
30 November 1993

Dear Dr. Kerridge,

I am writing to confirm my commitment and that of the Tropical Pastures and Forages Section of this Institute, to the special project entitled "Forages for Soil Improvement and Animal Feed Supply" which was jointly prepared by the Tropical Forages and Hillsides Programs of CIAT, and by the Universities of Bayreuth, Berlin and Hohenheim, and which will be proposed to BMZ.

Sincerely,

Rainer Schultze-Kraft

Rainer Schultze-Kraft

30 NOV. 1993

Recibido
Enviado

UNIVERSITÄT HOHENHEIM

INSTITUT FÜR PFLANZENPRODUKTION IN DEN TROPEN UND SUBTROPEN

Statement of project support and committment

The project titled "Forages for Soil Improvement and Animal Feed Supply" has been cooperatively developed and proposed by the Tropical Forages and Hillside Programs (CIAT) and the University of Hohenheim, Department of Plant Production in the Tropics and Subtropics. The research leader for the above mentioned project will be Prof. Dr. R. Schultze-Kraft. The project objectives, work plan, distribution of research responsibilities and proposed budget are supported in full by this cooperating partner.

Stuttgart-Hohenheim, 30 November 1993

Prof. Dr. D. Leihner
Head of Department

HUMBOLDT-UNIVERSITÄT ZU BERLIN
FACHBEREICH
AGRAR- UND GARTENBAUWISSENSCHAFTEN
Institut für angewandte Nutztierwissenschaften

HU Berlin - Institut für angewandte Nutztierwissenschaften
Lentzeallee 75, 14195 Berlin (Dahlem)

Prof. Dr. K.J. Peters

Fachgebiet: Tierzucht
in den Tropen und Subtropen

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Dr. Peter Kerridge
Tropical Forages Program
CIAT
Cali, Colombia

FAX: 0057 23 647243

30. November 1993
Pe/Tr

Ref.: **Project "Forages for soil improvement and animal feed supply"
to be submitted to BMZ as a special project proposed**

Dear Dr. Kerridge,

I herewith confirm the agreement to participate in the above mentioned project.

The terms and program of work to be implemented by a phD student and two MSc students are identified in the project with details to mentually agreed on.

I am looking forward collaborating in this special project.

With kind regards

Prof. Dr. K.J.Peters

01 DIC 1993

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