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Environmental Management of the Northern Zone Consolidation Project in Costa Rica:

Strategies for Sustainable Development

DESFIL

Development Strategies for Fragile Lands
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Environmental Management of the Northern Zone Consolidation Project in Costa Rica: Strategies for Sustainable Development

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LIST OF ACRONYMS

DESFIL	Development Strategies for Fragile Lands
DINADECO	Directorate for Community Development
EA	Environmental Assessment
EMS	Environmental Management Specialist
GOCR	Government of Costa Rica
IDA	Agrarian Development Institute
IEE	Initial Environmental Examination
MIDEPLAN	Ministry of Planning and Political Economy
MOPT	Ministry of Public Works and Transport
NZCP	Northern Zone Consolidation Project
NZIDP	Northern Zone Infrastructure Development Project
PCO	Project Coordinating Office

CHAPTER ONE

INTRODUCTION

1.1 Scope of Work

The U.S. Agency for International Development, through its Project Director for the Northern Zone Consolidation Project in Costa Rica (NZCP), requested technical assistance in environmental management activities to be implemented as part of the NZCP. A field review and technical analysis was carried out by a team of environmental management specialists from July through September of 1989. The team addressed the following environmental management concerns:

- **Support to Land Settlement and Titling: Assist the Agrarian Development Institute (IDA)** and participating Project communities in preparing initial environmental examinations (IEE) and/or environmental assessments (EA) for at least four farms purchased under the already completed Northern Zone Infrastructure Development Project (NZIDP) 041, including approval of a mechanism for effective management of areas identified as critical for reforestation and community watersheds.

- **Support to Crop Diversification:** Assist the Project Coordinating Officer (PCO) in preparing environmentally sound production technology packages for cacao, passion fruit, hert of plam, macadamia and black pepper. Project-supported potential cropping systems,best suited for pre-selected agriculatural areas, and other land use capabilities will be reviewed and evaluated to ensure the environmental sustainability of production activities

- **Support to Community Development:** Provide the Directorate for Community Development (DINADECO) and participating communities with recommendtaions on environmental considerations on potable water projects, including specific implementatin actins aimed at protecting and improving existing water sources and mitigating possible adverse environmental effects.

- **Support to Road Rehabilitation/Upgrading:** Assist IDA, Ministry of Public Works and Transport (MOPT) and the "Comision Mantenimiento Vial" (CMV) in providing for environmental impact assessments in mitigation needs relating to roading.

1.2 Project Background

The NZCP is a follow-on to the Northern Zone Infrastructure Development Project (NZIDP). The NZCP is expected to amplify the economic bases for the productive and sustainable development of the Northern Zone of Costa Rica through the following activities:

- Increasing non-traditional export-oriented crop production

- Developing a self-financed system for road maintenance and rehabilitation

- Supporting basic social infrasturcture improvements, including potable water projects, schools, and community health centers
- Consolidating current settlement activities through land purchases, titling services and integrated management plans for settlement areas.

1.3 Affected Environment

The project area covers approximately 265,000 hectares in the northwestern corner of Costa Rica, extending to the border with Nicaragua. A range of active volcanoes constituting the Guanacaste cordillera forms the western and southern boundaries of the project area. The northern and western boundaries are marked by the wetlands extending from Lake Nicaragua and Cano Negro, respectively.

Families are distributed in some 160 towns, villages, and hamlets, with total population estimates for the area ranging between 42,000 and 47,000 (DESFIL, 1988). Primary economic activities include small-scale crop production for domestic markets, cattle ranching, dairies, orchards, logging, and a variety of service industries. In terms of population distribution and per capita income, the Northern Zone of Costa Rica represents one of the least developed regions in the country (MIDEPLAN, 1987).

Ecologically, the Northern Zone includes a wide variety of life zones and biological communities. Using the Holdridge system of life zone classification, which integrates climatic, vegetative and other critical factors, at least seven distinct ecological zones can be identified in the project area.

The rapid change in elevation from approximately 200 meters in the lowland areas to greater than 2,000 meters at the summits of the volcanoes results in significant climatic variations. Rainfall in the lowlands is on the order of 2,500 mm per year, with distinct wet and dry seasons. On the slopes of the volcanoes, however, rainfall can be greater than 4,000 mm per year with precipitation received in all months.

The high rainfall, combined with a wide range of available habitats has encouraged a significant degree of biological diversity in this region, both in terms of plant and animal communities. The wetland areas on the northern and western edges of the project area are particularly significant areas in terms of biological diversity. The remnant primary rainforests on the slopes of the volcanoes also represent an important resource in terms of watershed protection, wildlife habitat, and plant genetic base.

1.4 Environmental Impacts From the NZCP

An Environmental Assessment (EA) of the NZCP conducted in 1988 determined that road construction and rehabilitation, in combination with proposed resettlement plans and medium-input agricultural technologies that include agrochemical use, can have potentially adverse affects on the regional environment (DESFIL, 1988).

Specifically, the activities of the NZCP will increase and concentrate human populations at the base of the heavily forested Guanacaste cordillera. Human population densities in this area are presently very low, and biological diversity is high. Increased human population densities will place more intensified demands on the fragile natural resource base in this area. In particular, new settlements will likely result in increased uses of adjacent forest resources. These uses could potentially reduce forest cover and composition.

Increased human pressures on the forest resources can result in several adverse affects, however, including the following:

- Reduction of biological diversity through habitat destruction
- Economic loss through forest conversion and poor harvesting techniques
- Changes in runoff patterns, resulting in increased downstream flooding and significant variations in seasonal surface water flows
- Increase in bare surface areas, resulting in loss of valuable topsoil and poor forest regeneration
- Degradation of surface water quality through increased instream sedimentation
- Degradation of downstream wetland biotic communities due to imbalanced sediment load depositions.

For example, recent research demonstrates that poorly managed forest harvesting can fragment forest cover and create an "island" effect within the forest community (Harris, 1984). Patches of remnant forest may not serve as sufficient habitat for many plant and animal species. Overall biotic diversity can be reduced and the genetic base for some species threatened.

It will be essential for the NZCP to include and implement careful environmental management programs to assure that changes in population centers and densities do not adversely affect remaining valuable natural resources.

1.5 Recommendations From the 1988 Environmental Assessment

The 1988 EA completed for the NZCP recommended that new activities emphasizing environmental management be included in the project implementation (DESFIL, 1988). The proposed activities for environmental management included measures to facilitate the following:

- Land-use planning and monitoring of environmental conditions
- Watershed management
- Community-based production forestry
- Conservation of wildlands and wildlife
- Environmental education and extension

To facilitate the implementation of these activities, the NZCP added an Environmental Management Specialist (EMS) to the project staff. The role of the EMS includes coordinating and directing field programs that will accomplish the measures identified in the EA.

1.6 The Role of Preliminary Environmental Planning

The objective of the present assignment was to allow the NZCP to address immediate environmental concerns relating to project implementation activities prior to the arrival of the EMS. Developing preliminary environmental management strategies for specific project components enabled the NZCP to proceed with implementation activities in a sustainable manner.

The technical assistance in environmental management was also designed to assist and facilitate the initial work of the EMS. It is anticipated that this preliminary environmental planning in a) watershed protection/community development, b) land use planning for resettlement areas, c) road maintenance, and d) sustainable agricultural technologies, will be expanded by the EMS to include all of the measures identified in the 1988 EA.

1.7 Contents of the Present Report

An individual report was prepared by each of the four team members to address the environmental management needs for the area of assignment. Each report provides detailed descriptions of the following:

- Present environmental conditions
- A summary of field and reseach activities conducted during the assignment
- Recommendations to assure that implementation activities are done in an environmentally sustainable manner.

Hopefully, the guidance in these recommendations will minimize potential adverse environmental impacts which could follow from changes in demographic and economic conditions brought about by NZCP activities.

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CHAPTER TWO

ROAD MAINTENANCE AND REHABILITATION

by Raymond Douglass
Road Engineer

2.1 Introduction

2.1.1 Scope of Work (SOW)

The SOW states, "The contractor will assist IDA, MOPT and the Comision Mantenimiento Vial (CMV) in providing for environmental impact assessments and mitigation needs relating to roading." The present report responds to this request by providing the following:

- evaluations of existing conditions, environmental impacts, and necessary mitigative measures for specific road lengths in the project area
- guidelines for environmentally sound road rehabilitation and maintenance activities
- a general review of environmental concerns which should be included in road design and maintenance
- a flow chart for preparing simple environmental impact assessments.

2.1.2 Detailed Road Related Tasks

The Roads Rehabilitation and Maintenance Specialist (RRMS) worked in Costa Rica from July 5 - July 19, 1989. Most of this time was spent conducting field reviews and meeting with project staff in the project area.

The desired activities of the Roads Engineer were defined by the Project Director and Project Advisor as follows:

First Priority - Look Into Route 4 (Trunk Road) Problems

1. Check the section of road from Upala west to the Route 4 connection, to see what can be done to prevent flooding of the road. Provide comments and suggestions.

2. Check Route 4 about 5 kms west of San Jose de Upala, to see what can be done to eliminate road failure problems along the road there. Provide comments and suggestions.

3. Check Route 4 about 2 kms to the west of Guatuso, where it passes through the Miravia Settlement, to see what can be done to prevent flooding of the road. Provide comments and suggestions.

4. Check Route 4 about 10 kms west of Upala, near Santa Clara, to see what can be done to prevent flooding of the road. Provide comments and suggestions.

Second Priority - Upala By-Pass

1. Make a reconnaissance of the proposed by-pass road between Llano Azul (near Canalete) on the Upala - Canas road and Colonia Puntarenas on Route 4 east of Upala, and identify any environmental impacts and mitigating needs. A set of the design plans for the road is being sent to Upala by the USAID for this purpose. Check the proposed location of a bridge over the Rio Chimurria.

Third Priority - Road to Aguas Claras

1. Make a reconnaissance of the section of road to be rehabilitated and upgraded between the Los Cartagos Junction near Cuatro Bocas to Aguas Claras, and identify any environmental impacts and mitigating needs.

Fourth Priority - Road from Colonia Puntarenas to Cano Negro

1. If time allows check the recently graveled road from Colonia Puntarenas to the National Wildlife Reserve at Cano Negro for environmental impacts.

Fifth Priority - Road from Aguas Claras to Colonia La Libertad

1. If Time allows check this road for environmental impacts.

Sixth Priority - Settlement Roads

1. Meet Carlos Saenz, IDA, to discuss roads to 4 planned settlements. However, be sure he understands that assistance can only be provided if Priority Tasks 1 through 5 are completed. Also, have him identify the 4 settlements in order of priority.

2. If time allows, perform a reconnaissance of the number 1 priority settlement road and identify environmental impacts and mitigating needs. Set up a procedure and model for this road which can be used by IDA for laying-out and constructing the other settlement roads.

2.1.3 Depth of Studies

The flood related tasks have been studied only superficially due to the short period of time available and lack of data on the elevation of flood waters at various critical points. Conclusions have been reached on the basis of experience, data available in the Project Office in Upala, meetings and discussions held with residents of the area, and field observations.

2.2 Route 4 Problems

During a meeting on July 8, 1989, Harry Peacock, USAID Advisor to subject project, requested an assessment of several problems related to Route 4, the recently reconstructed east-west trunk road passing through the project area. Specifically, the following actions were requested:

1. Check the section of highway to Canas where it exits Upala to the west as far as the turn-off point of Route 4 in the direction of Santa Cecilia, to see what can be done to relieve flooding of the road in this area.

2. Check Route 4 near Santa Clara to see what can be done to relieve flooding of the road in the area.

3. Check Route 4 between 40 and 45 kms west of Upala to see what can be done to eliminate the problem of slides and failure of the roadbed in side hill cut areas.

4. Check Route 4 west of Guatuso to see what can be done with the road to ease flooding of the road in the Moravia Verde Settlement area.

During the following days several visits were made to the above areas. Evaluations and recommendations include the following:

2.2.1 Flooding of Area South of Upala

The elevation of the road to Canas is a not a major factor contributing to the periodic flooding of the area. The flooding is being caused by a number of interrelated factors. Degradation of upstream watershed conditions is changing the timing and quantity of instream flows. These increased periodic flow rates, combined with increased sediment loads, is resulting in changes in channel characteristics. In particular, upstream meanders south of town may be restricting the flow of water and causing it to back up and flood the area.

Although several culverts already exist under the road through Upala, during flooding there is more water on the south side of the road than on the north side and the water has at times run over the road. To prevent the road from being flooded, it could be raised. Additional culverts could then be placed under the road to help drain the area south of the road more rapidly. The size and number of the culverts must be based on a calculation of the anticipated quantity of flood water.

An alternative to the additional culverts would be the use of paved fords in the road. However, the fords would cause a slowing of traffic on a year round basis.

2.2.2 Flooding of Area Near Santa Clara

A field inspection was made of the area on Route 4 about 10 kms west of Upala adjacent to Santa Clara. Observations and discussion with local residents indicated that the areas on both sides of the road between the Rios Guacalito and Pizotillo are subject to flooding. The road itself has been flooded, with water running over it to a depth of 1.00 meter in several locations. One result of this flow was erosion on the downstream side and some destruction of the road.

The problem was studied in November, 1986 by the firm IMNSA-Ingenieros Consultores, who recommended, as a short-term solution, that 5 fords be placed in the road in the locations where the road was previously damaged. As a long term solution, the firm recommends that low-arch corrugated steel plate culverts, 2.13 meters wide by 1.50 meters high, replace the fords.

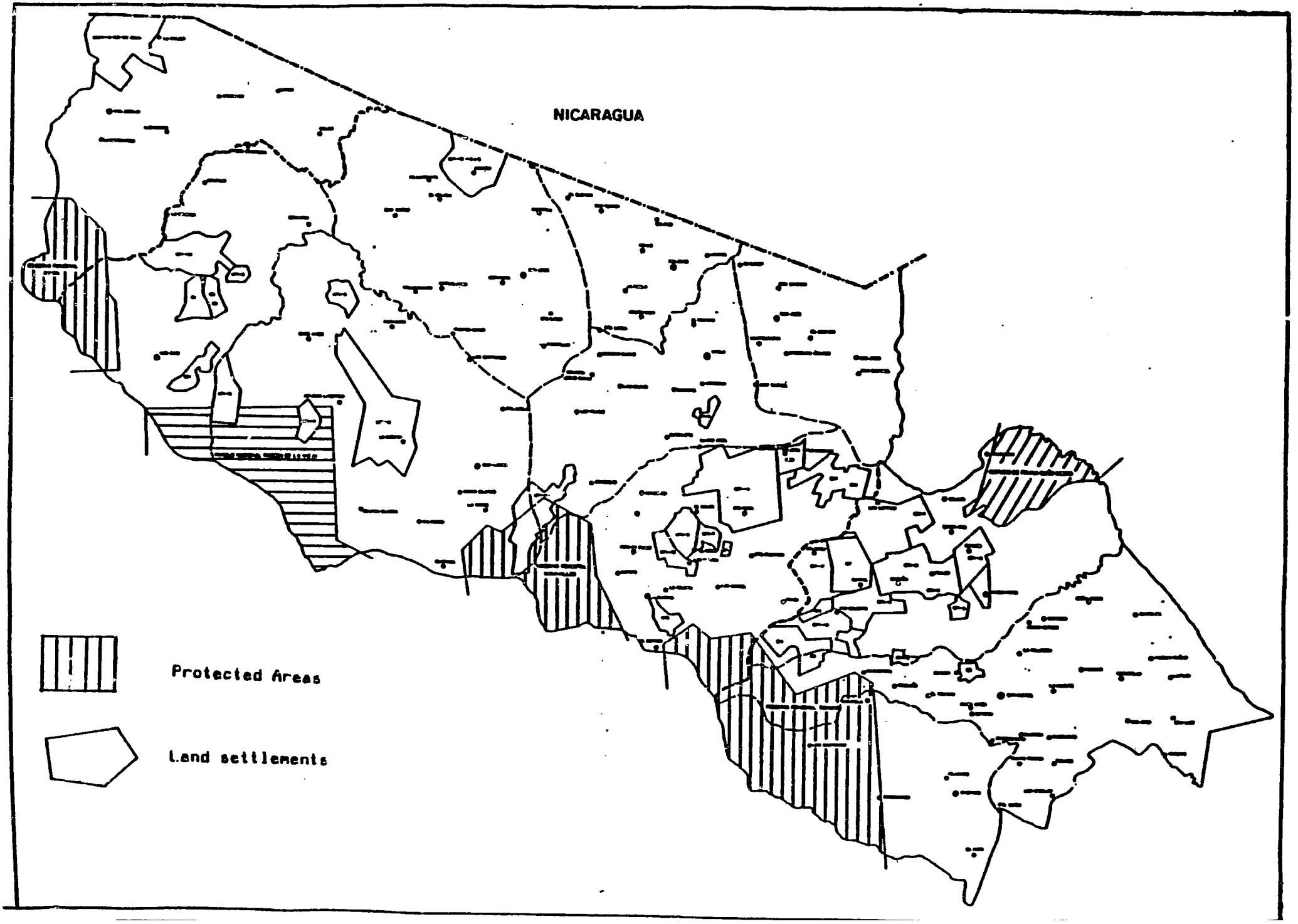
During a recent field visit neither the recommended fords nor the culverts were found, indicating that the recommendations of IMNSA have not been implemented. The culverts are necessary to prevent a reoccurrence of the road flooding, and must be installed. This will ultimately reduce erosion and siltation of the natural stream courses.

2.2.3 Flooding of the Area Around Moravia Verde Settlement

The land on both sides of Route 4 where it passed through the Moravia Verde Settlement is quite hilly, and appears to be at the same general elevation. However, the water does flow to the north, as noted at a point where a large (2 meter diameter) culvert passes under the road.

A ditch is supposed to connect the culvert to a natural water course (Rio Frio) some distance to the north. However, indications are that this ditch was never completed, so the water has no outlet and ponds adjacent to the road. To prevent future flooding, it is essential that the outlet ditch be completed to the Rio Frio as planned.

FIGURE 1
MAP OF THE NORTHERN ZONE



2.2.4 Road Failure Near Valle Bonito

A visit was made to the section of road near Valle Bonito (8 kms west of San Jose de Upala) to observe the area where there was a serious slipping of the roadbed. The road has since been completely reconstructed and realigned so the failure is not apparent.

From the location of the failure it is obvious that the fill side of a sidehill cut and fill section of the road slipped. This was probably due to the infiltration of water into the fill material. The action taken to correct the failure was to cut further back into the hill to permit the entire roadbed to rest on undisturbed soil. The roadside drainage was also improved with concrete lined ditches leading to a natural drainage canal.

Some damage to the road surface was noted due to water flowing down the road instead of to the ditches. Action should be taken quickly to reestablish the road crown and assure proper drainage on the hilly sections of the road.

2.3 Assessment of the Proposed Upala By-Pass Road From Llano Azul to Colonia Puntarenas

One of the sub-projects being considered under the NZCP Project is the rehabilitation of an existing 7 km rural road running between Llano Azul on the Upala -- Canas highway to Colonia Puntarenas on Route 4, between Upala and St. Rafael de Guatuso. It is intended that the rural road be upgraded to a two lane all weather standard, and serve as a section of Route 4, the major trunk road between the Atlantic and Pacific coasts of Costa Rica.

The present road is not constructed to a desirable standard, with steep hills, sharp curves, extremely rough and uneven surface, and poor to non-existent drainage subject to erosion. The area adjacent to the road is fully settled and developed.

2.3.1 Description of the Existing Road

The existing road leaves the Upala-Canas road about 2 kms after the Canalete turn off, when traveling from Upala. It is about 4.0 meters wide with a rough stone surface and no apparent drainage. The right of way appears to be about 10 meters. The area on both sides of the road is cleared back about 100 meters for most of its

length, with forests beyond that distance in many places. The area along the road is settled.

The road crosses short, steep hills with grades of up to 10 percent, with low points between them over the full distance of 7 kms. Some culverts were noted at the low points but water was standing on the road at some of these points as well as at other low spots. Many areas of roadside ponding were noted. There is a narrow wooden bridge over the Rio Chimurria followed by a steep hill as the road enters Colonia Puntarenas.

2.3.2 Design of the Proposed Upgraded Road

A complete design of the proposed road has been prepared by the Ministry of Public Works (MOPT). The design is based on a topographic survey of the road alignment and MOPT standards for 2-lane, all weather roads. The road will be 6.0 meters wide with 1.0 meter shoulders on each side. The road surface will be a minimum of 15 cms of select granular material over a compacted sub base of select material. The road crown will have a 4 percent slope to shoulders with a 5 percent slope. Ditches will have a 1:1 slope. Curves are designed with a minimum radius of 200 meters and the maximum slope of the road is 3.8 percent, except for a short section at 5 percent where the road enters Colonia Puntarenas.

A total of 22 culverts have been located at low points in the road to allow uninterrupted flow of natural drainage. Two of these culverts, at the Rios Patriota and Achiote, are made of large corrugated steel plates, while the others are concrete pipe of varying sizes. Also included is a 32 meter long bridge over the Rio Chimurria.

Provisions have been included in the design to minimize earth movement during construction. Erosion in deep cuts will be controlled during construction by placing berms at the tops of cuts to prevent water from cascading down the cut faces. As a feature of the design, crown ditches will be placed at the top of the cuts to intercept runoff water and route it away from the cut faces. Where considered necessary, sub-drains are to be placed under shoulders in deep cuts.

2.3.3 Environmental Impacts and Mitigation Measures

The proposed Project is for the rehabilitation/upgrading of an existing road and will not include construction of new roads. The area along the road is already developed so no new areas will be opened. Accordingly, the potential for direct environmental

impact will be limited to clearing of right-of-way, minimal diversion of drainage patterns and minor levels of dust and/or stream sedimentation during construction.

In developing the design, every effort has been made to minimize earth work operations and maintain the natural drainage flow to the maximum extent. The possibility of erosion caused by construction, roadbed rehabilitation and associated altered drainage patterns can be further minimized by seeding and mulching of road shoulders and the installation of small check dams in the drainage ditches on steep slopes. Consideration should also be given to the paving of steep grades and bridge approaches with asphalt or soil cement.

Drainage structures,bridges and culverts have been designed to channel drainage water in a manner which will not disrupt traditional drainage patterns or create potential habitats for disease vectors, or otherwise hamper the free passage of water or disrupt the aquatic plant and animal environment.

Indirect environmental impacts include increased access to local natural resources for the rural population and changes in land use. Anticipated changes in land use include more intensive cultivation of land, harvesting of wood and non-wood forest products, and conversion of remnant forests to pasture. These actions could change the timing and quantity of water and sediment received downstream, and may affect road rehabilitation and maintenance efforts.

In order to avoid future adverse environmental impacts, it is essential that the road be adequately maintained. This will require training of maintenance personnel, adequate materials and equipment to conduct field work, and provision of financing for maintenance activities. Training in maintenance tasks must include the following:

- Cleaning of drainage ditches, culverts and other drainage structures
- Maintaining a crown on the road to assure rapid water runoff
- Repair of pot holes and other surface failures
- Rapid removal of slides in ditches and on the roadbed
- Vegetative cover on shoulders and in ditches
- Protection and repair of fill slopes

The proposed by-pass road from LLano Azul to Colonia Puntarenas can have a beneficial effect on the Project area if environmentally sound designs are prepared, training opportunities are provided to maintenance staff, and regular maintenance schedules are followed. In addition, environmentally appropriate land use management practices

must be enforced in this area. Environmental education programs must establish the importance of local natural resource conservation and sustainable resource extraction practices.

2.4 Assessment of the Proposed Road From Los Cartagos to Aguas Claras

A sub-project being considered under the NZCP is the rehabilitation of an existing 10 km rural road running between the Los Cartagos intersection on the San Jose -- Cuatro Bocas road to San Isidro in the Aguas Claras region. A field inspection indicated that the present road condition includes (a) steep hills, (b) sharp curves, (c) extremely rough and uneven surface, (d) and poor to non-existent drainage in side hill cuts subject to significant erosion. It is proposed that the road be upgraded to an all-weather standard.

2.4.1 Description of Existing Road

From the Los Cartagos junction, the road goes about one and one-half kilometers (kms) through a flat area, with open fields on both sides. The road right of way is 10 meters wide and the road has a five meter rock surface in fair condition. Drainage is minimal.

Starting at km 1.5, the terrain changes to rolling for one km. The road then climbs steadily through wooded hills with extensive side hill cuts for the next three kms. There is a narrow wooden bridge and a ford in this section. The road narrows to about four meters through this section and should be widened. This will involve cutting back the uphill slope to widen the platform.

Improvements to the roadside drainage are needed on the cut side. Drainage, with shoulder protection, must be provided on the fill side. Culverts to carry water from the cut side under the road to the fill side will have to be provided at selected locations.

The road has a slope of from 10-14 percent in this section and has a very rough surface of large stones. An MOPT grader was observed working down the hill, scraping ditches and placing the excavated soil on the road to provide a smoother riding surface.

At km 5.5, the terrain levels off and opens up to the Aguas Claras valley, then descends gradually to the valley floor and crosses another wooden bridge before arriving in San Isidro.

2.4.2 Environmental Analysis and Mitigating Measures

The proposed Project will not include construction of new roads. No penetration roads will be built nor will new areas be opened. All activities will focus on the upgrading and maintenance of the existing roadbeds and replacement of bridges. Some side hill cuts must be widened and drainage improved. Accordingly, the potential for direct environmental impact can be limited to widening of the right-of-way in side hill cuts, earth movement, minimal diversion of drainage patterns with some erosion and stream sedimentation, and minor dust pollution during construction.

All of these potential impacts can be controlled or avoided through proper road design and environmentally appropriate construction practices. For example, increased erosion resulting from earth movement, roadbed rehabilitation and associated altered drainage patterns during construction can be minimized through the use of (1) temporary diversion ditches, (2) seeding and mulching of road shoulders, and (3) the installation of small check dams in drainage canals on steep slopes.

Bridges and culverts must be designed to allow the free passage of water and avoid disruption of the aquatic plant and animal environment. Consideration should be given to the paving of steep grades and bridge approaches with asphalt or soil cement.

Indirect environmental impacts include increased access to local natural resources for the rural population and changes in land use. Anticipated changes in land use include more intensive cultivation of land, harvesting of wood and non-wood forest products, and conversion of remnant forests to pasture. These actions could change the timing and quantity of water and sediment received downstream, and may affect road rehabilitation and maintenance efforts.

In order to avoid future adverse environmental impacts, it is essential that the road be adequately maintained. This will require training of maintenance personnel, adequate materials and equipment to conduct field work, and provision of financing for maintenance activities. Training in maintenance tasks must include the following:

- Cleaning of drainage ditches, culverts and other drainage structures
- Maintaining a crown on the road to assure rapid water runoff
- Repair of pot holes and other surface failures
- Rapid removal of slides in ditches and on the roadbed
- Vegetative cover on shoulders and in ditches
- Protection and repair of fill slopes

Other maintenance tasks requiring the use of equipment, to be performed on a periodic basis include:

- Grading of roadway to bring surface material back on to the road and reestablish the road crown
- Recharging of select surface material
- Compacting of road surface and shoulders
- Reshaping of ditches
- Repair or addition of culverts where needed
- Repair of road sections damaged by land slides or flooding

The proposed road from Los Cartagos to Aguas Claras can have a beneficial effect on the Project area if environmentally sound designs are prepared, training opportunities are provided to maintenance staff, and regular maintenance schedules are followed. In addition, environmentally appropriate land use management practices must be enforced in this area. Environmental education programs must establish the importance of local natural resource conservation and sustainable resource extraction practices.

2.5 Assessment of the Proposed Road from San Isidro to Colonia La Libertad

One of the sub-projects being considered under the NZCP is the rehabilitation of an existing 17 km rural road running from San Isidro in the Aguas Claras region, through Colonia Blanca, to Colonia La Libertad. The present road passes through flat areas and rolling hills, has a rough and uneven surface, and poor to non-existent drainage. It is proposed that the road be upgraded to an all-weather standard.

2.5.1 Description of Existing Road

From San Isidro the road has an irregular stone surface of six meters width, with minimal drainage. In the first five kms there are four small wooden bridges and a culvert over streams, with the alternative of using adjacent fords instead of the bridges. The area is flat with open fields on both sides. The road right of way is about 10 meters wide. Rio Negro is at km 4 of this section.

Starting at km 5, the valley narrows and the terrain changes to rolling. The area adjacent to the road is cleared while the upper slopes are forested. In this section and until Colonia Blanca at km 10, there are two narrow wooden bridges, with adjacent fords, and two culverts.

Leaving Colonia Blanca the road passes over a very small wooden bridge, with adjacent ford, and passes through Zapel Settlement. The terrain is slightly rolling and areas adjacent to the road are partially cleared. The road passes over another narrow wooden bridge and through a ford before leaving the Settlement area at km 15.

Just outside the settlement a logging operation was being carried out. The last two kms of the road pass through rolling hills with frequent side hill cuts. In this section are three narrow wooden bridges, a ford and two culverts. At km 16 the land opens up to Colonia La Libertad at km 17.

2.5.2 Environmental Analysis and Mitigating Measures

The proposed Project will not include construction of new roads. No penetration roads will be built nor will new areas be opened. All activities will focus on the upgrading and maintenance of the existing roadbeds and replacement of bridges. Some side hill cuts will have to be widened and drainage improved. Accordingly, the potential for direct environmental impact can be limited to clearing of right-of-way, minimal diversion of drainage patterns and minor levels of dust and/or stream sedimentation during construction. All of these potential impacts can be controlled or avoided through design of the road to acceptable standards and prudent construction practices.

All of these potential impacts can be controlled or avoided through proper road design and environmentally appropriate construction practices. For example, increased erosion resulting from earth movement, roadbed rehabilitation and associated altered

drainage patterns during construction can be minimized through the use of (1) temporary diversion ditches, (2) seeding and mulching of road shoulders, and (3) the installation of small check dams in drainage canals on steep slopes.

Bridges and culverts must be designed to allow the free passage of water and avoid disruption of the aquatic plant and animal environment. Consideration should be given to the paving of steep grades and bridge approaches with asphalt or soil cement.

Indirect environmental impacts include increased access to local natural resources for the rural population and changes in land use. Anticipated changes in land use include more intensive cultivation of land, harvesting of wood and non-wood forest products, and conversion of remnant forests to pasture. These actions could change the timing and quantity of water and sediment received downstream, and may affect road rehabilitation and maintenance efforts.

In order to avoid future adverse environmental impacts, it is essential that the road be adequately maintained. This will require training of maintenance personnel, adequate materials and equipment to conduct field work, and provision of financing for maintenance activities. Training in maintenance tasks must include the following:

- Cleaning of drainage ditches, culverts and other drainage structures
- Maintaining a crown on the road to assure rapid water runoff
- Repair of pot holes and other surface failures
- Rapid removal of slides in ditches and on the roadbed
- Vegetative cover on shoulders and in ditches
- Protection and repair of fill slopes

Other maintenance tasks requiring the use of equipment, to be performed on a periodic basis include:

- Grading of roadway to bring surface material back on to the road and reestablish the road crown
- Recharging of select surface material
- Compacting of road surface and shoulders
- Reshaping of ditches

- Repair or addition of culverts where needed
- Repair of road sections damaged by land slides or flooding

The proposed road from San Isidro to Colonia La Libertad can have a beneficial effect on the Project area if environmentally sound designs are prepared, training opportunities are provided to maintenance staff, and regular maintenance schedules are followed. In addition, environmentally appropriate land use management practices must be enforced in this area. Environmental education programs must establish the importance of local natural resource conservation and sustainable resource extraction practices.

2.6 Assessment of the Proposed Road From Colonia Puntarenas to Cano Negro

One of the sub-projects being considered under the NZCP Project is the rehabilitation of an existing 26 km rural road running between Colonia Puntarenas on Route 4 south of Upala to Cano Negro in the National Wildlife Reserve. The present road has steep hills, sharp curves, rough and uneven surface, and poor to non-existent drainage. It is proposed that the road be upgraded to an all-weather standard.

2.6.1 Description of Existing Road

From Colonia Puntarenas the road heads north through rolling hills. The road right of way is about 10 meters wide and the road has a four to five meter rock surface in fair condition. Drainage is minimal.

Ponding is evident at many location along the sides of the road. Frequently water was standing in the road at low points. Culverts were noted at some of the low points but were not always open. As a result, standing water is found frequently in the road.

Starting at km 4, traces of a grader having passed and scraped longitudinal ditches were evident but the excavated material was left on the shoulders. Additional improvements to the roadside drainage is needed. Additional culverts are needed to carry water under the road at low points.

At km 6.5 the terrain becomes more hilly, with grades of up to 12 percent on short streches. At kms 8.7 and 14.5 there area large culverts under the road, with ponding on both sides. At km 16.5 the terrain flattens and the surface improves until arrival in Cano Negro at km 26.

2.6.2 Environmental Analysis and Mitigating Measures

The proposed Project will not include construction of new roads. No penetration roads will be built nor will new areas be opened. All activities will focus on the upgrading and maintenance of the existing roadbeds and replacement of bridges. Some side hill cuts must be widened and drainage improved. Accordingly, the potential for direct environmental impact can be limited to widening of the right-of-way in side hill cuts, earth movement, minimal diversion of drainage patterns with some erosion and stream sedimentation, and minor dust pollution during construction.

All of these potential impacts can be controlled or avoided through proper road design and environmentally appropriate construction practices. For example, increased erosion resulting from earth movement, roadbed rehabilitation and associated altered drainage patterns during construction can be minimized through the use of (1) temporary diversion ditches, (2) seeding and mulching of road shoulders, and (3) the installation of small check dams in drainage canals on steep slopes.

Bridges and culverts must be designed to allow the free passage of water and avoid disruption of the aquatic plant and animal environment. Consideration should be given to the paving of steep grades and bridge approaches with asphalt or soil cement.

Indirect environmental impacts include increased access to local natural resources for the rural population and changes in land use. Anticipated changes in land use include more intensive cultivation of land, harvesting of wood and non-wood forest products, and conversion of remnant forests to pasture. These actions could change the timing and quantity of water and sediment received downstream, and may affect road rehabilitation and maintenance efforts.

In order to avoid future adverse environmental impacts, it is essential that the road be adequately maintained. This will require training of maintenance personnel, adequate materials and equipment to conduct field work, and provision of financing for maintenance activities. Training in maintenance tasks must include the following:

- Cleaning of drainage ditches, culverts and other drainage structures
- Maintaining a crown on the road to assure rapid water runoff
- Repair of pot holes and other surface failures
- Rapid removal of slides in ditches and on the roadbed

- Vegetative cover on shoulders and in ditches
- Protection and repair of fill slopes

Other maintenance tasks requiring the use of equipment, to be performed on a periodic basis include:

- Grading of roadway to bring surface material back on to the road and reestablish the road crown
- Recharging of select surface material
- Compacting of road surface and shoulders
- Reshaping of ditches
- Repair or addition of culverts where needed
- Repair of road sections damaged by land slides or flooding

The proposed road from San Isidro to Colonia La Libertad can have a beneficial effect on the Project area if environmentally sound designs are prepared, training opportunities are provided to maintenance staff, and regular maintenance schedules are followed. In addition, environmentally appropriate land use management practices must be enforced in this area. Environmental education programs must establish the importance of local natural resource conservation and sustainable resource extraction practices.

2.7 Assessment of Internal Roads for Zapal Settlement

2.7.1 Land Settlement and Titling

One component of the NZCP involves the consolidation of Agrarian Development Institute (IDA)-organized settlements within the overall development of the project area. A specific feature of this program is the establishment of new IDA settlements during the first four years of the Project.

To qualify for financing under the Project, IDA is required to obtain the approval of AID on all road-related activities within the settlements. This approval is based in part on the results of an Environmental Impact Assessment.

IDA has identified four top priority settlements which they plan to include in the AID funded program. The four new settlements in IDA's order of priority are:

First - Zapal (near Colonia Blanca)
Second - Argendora (near Brasilia)
Third - Argelia (near Dos Rios)
Fourth - Alfonso Bustos (near Dos Rios)

The Zapal Settlement is located near Colonia Blanca, on both sides of an existing rural road between Aguas Claras and Colonia Libertad. The present road is not constructed to a desirable standard, with steep hills, sharp curves, extremely rough and uneven surface, and poor to non-existent drainage subject to erosion. Poor drainage is causing ponding on the sides of the road and killing stands of native forest. Improvement of this road is planned as a separate sub-project under the roads rehabilitation/upgrading component.

The Zapal settlement area is not yet developed, although a plan of the lots and internal roads has been prepared by IDA and the lots and internal roads have been laid out. An Environmental Impact Assessment is required before work can start on these internal roads.

2.7.2 Environmental Analysis of Zapal Settlement

The proposed Zapal Settlement Project will include construction of approximately eight kms of new roads to provide access to the various lots. Direct environmental impacts will be limited to clearing of right-of-way, minimal diversion of drainage patterns and minor levels of dust and/or stream sedimentation during construction.

All of these potential impacts can be controlled or avoided through proper road design and environmentally appropriate construction practices. At present, detailed road designs do not exist for these settlement roads.

The eight kms total of roads can be separated into 10 access roads, varying in length from 450 meters to 1,250 meters. Three of the roads cross flat open areas with only a few trees. The others pass through slightly rolling country with several drainage crossings, and one of the roads crosses a ravine which has a small stream at the bottom.

A topographic survey and detailed road design must be done prior to any construction activities. The possibility of erosion caused by earth movement associated with construction of the roads and drainage systems has to be studied as part of the road designs. Designs are to be done by the Infrastruture Rural Section of the IDA.

Location and size of culverts and dispersal of water from the road ditches without flooding agricultural lands or contributing to siltation of adjacent waterways must also be a consideration. The erosion can be minimized by seeding and mulching of road shoulders and the installation of small check dams in main drainage canals.

Bridges and culverts must be designed to allow the free passage of water and avoid disruption of the aquatic plant and animal environment.

The Project's environmental effects will be both direct, affecting the roads themselves, and indirect, affecting the people and lands served by the roads. Direct effects include such things as reducing erosion of road beds, improving drainage along roads, and eliminating standing water on the roadway.

Indirect environmental impacts include increased access to local natural resources for the rural population and changes in land use. Anticipated changes in land use include more intensive cultivation of land, harvesting of wood and non-wood forest products, and conversion of remnant forests to pasture. These actions could change the timing and quantity of water and sediment received downstream, and may affect road rehabilitation and maintenance efforts.

Specifically, new roads will create access to remnant secondary forests and steep lands. Forest clearing and cultivation of steep slopes could result in increased stormflows and sediment received downstream. Access roads will need to be coordinated with land use management strategies implemented for the settlement area.

All of these potential impacts can be controlled or avoided through proper road design and environmentally appropriate construction practices. For example, increased erosion resulting from earth movement, roadbed rehabilitation and associated altered drainage patterns during construction can be minimized through the use of (1) temporary diversion ditches, (2) seeding and mulching of road shoulders, and (3) the installation of small check dams in drainage canals on steep slopes.

In order to avoid future adverse environmental impacts, it is essential that the road be adequately maintained. This will require training of maintenance personnel, adequate materials and equipment to conduct field work, and provision of financing for maintenance activities. Training in maintenance tasks must include the following:

- Cleaning of drainage ditches, culverts and other drainage structures
- Maintaining a crown on the road to assure rapid water runoff
- Repair of pot holes and other surface failures
- Rapid removal of slides in ditches and on the roadbed
- Vegetative cover on shoulders and in ditches
- Protection and repair of fill slopes

Other maintenance tasks requiring the use of equipment, to be performed on a periodic basis include:

- Grading of roadway to bring surface material back on to the road and reestablish the road crown
- Recharging of select surface material
- Compacting of road surface and shoulders
- Reshaping of ditches
- Repair or addition of culverts where needed
- Repair of road sections damaged by land slides or flooding

The proposed construction of the internal roads for the Zapal Settlement can have a minimal affect on the Project area if environmentally sound road designs are coordinated with appropriate land use management plans. No detailed road designs have been prepared to date. When completed, the design of the roads and provision for drainage should be checked by the Environmental Management Specialist (EMS) or an engineer.

Environmentally appropriate land use management practices must be enforced in this area. Environmental education programs must establish the importance of local natural resource conservation and sustainable resource extraction practices. Recommendations for appropriate land use management plans for these settlement areas are included in Chapter Five of this present volume.

2.8 Assessment of Internal Roads for Argendora Settlement

2.8.1 Land Settlement and Titling

The second priority Argendora Settlement is located west of Brazilia on Route 4, between Brazilia and Santa Cecilia. Two of the internal roads enter the settlement north and south from Route 4, west of the Rio Los Haciendas, while the third internal road leaves Route 4 to the north between the Rios Mechas and Los Haciendas. The Rio Las Hacienda passes through the settlement, and the Rio Mechas passes along the western edge of the settlement.

Route 4 has been recently reconstructed to a two lane all-weather road as part of the NZCP, and is in excellent condition. The road into the settlement between the two rivers is presently a narrow earth road with no drainage.

The Argendora Settlement area is not yet developed, although plans of the lots and internal roads have been prepared by IDA and the lots and internal roads have been laid out.

2.8.2 Environmental Analysis of Argendora Settlement

The proposed Argendora Settlement Project will include construction of approximately four kms of new roads to provide access to the various lots. Accordingly, there is a potential for direct environmental impact. These impacts will be limited to clearing of right-of-way, minimal diversion of drainage patterns and minor levels of dust and/or stream sedimentation during construction. All of these potential impacts can be controlled or avoided through design of the road to acceptable standards and prudent construction practices.

The four kms of roads to be constructed include three separate access roads, of 2.0, 1.0 and 1.0 kms in length, respectively. The land in the settlement area has been generally cleared but now has secondary growth. It has flat to rolling terrain with several minor ravines leading to one or other of the two rivers. Large fills are required where two of the roads leave Route 4 and large diameter culverts are required to assure the drainage of Route 4.

There should be minimal environmental degradation resulting from the construction of the internal roads as long as they are designed to account for proper gradient and

road crowns. Roadside drainage must be directed to low-lying vegetated areas to trap and filter sediment, and limit degradation of instream water quality. Designs for the roads are to be done by the Infrastructure Rural Section of the IDA. This work must be reviewed by the Environmental Management Specialist (EMS) to assure that long-term maintenance of soil and water quality can be assured. the road designs. Location and size of culverts and A topographic survey will be required prior to detailed road design. Increased erosion caused by earth movement during road construction must be minimized by the road designs. Location and size of culverts, and dispersal of water from the road ditches without flooding agricultural lands or contributing to siltation of adjacent waterways, must also be a consideration in road designs. The erosion can be minimized by seeding and mulching of road shoulders and the installation of small check dams in main drainage canals. Bridges and culverts must be designed to allow the free passage of water and avoid disruption of the aquatic plant and animal environment.

The Project's environmental effects will be both direct, affecting the roads themselves, and indirect, affecting the people and lands served by the roads. Direct effects include such things as reducing erosion of road beds, improving drainage along roads, and eliminating standing water on the roadway.

Indirect environmental impacts include increased access to local natural resources for the rural population and changes in land use. Anticipated changes in land use include more intensive cultivation of land, harvesting of wood and non-wood forest products, and conversion of remnant forests to pasture. These actions could change the timing and quantity of water and sediment received downstream, and may affect road rehabilitation and maintenance efforts.

Specifically, new roads will create access to remnant secondary forests and steep lands. Forest clearing and cultivation of steep slopes could result in increased stormflows and sediment received downstream. Access roads will need to be coordinated with land use management strategies implemented for the settlement area.

All of these potential impacts can be controlled or avoided through proper road design and environmentally appropriate construction practices. For example, increased erosion resulting from earth movement, roadbed rehabilitation and associated altered drainage patterns during construction can be minimized through the use of (1) temporary diversion ditches, (2) seeding and mulching of road shoulders, and (3) the installation of small check dams in drainage canals on steep slopes.

In order to avoid future adverse environmental impacts, it is essential that the road be adequately maintained. This will require training of maintenance personnel, adequate materials and equipment to conduct field work, and provision of financing for maintenance activities. Training in maintenance tasks must include the following:

- Cleaning of drainage ditches, culverts and other drainage structures
- Maintaining a crown on the road to assure rapid water runoff
- Repair of pot holes and other surface failures
- Rapid removal of slides in ditches and on the roadbed
- Vegetative cover on shoulders and in ditches
- Protection and repair of fill slopes

Other maintenance tasks requiring the use of equipment, to be performed on a periodic basis include:

- Grading of roadway to bring surface material back on to the road and reestablish the road crown
- Recharging of select surface material
- Compacting of road surface and shoulders
- Reshaping of ditches
- Repair or addition of culverts where needed
- Repair of road sections damaged by land slides or flooding

The proposed construction of the internal roads for the Argendora Settlement can have a minimal affect on the Project area if environmentally sound road designs are coordinated with appropriate land use management plans. No detailed road designs have been prepared to date. When completed, the design of the roads and provision for drainage should be checked by the Environmental Management Specialist (EMS) or an engineer.

Environmentally appropriate land use management practices must be enforced in this area. Environmental education programs must establish the importance of local natural resource conservation and sustainable resource extraction practices. Recommendations for appropriate land use management plans for these settlement areas are included in Chapter Five of this present volume.

2.9 Maintenance of Project Roads

Once the roads in the Northern Zone Consolidation Project have been constructed, rehabilitated, or upgraded, it is essential that they be adequately maintained. Road maintenance will reduce erosion and subsequent silting of natural waterways. The NZCP provides for the CMV (Northern Zone Municipal Road Maintenance Commission) to manage this maintenance program.

Maintenance of rural roads can be done at two levels:

1. Routine Maintenance, using hand tool provided by the Project and hand labor provided by the various communities along a specific section of road, and
2. Periodic Maintenance, using equipment and personnel provided by the project.

2.9.1 Routine Maintenance By Hand

Through this program community workers will perform scheduled maintenance tasks. They will (a) clean the road ditches, (b) fill in holes and low places on the roads and (c) clean culverts and drains. Weeds and other vegetative growth along shoulders and in ditches will be cut. Small landslides will be quickly removed. The road surface will be smoothed as feasible, and other minor routine hand maintenance tasks will be done. Each worker will be assigned from 2 to 5 kms of road to maintain, depending on the terrain and number of workers available.

Each worker will be provided, with and be held responsible for, the following equipment:

1	wheelbarrow	1	pick
1	shovel	1	rake
1	hoe	1	file
1	machete	1	hand tamper

Each group of five workers will be supervised by a person appointed by the community. This supervisor will:

- review the work accomplished by each worker
- outline a work schedule for the next two week period

- sign a timecard
- deliver the worker's pay each month

The supervisors will receive training from the Project, and instruct the workers as found necessary.

Truck loads of select road surface material will be stockpiled along the roads, especially adjacent to points where there is danger of washouts during heavy rains. This material will be delivered by Project equipment.

2.9.2 Periodic Maintenance of Equipment

In addition to the hand labor maintenance program, periodic maintenance will be accomplished by a brigade using equipment and operating personnel provided by the Project. The brigade will have the following equipment:

1 dozer	1 grader
1 roller	1 loader
5 dump trucks	1 water truck
1 lowboy	1 maintenance truck
2 pickup trucks	1 general service truck

The equipment brigade will make a pass on each section of road twice a year to do grading, reestablishing of road crowns, recharging of select surface material, compacting of road surface and shoulders, reshaping of ditches, repair or addition of culverts where needed and repair of road sections damaged by land slides or flooding.

CHAPTER THREE

AGRO-ECOLOGICAL ANALYSIS OF AREAS AND CROPS

by Francisco Rodriguez
Agronomist

3.0 Terms of Reference:

The consultant was hired to conduct two priority activities.

- To provide support for agricultural diversification through the development and/or analysis of technological packages for the crops proposed: heart of palm/peach palm, cacao, black pepper, maracuya and macadamia. The framework of this analysis was the agro-ecological conditions of the zone: soil and climate; and the ecological characteristics of the crops selected.
- To ensure sustained development within a framework of environmental protection and in accordance with the zone's agrological conditions. An analysis was conducted and the Project advised on soil-use capability and the systems of cultivation best suited to the pre-selected areas.

Pre-selected Areas, Hectares and Centers of Population

AREA	HECTARES	CENTERS OF POPULATION
1	2000	Cabanga
2	3000	Jonjibe, Sol, Margarita, El Silencio
3	4600	Colonias, Las Letras, El Valle, Naranjena, Florida, Rio Celeste
4	3500	Los Angeles, Veracruz, Monico
5	3600	La Cruz, San Isidro, Montecristo, Cinco Esquinas
6	3700	Bijagua, Zapote
7	8300	Canolete, Pueblo Nuevo, San Jorge, Valle Azul, Buena Vista
8	1800	Delicias, Mexico, San Ramon, Victoria
9	2100	Sta. Clara, Moreno Canas, Las Brisas
10	5300	San Isidro, Aguas Claras, Colonia Blanca and La Libertad
11	1700	Cuatro Bocas, El Porvenir, Los Cartagos
12	1800	Villa Nueva, Fatima
13	2400	San Luis/Cooperativa Buenos Aires - Gavilan
14	2100	El Encanto, La Jabalina, La Lucha
15	2900	Sta. Cecilia, Sta. Elena, La Virgen

TOTAL	48800 Has	

The areas were assigned a number in order to identify them and to make it possible to organize the presentation better, but these areas are only a guide to the characteristics of adjacent areas.

3.1 Description of Work

A total of 50,000 hectares divided into 15 pre-selected areas was inspected and analyzed. Within these pre-selected areas suitable locations were identified for growing the following pre-selected crops:

CROP AND AREAS TO BE DEVELOPED

CROP	NO LESS THAN	NO MORE THAN
CACAO	5000 has	7500 has
HEART OF PALM/ PEACH PALM	2000 has	3000 has
MACADAMIA	1000 has	1500 has
MARACUYA	1000 has	1500 has
BLACK PEPPER	200 has	300 has
TOTALS:	9200 has	13800 has

Matrixes

This work uses two matrixes:

- Table No. 1. Agro-ecological characteristics of the crops.
- Table No. 2. Characteristics of the zone in regard to land-use, soil, climate and topography.

These matrixes are complemented with essential annexes that summarize some socio-economic characteristics of activities that surfaced during the process of the study; through visits, interviews with farmers, technicians and institutions and observations based on the author's experience.

The objective is to establish a "cross"-analysis mechanism for defining:

- The zone and its characteristics
- The crop and its soil and climate needs

Recommendations are made of zones most suitable for at least two of the crops identified by the Project. In some cases a third crop is included so they may

complement -- either as a system or as an agro-industrial or socio-economic factor - the development of the area or the management of sustained growth with regard to the soil resource.

3.2 Master Charts for Area Analyses

The analysis of the areas is based on a Master Chart, which in conjunction with Table No. 1, helps to define areas, extension by crop in each area, as well as recommendations regarding technology, systems and cultivation schedules.

3.2.1 Table No. 1

Table No. 1 shows the characteristics of the areas evaluated in order to classify them, and is the basis of the cross analysis with Table No. 2: Agro-ecological Analysis by Crop. It is necessary to clarify the procedure and some of the characteristics of the following parameters used in the analysis:

- There are micro-climates and variations at area level that require more careful observation and analysis.
- The indications and parameters must be considered as a guide for the development of each area.
- Tables Nos. 1 and 2 are the answer to the terms of reference of this consultancy, but we recommend that it be the basis of an Information System for all of the Northern Zone.

Concepts for Each Parameter

The Classification System of the Tropical Scientific Center is used in the measuring the following parameters:

Rainfall
Intensity and Dry Months
Relief and Terrain
Rockiness
Drainage
Erosion and Extent of Erosion

Relative Humidity is defined in accordance with the following scale:
High = 85/90%
Low > 80k%

TABLE 1
GENERAL SUMMARY OF ANALYSIS OF AREAS

Main Aspects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. ECOLOGICAL CLASSIFICATION - LIFE ZONES	bp-P bmh-T	bmh-T	bmm-T bmh-T bp-P	bh-T	bh-T	bmh-P bmh-T	bmh-P bmh-T	bh-T	bmh-P	bmh-T	bmh-P	bb.T	bb.T bmh.T	bmh-T	bb-T bb-T
2. CLIMATE															
2.1 MAPS															
2.2 TEMPERATURE (ºC)															
MAX	26	29	28	30	30	23	25	30	21	25	29	30	29	30	>30
MIN	17	18	17	22	23	18	10	22	22	17.5	22	22	19	20	20
AVERAGE	22.5	22	25	27	26	20	21	25	25	21.5	25	25	24	24	25
DISTRIBUTION															
2.3 PRECIPITATION															
RANGES	3500	>3000	3500	3000	3000	>4000	3500/ 4000	2500	3/4000	5000	4000	3000/ 3500	3000/ 3500	3000/ 3500	2500/ 3000
INTENSITY	1	1	1/2	2	2	1	1/2	1/2	2/3	2/3	-3	2	2	>2	>3
DRY MONTHS	1,2	1,2	2,3	4,3	2,3	1,2	1,2,3	1,3	1,2,3	1,2,3	1,2,3	2,3	2,3	2,3	2,3
2.4 RELATIVE HUMIDITY HYDRIC BALANCES															
2.5 INSOLATION/HOURS/ DAY/YEAR ANNUAL DISTRIBUTION	4/6	4/5	4	5	5/6	5	3/4	4/6	5	4/5	5	4/6	4/5	5	5
2.6 WIND	II	I	not much	not much	not much	II	not much	I	not much	X	not much	not much	not much	not much	not much
FREQUENCY															
INTENSITY (1,2)*	2	1	1	1	1	2	1	1	1	2	1	1	1	1	1
VARIATIONS (MONTHS)															
3. SOILS															
SOILS MAPS															
- ALTITUDE	300/ 400	50/150	50/100	30/100	30/80	400/ 600	100/ 300	30/80	50/70	290/ 600	50/100	50/150	150/ 500	150/ 500	70/350
- RELIEF/TOPOGRAPHY	3,4	3,4	1,2,3	1,2	1,2	2,3,4	2,3	1,2	1,2	1,2,3	1,2,3	1,2	1,2,3	1,2,3	2,3
EROSION:															
- DEGREE OF EROSION (1,2)	0,2,3	0,2,3	0,1,2, 3	0,1,2	0,1,2	0,2,3	0,1,2, 3	0,1,2	0,1,2	0,1,2, 3	0,1,2	0,1,2, 3	0,1,2 3	0,1,2	1,2,3, 4
- CONTROL PRACTICES (yes, no)															
LIMITITING FACTORS (AGRO-ECOLOGICAL)															
CRITICAL *															
SEVERE **															

Analysis and some observations in regard to Table 1 are presented on the following pages.

TABLE 2
AGRO-ECOLOGICAL CHARACTERISTICS BY CROP

		Temperature		Topography		Precipitation			Soil							Light Hrs/Day		Wind	
	Altitude	Range	Critical Phase	Relief	%	Range	Relative Humidity	Dry Months	P.H.	Texture	Structure	Phreatic Level	Drainage	Depth	Fertility	Intensity	Critical Phase	Critical Phase	Intensity
Cacao	0-800	20-30°C	Flowering	Flat	>20	1500/2500	80%	0-2	5.5/7			1/1.5 mt	2	2	2			Flower	2
Pepper	0-600	21-23°C		Gently rolling to flat	>15	2000	60-90%	0-2	>5.5	11		>1 mt	11		1	1	Fruit	Fruit	2
Heart of Palm	0>1000	24-28		Flat rolling	>30	1900/6000	90%	1-2	5.7	1		1/1.5 mt	1		1			Pruning	
Maracuya	0-700	15-32°C		Flat to gently rolling	>20	1500/2500	80%	2	5.6/8	1		1 mt	2	2	2	1;	Pollination	Pollination	2
Macademia	0<600 600-1200	Variation 17-32°C	Pollinate	Rolling	Max 30	1500/4000	80%	2	5.5/6.5	1		1 mt	2	2	2	4-8 hours/day	Pollination	Pollination Fruits	11

1. Limiting factors (*)
   * = critical limiting factor
   ** = severe limiting factor
2. Critical phase
   This refers to the relation between soil or climactic parameters and the agro-ecological characteristics of the crops or management and its influence over production.
3. Structure
   This is an aspect that requires further analysis.

This is one aspect that deserves a more careful analysis as to its influence on specific crops and on development of pests and diseases.

Temperature: An approximation is given in most of the cases. An effort was made to complement the few data of three weather stations with the observations and comments of farmers and technicians in the zone.

Rainfall: This is an aspect that requires observation as regards its spatial distribution in each zone, since the height/temperature/rainfall ratio varies and some very interesting micro-climates are produced; such is the case of certain sub-zones in areas No. 7, 13 and 10. Area No. 7 is also a good example of variations in intensity due to the effects of convection and altitude.

pH and Texture: The results of the laboratory analysis are included in Annex No. 3. The data in the Table are the result of an extrapolation that defined the lowest and highest pH found in an area and the most common texture data in the analysis of each area.

- It is necessary, at sub-area or farm level, to refine this process.
- The range of pH in the zone goes from 4.5 to 7 even though most of the results are around 5.5 and the texture is mostly clayey with some important variations at sub-area which must be analyzed.
- The laboratory samples for areas 4 and 5 were misplaced. Some results of the sampling made with drill, are given.

Fertility: In accordance with the CCT manual, there are important relations between pH, texture and fertility. However, there are not enough analyses or observations to give a reliable recommendation on the zone.

Wind: In this connection, what is important is to set up patterns and/or variations throughout the year (gusts and effects on the crops).

Erosion: There are no erosion control systems in the zone.

Hydric Balances: These are not given because they require extrapolation in most cases and there is not enough information available in the zone.

Life Zones: The zone in general falls into the category of very humid tropical forest or humid tropical forest with some exceptions of transition to pre-montane.

Altitude: The altitude of most of the areas is, in general under 400 meters with exceptions in area No. 6: above 600 meters and areas 13 and 14: 500 meters. As to the low zones, areas 4, 5 and 12 are the lowest: under 30 meters.

Through the cross analysis: area/crop (Tables Nos. 1 and 2) are defined limiting by zone and by crop and an effort is made to provide management alternatives that will allow modifications at important parameters such as: drainage; erosion or relief; protection of fragile soils; wind; and pest and disease control.

In all cases the main emphasis of the management activities is the protection and the conservation of the environment through systems that will allow sustainable development.

1. Limiting Factors
   Critical Limiting Factor
   Severe Limiting Factor

2. Critical Phases
   Refers to the relation between the parameters of soil or climate and the agro-ecological characteristics of the crops or the management and its influence on production.

3.2.2 Agro-ecological Characteristics

Table No. 2 is a summary of the agro-ecological characteristics of the five target crops: basis of the recommendations given as to "suitability" of the crops to be introduced into the 15 zones analyzed.

The crops, with the exception of cacao, can be classified as "non-traditional" in the Northern Zone, even though there are experiences with passion fruit, macadamia and heart of palm in some specific areas, which are not enough yet to validate their economic importance.

However, upon making a "cross" analysis between the Master Tables Nos. 1 and 2, we can draw some important conclusions, which are reinforced with the observation work in the field: in areas of the zone and in similar areas in other zones, in which the crops have been grown for several years.

The parameters that are considered in the Table originate largely in the following publications, interviews and observations.

CACAO:	CAAP: National Program and the Cacao Program of the Upala Cantonal Agricultural Center.
BLACK PEPPER:	CAAP/IDA: National Program
PASSION FRUIT:	San Carlos Regional Agricultural Center: Conversations with Engineer Santamaría.
MACADAMIA:	CAAP: National Program
HEART OF PALM:	National Program/ASBANA

The development of the technological packages and the production schedules are the most important parameters by crop and they are given priority in what we call "Critical and Limiting Phases".

Critical Phases: In this respect, we refer to phases -- growth stages of each crop in which some parameters of soil or climate play a more important role.

Thus, we place emphasis on the following aspects by crop or by area:

Temperature:

Cacao: The temperatures under 20 degrees Centrigrade affect flowering.

Macadamia: Even though it seems that the new clones are more adaptable, macadamia planted below 600 meters needs alternate cold periods in order to obtain a good pollination.

Sunshine:

Black pepper, macadamia and passion fruit require intense periods of sunlight during relatively long periods of time in order to form fruit, pollinate and prevent diseases.

In this respect, the number of dry months plays an important role and also affects the growth and production of these and other crops.

Wind:

The intensity of the wind affects almost all crops, but it is a strong limiting factor in macadamia and somewhat less in passion fruit and black pepper, in which it affects pollination, forming of fruit and the gripping of the lianas.

Limiting Factors:

On Table No. 2 are characterized the limiting factors as critical and severe as to their effect on the growth of the crops. Thus we have:

Black Pepper: Limiting factors due to drainage and texture and their effect on the growth of the roots and therefore, the plant is weakened as regards its resistance to diseases or retards growth and production.

Passion Fruit: Rainfall and lack of sunlight, which affect pollination and attacks by pests and diseases.

Macadamia: The characteristics of its root system makes it susceptible to wind and the altitude affects pollination (under 600 meters).

In general, the most important parameter because of its effect on the soil is rainfall and its relation to drainage, slope and loss of nutrients.

3.3 Criteria for Area Analyses

The "analysis" follows the following pattern, summarizing the results of the Area Analyses in the following way:

- Surface Area of Land Involved
- Centers of Population
- Specific Areas: (Sub-areas)

This section gives the approximate sub-areas with similar characteristics or that are in some way related insofar as the management or crop that is recommended.

- Watersheds
- Present Use

  An approximation on the basis of field observations.

- Classification of:
  - Life zones (Holdridge)
  - Soils:
    - Soil-use capability (The Sepsa system is used in order to permit comparisons of data with other assessments conducted in the zone.)
    - Origin and Topography (used as Ramirez proposes in the Agro-forestry Feasibility Study.)
  - Limiting Factors:
    - Technology
- Recommendations
  - Crop and Surface Area of Land Systems: This refers to crop associations that protect the soil, provide employment or are economic in the area.

    General

  - Projection for the area
    Potential of the area in regard to the surface area that could be added for production of the selected crops and/or its potential for forming part of a focus of development, as a market or for processing.

3.3 Area Analyses

AREA NO. 1

Surface Area: 2000 has. It is proposed that the area be changed slightly so as to cover an area near the road towards Cote and Tilaran.

Centers of Population: Cabanga and, if the proposal is accepted, El Silencio will be incorporated.

Specific Areas: a) Zones to the right of the road, including Guatusos-Tilaran; b) Zones near the river (to the left of the road); and c) Zones to the west of Cabanga.

Watershed: Cote and Queguer Rivers

Present Use:
Livestock - 50 percent of the area
Agricultural - 30 percent of the area
Forestry/protection - 20 percent of the area

Classification: Life Zones (Holdridge)
bp - P
bm - h - TA

Soils: Soil-use capability
This is mostly land with severe limitations as far as growing annual crops is concerned. Therefore its rational utilization would be grazing, trees and as a refuge for wildlife. Cropping practices are sophisticated in order to correct the soil's limitations (heavy texture) or to avoid the risk of erosion due to steep slopes. Erosion is evident at present.

The observations indicate that approximately:

- 25 percent of area has an inclination of more than 40 percent
- 40 percent of area has an inclination of 30 percent
- 25 percent an inclination of less than 20 percent
- 10 percent an inclination of less than 10 percent

Origin and Topography: Approximately 25 percent of the soils are volcanic in origin, with rolling topography. The remainder have steep slopes and low fertility (clays).

T.S.C. Classification: Technology - Traditional for Basic Grains and Livestock; Advanced in macadamia.

Limiting Factors:

- Soils (Texture, Slope and Fertility)
- Precipitation on soils that are unprotected and have pronounced slopes
- Ownership

RECOMMENDATIONS:

Use and area:

Livestock - 30 percent (Extensive: 20 percent, Intensive 10 percent)
Agriculture - 15 percent
Corn, fruit trees (pineapple, citrus fruits, avocado)
Macadamia: 20 percent
Heart of Palm: 10 percent
Forestry - Tree systems: 10 percent
Protection: 15 percent

Systems: The area requires agroforestry and silvo-pastoral systems that incorporate legumes, laurel and peach palm/heart of palm. In regard to the crops selected, macadamia and heart of palm are recommended with legumes and perhaps grazing for small animals.

General:

- To define ownership, land-purchase - IDA
- To define area for the management of tree systems: fruit trees, laurel, peach palm, macadamia
- Grazing, with great care
- Protection of areas against erosion through the use of legumes and conservation efforts

Projection for this area: The area was proposed in order to try to solve the problem of the lack of land for farmers in or around Cabanga. The projection in regard to area is uncertain, and as far as the crop is concerned, the area should be incorporated into the focus of Macadamia production in Cote. If the area is developed on the basis of the crops involved it could incorporate some 2000 has. more and help to define and improve the situation regarding ownership.

AREA NO. 2

Surface Area: 3000 Has. It is proposed that this area be reduced.

Centers of Population: Silencio, Margarita, Tonjibe, Viento Fresco, El Sol

Specific Areas:

- Hilly areas - gentle slopes, inclination of up to 30 percent
- Low lying areas: 5-20 percent slope
- Hilly area with steeper slopes > 30 percent

Watershed: Rivers Cucaracho, La Muerte, El Sol

Present Use:

Livestock	: 50 percent
Agricultural (Basic grains, fruit trees)	: 25 percent
Forestry/Protection	: 25 percent

Classification:

Life zones:
bmh - T

Soils:

Soil use capability: This land has severe limitations as far as annual crops are concerned; therefore a rational use would be grazing, trees and as a refuge for wildlife. Cultivation practices require soil conservation efforts and a covering of legumes in order to avoid the risk of erosion and to improve texture.

Origin and Topography: Soils originating from pyroclastics and other meteorized volcanic materials, with rolling topography, deep in over 50 percent of the area; the soils of the alluvial plain are flat with moderate drainages and account for more than 30 percent of the area.

T.S.C. Classification:

Limiting factors:

- Slope/erosion
- Fertility - Acid or Clayey Soils
- Slope > 30 percent
- Situation regarding ownership that makes access to credit impossible

Technology: Generally speaking traditional as far as basic grains and cattle ranching are concerned.

RECOMMENDATIONS:
(for 2000 has)

Use and Surface Areas:

- Livestock: : 15 percent
  Intensive use : 10 percent
  Silvo-pastoral [agroforestry] systems
- Agriculture: corn, rice, pineapple, mango, citrus fruits : 20 percent
- Heart of palm/Peach Palm : 25 percent
- Macadamia/legumes/grazing : 20 percent
- Forestry/Protection:
  Systems: Laurel/cacao or laurel, grazing : 20 percent

Systems:

- The heart of palm/peach palm system is recommended so as to incorporate a crop that provides not only money but food, timber and soil protection.
- Macadamia is another alternative -- perhaps in a system with peach palm that would permit grazing of small animals such as sheep -- using a legume as soil protection and as a source of nitrogen or proteins for the animals.

General:

- The zone is deserving of an institutional effort to define the status of the communities of Indian and white inhabitants, in order to initiate productive development programs backed by credit and technical assistance.
- Definition of some kind of ownership that makes credit possible and offers the owner security.

Projection for the Area: Unless steps are not taken to resolve the problems of ownership and its status as an Indian Reserve, this is an area with great limitations. It is proposed that: the area be reduced to 2000 has. -- leaving 1000 has. of the Indian Reservation in areas where the indians still have some responsibility; or, as CONAI would like, work on a farm that is in the process of being acquired and which will be administered by the indian group.

Chart No. 2
Area No. 2
Land Use: Crops and surface area

	CROP	% (HA)
A.	HEART OF PALM/ PEACH PALM	500
	MACADAMIA/PASTURE	400
B.	CACAO/LAUREL	200
C.	Other crops	

AREA NO. 3

Surface Area: 4600 has

Centers of Population:
Colonies/settlements: Las Letras; El Valle; Naranjena; Rio Celeste; Buenos Aires
Specific Subareas:

- Area near to the mountain range, mountainous topography
- Hills: rolling topography located in the center of the zone
- Areas near to the rivers:

Watershed: Rivers: Rito; Monico; Tiales o> Buena Vista Guayabo and Guayabito Frio

Present Use*:

Agriculture: (Fruit trees, root crops, pineapple, grains)	= 45 percent
Livestock:	= 25 percent
Forestry:	= 10 percent
Cacao:	= 10 percent
Charral (protection):	= 10 percent

Classification:
Life zones:
bmh - T a bp - P
bmh - T

Soils:

Soil use Capability: This is land that may be considered agricultural: for annual crops, grazing and trees. Although there are limitations of slope and fertility in over 60 percent of the area. The steep slopes and rainfall represent risks of erosion.

Origin/Topography: They are mostly volcanic soils with mountainous topography, moderately deep, formed by the recent depositing of ashes; in parts they are soils originating from pyroclastics and other meteorized volcanic materials; rolling topography; deep.
As for the topography, 15 percent forms part of the foothills of the Guanacaste volcanic mountain range and the rest we consider as low hillocks with a 15 percent to 30 percent slope.

T.S.C. Classification:

Limiting factors:

- saturated as far as credit is concerned
- paternalism

State of Technology: It is a zone where it is possible to define levels of technology. Although the technology of traditional crops and cacao is low, or the settlers do not accept it for sociopolitical or credit reasons.

Approximation based on observations

RECOMMENDATIONS:

Land Use:

- Agricultural: = 25 percent
  Pepper = 10 percent
  Maracuya = 15 percent
- Systems: Pineapple, citrus fruits, avocado soursop = 20 percent
- Livestock: = 15 percent
- Cacao: = 20 percent
  Old Cacao = 10 percent
- Macadamia = 10 percent
- Forestry = 10 percent

Systems: Associations with legumes such as the forage peanut (Arachis) or with trees such as leucaena, alley cropping of laurel and legumes with grazing potential with small animals.

General: The area should be carefully analyzed. The settlers are saturated with various lines of credit. User selection is necessary and a process to sensitize and organize groups would appear to be essential.

Projection for this area: Several crops are included in this area since they are already being validated by several farmers. The area needs several socioeconomic and organizational aspects to be defined and consolidated, in order to consolidate it without State paternalism. The area is very important for the formation and growth of a focus of development in Guatusos.

Chart No. 3
Area No. 3
Land Use: Crops and surface area

	CROP	% (HA)
A.	CACAO (25% C/U)	1150
B.	MARACUYA	450
	PEPPER	450
	MACADAMIA	450
C.	Other Crops	
	PINEAPPLE	450
	AVOCADO, Etc.	450

AREA NO. 4

Surface Area: 3500 Ha.

Centers of Population: Los Angeles, Veracruz, Monico
San Gabriel, Campo Verde

Specific Areas: It can be divided into: an area of low hills and flat, low areas near the River Cano Negro.

Watershed: Rivers: Rito and Cano Negro
Canos

Present Use:

Agriculture: (rice, root crops)	: 20 percent
Livestock; (extensive)	: 25 percent
Cacao: (Old - New) (20 percent)	: 30 percent
Forestry: (protection, "raicilla")	: 10 percent

Classification:

Life zones:
bh - T

Soils:

Soil use capability: This is land that we may consider agricultural: for annual crops, grazing and trees, over 70 percent of the area; limitations include slope, fertility and texture, as well as deficient drainage and a high phreatic level; these are limitations that are difficult to correct, in over 30 percent of the area. This land should be used for purposes such as refuge for wildlife, recreation, scenic considerations and protection of waters.

Origin and Topography: Most of these soils are in low-lying plains with a flat topography: in over 70 percent of the area, they have developed on high and low river terraces, old and more recent. The other 30 percent are marshy areas where water is present either permanently or temporarily.

T.S.C. Classification

Limiting factors:

- Drainage, marshy lands, phreatic level of > 50 cm. (water is present permanently or temporarily)
- Immigration status affects credit and ownership
- Lack of infrastructure: roads.

Technology: Traditional for cacao, basic grains.

RECOMMENDATIONS:

Land Use:

- Agricultural : 25 percent
  (pepper 10 percent)
- Livestock: : 20 percent
- Forestry: : 15 percent
  Cacao/Laurel : 5 percent
- Cacao: : 25 percent
  New : 20 percent
- Protection: : 15 percent

Systems:

General: The area requires drainage to improve the crops selected; however, the main recommendation is either to define the immigration status of the Nicaraguan population or somehow to incorporate them into production.

Projection for this Area: With a plan for ecotourism and management of the wetlands, it could become an important focal point for development in the zone.

Chart No.4
Area No.4
Land Use: Crop and surface area

	C R O P	% (HA)
A.	CACAO	1225
	Old:	875
B.	Pepper	350
	Cacao/Laurel	175
C.	Other crops	
	Rice - Tubers	
	Pineapple - Raicilla	

AREA NO. 5

Surface Area: 3000 Ha.

Centers of Population: La Cruz; San Isidro; Montecristo; Cinco Esquinas

Specific Areas:
- La Cruz
- San Isidro
- Cinco Esquinas

Watershed: Rivers: Zapote and Cabeza de Leon

Present Use:

Agriculture:	: 25 percent
Rice	
Livestock:	: 25 percent
Cacao:	: 25 percent
Old	
Forestry:	: 15 percent
Other/charral	: 10 percent

Classification:

Life zones:

bh -

Soils:

Soil use Capability: A small part of the area is suitable for use with all annual crops although there are limitations regarding soil depth and fertility in over 30 percent of the area.
Over 40 percent of the area also has drainage problems and there is a risk of flooding almost every year. There are also limitations in regard to texture and ph acid.

Origin and Topography: The area is composed mainly of low plains with a flattish topography: the soils are alluvial in origin, situated in depressions which flood permanently or temporarily.
There are also soils that have developed on high and low river terraces with slopes of more than 5 percent.

T.S.C. Classification

Limiting factors:

- Drainage/flooding/high phreatic level in the low-lying areas.
- pH acid and clay on the hills
- Problems concerning ownership and immigration status.

Technology: Traditional for cacao, basic grains and grazing.

RECOMMENDATIONS:

Land Use:

- Livestock: = 20 percent
  Improve grazing and management
- Cacao: = 25 percent
  Old and new
- Agriculture: = 20 percent
  Rice
- Pepper = 15 percent
- Forestry = 15 percent
  Cacao/laurel
  Heart of palm/Peach palm
- Protection = 5 percent

Systems: Agro-forestry systems including cacao and heart of palm are recommended.

General: The area has great potential for cacao production if management of old cacao is improved along with processing and marketing (storing and information on markets.) It is also necessary to define the drainage of some areas; this requires the participation of farmers groups or organized communities.

Projection for this area: To develop two focuses of development: one towards Cinco Esquinas, the other toward La Cruz or Montecristo.

The area permits validation of certain aspects of:

- management of old cacao
- drainage of fertile lands -- of great potential in the long-term for annual crop production.

Chart No.5
Area No.5
Land Use: Crop and surface area

	CROP		% (HA)
A.	CACAO	(25%)	750
	- Old - Cocoa/ Laurel	(5%)	150
B.	PEPPER	(15%)	450
	Heart of Palm/ Peach palm	(5%)	150
C.	Other crops		

AREA NO. 6

Surface Area: 3700 Ha.

Centers of Population: Bijagua/Zapote

Specific Areas:

- Settlement: Bijagua - Zapote
- Grazing area around Bijagua
- Horticultural/Agricultural area heading toward Upala along the road.

Present Use:

Livestock:	: 45 percent
Agricultural:	: 25 percent
Forestry:	: 30 percent
Protection or not suitable	: 10 percent

Watershed: River Bijagua, tributary of El Zapote

Classification:

Life zones:
bmh - P
bmh - T

Soils:

Soil use Capability: Some 30 percent of the soils in the area could be used for annual crop production. The other 70 percent involve land with severe limitations for annual crops; therefore rational use would be grazing, trees and protection, given the limitations of the soil in regard to depth (shallow soils) and clayey texture, very steep slopes with very high rainfall and very high erosion potential.

Origin and Topography: Over 30 percent of the area is covered by soils of volcanic origin, typical of the volcanic mountain range, rugged to mountainous topography, very dissected. In the rest of the area the topography ranges from rolling to very rolling, formed by the recent depositing of volcanic ashes (50 percent of the area); the rest of area consists of soils originating from pyroclastics and other meteorized volcanic material with rolling topography, deep.

T.S.C. Classification

Limiting factors: The area has the highest precipitation in the zone and winds of great intensity during a good part of the year. As well as clayey soils and pronounced slopes.

Technology: It varies according to the crops and/or livestock use -- though it is not advanced.

RECOMMENDATIONS:

Land Use:

- Livestock: = 25 percent
  Intensive (15 percent)
  Extensive (10 percent)
- Agriculture = 25 percent
  Maracuya (5 percent)
- Macadamia: = 25 percent
- Forestry: = 15 percent
- Protection = 15 percent
  Heart of Palm/Peach of Palm (10 percent)

Systems: Agro-forestry and silvo-pastoral systems should be incorporated into the management and production of this zone, especially those that protect soil from erosion.

General:

- The area requires windbreaks
- The soil should be protected with conservation efforts:

  -- Covering of grazing or legumes
  -- Soil pits and contouring
  -- Protection of drainage channels and ditches

- Observe the existing Maracuya plantation = validate the technology

Projection for this area: It is a very specific area in this zone in regard to its rain, cloud, wind and slope characteristics. The surface area should be reduced to some 2500 has. in order to validate the area with potential for the development of the crops selected. The area has potential for ecological tourism due to its special characteristics: forest, rivers, and natural beauty in general.

Chart No. 6
Area No. 6
Land Use

	CROP	% (HA)
A.	MACADAMIA	1000
	MARACUYA	150
B.	HEART OF PALM	300
C.	Other crops	

AREA NO. 7

Surface Area: 5300 Ha.

Centers of Population: Canalate; Chimurria Arriba; Pueblo Nuevo; San Jorge; Valle Azul, El Higueron, Buena Vista

Specific Areas:

- High Zone: Chimurria - Pueblo Nuevo - Buena Vista
- Low Zone: Canalate - San Jorge
- Intermediate Zone: Valle Azul, El Higueron

Watershed: Zapote, Canalate and Chimurria Rivers

Present Use:

Livestock	: 30 percent
Agriculture	: 25 percent
Cacao	: 25 percent
Other	: 10 percent
Forestry	: 10 percent

Classification:

Life zones:
bmh - P
bmh - T

Soils:

Soil use Capability: IV s2el; VI s2el2
Part of these soils (approximately 30 percent) could be used to produce almost all the annual crops, grazing and trees possible in this type of climate. By definition this land is suitable for "agricultural use", albeit with limitations due to slopes of under 30 percent and low fertility. The rest of the soils in this area have severe limitations as far as annual crops are concerned; therefore, their rational use would involve agro-forestry or silvo-pastoral systems that protect the soil from rain and erosion.

Origin and Topography: Most of these soils have developed on high and low river terraces, old and more recent, and their topography is rolling or abrupt to rolling, formed by the recent depositing of volcanic ashes. In parts these soils are deeper, also of volcanic origin, though more mature and developed. The presence of rocks and steep slopes with gradients of up to 50 percent was detected in this area. As for fertility, this land is moderately fertile and clayey.

T.S.C. Classification:

Limiting factors:

- Slope conditions in the highest zone - erosion
- Clayey soils, low fertility, and low pH in the zones in use the longest
- Settlers saturated as far as credit is concerned

Technology:

- Traditional in most cases
- Lack of information and technical assistance

RECOMMENDATIONS:

Land Use:

- Agriculture : 25 percent
  (Maracuya, pepper = 10 percent)
- Extensive Livestock : 15 percent
- Heart of Palm : 35 percent
- Cacao : 10 percent
  Rehabilitation/Renewal
- Forestry/Others : 15 percent
  Heart of Palm/Peach Palm 5 percent

General: The farmers participating should be very carefully selected, since 60-70 percent are IDA settlers. The area requires systems that incorporate soil conservation efforts based on the use of legumes.
The cultivation of heart of palm could be very important should it be possible to create a development area by integrating this area with that of Dos Rios.
The area also offers good conditions for pepper and maracuya production, though in very specific subareas.

Projection for this area: The area represents the most important inhabited area of the project and heart of palm needs to be defined as an agro-industrial crop.
This is the zone that could have a bearing on the project's national-level impact in view of private enterprise involvement in the production of heart of palm and maracuya.

Chart No. 7
Area No. 7
Land Use

	CROP	% (HA)
A.	HEART OF PALM (35%)	1800
	Heart of palm/peach palm	250
B.	CACAO: Old	> 500
	MARACUYA	550
	PEPPER	500
C.	Other Crops	

AREA NO. 8

Surface Area: 1800 Ha.

Centers of Population: Delicias, Mexico, San Ramon - Victoria ii

Watershed: Rivers: Salto and San Ramon
Cano Nino

Specific Areas:

- Delicias/La Cruz
- Victoria/San Ramon

Present Use:

Livestock	: 20 percent
Agriculture (Rice)	: 20 percent
Old Cacao	: 40 percent
Forestry	
Protection/Not suitable	> 20 percent

Classification:
Life zones:
bh -

Soils:

Soil use Capability: The area contains roughly 30 percent of soils that are low-lying plains with a flat topography that is subject to flooding, either permanently or temporarily; this land is classified as VIII and should be used for the protection of water sources, wildlife or recreation. Some 70 percent of the area consists of land that is alluvial in origin, flat with drainage that ranges from moderate to bad, with serious limitations as far as the phreatic level, depth and fertility of the soil are concerned.

Origin and Topography: Due to their origin, the soils are mostly alluvial or lacustrine.

T.S.C. Classification

Limiting Factors:

- Surface and internal drainage: phreatic level
- Bridges, roads
- Immigration/credit status
- Unalienable zone

Technology: Traditional for cacao and subsistence crops

RECOMMENDATIONS:

Land Use:

- Cacao: New and Old : 30 percent
  New Cacao 15 percent
- Agriculture: : 25 percent
  Pepper 15 percent
- Livestock : 20 percent
- Forestry : 25 percent
  Protection 15 percent
  Heart of Palm/Peach Palm 10 percent

General:

- To define San Jose-Upala as an "area of influence" that includes Victoria and an area taking in Delicias and/or La Cruz.

- These areas require cultivation systems such as:

  -- Cacao/Laurel/Cedar
  -- Heart of Palm/Peach Palm

- For planting pepper, drainage should be improved through works such as:

  -- Canals
  -- Ridging and the incorporation of organic materials.

- The area and the soil in the area make planning efforts for the future worthwhile, developing a validation/demonstration area to show how drainage improves the characteristics of these soils and could efficiently produce annual crops or more difficult ones such as pepper.

Projection for this area: Very little, as there are problems concerning immigration status and the government-protected zone that affect the stability of individuals, ownership and credit. Drainage in the zone could demonstrate the potential of similar land in the low/border area.

Area No. 8
Chart No. 8
Land Use

	C R O P	% (HA)
A.	CACAO:	550
	OLD	250
	NEW	
B.	PEPPER	250
	HEART OF PALM/PEACH PALM	200
C.	Other Crops	

AREA NO. 9

Surface Area: 2000 Ha.

Centers of Population: Sta. Clara; Moreno Canas, Las Brisas

Watershed:
- River Guacalito
- River Canalete-Zapote

Specific Areas:

- Area at the foot of the mountain - steeper slopes
- Flatlands - central area - near rivers
- Hills - less steep slopes

Present Use:

Livestock	: 25 percent
Agriculture (Rice, corn, root crops)	: 25 percent
Cacao	: 25 percent
Charral/Forestry	: 15 percent
Other	: 10 percent

Classification:

Life zones:
bmh - P

Soils:

Soil use Capability: As far as soils are concerned, most of the area is suitable for agricultural use with annual crops although there are limitations involving soil depth and fertility, as well as surface drainage and a high water table in certain subareas.

Origin and Topography: As far as origin is concerned, the soils mainly developed on high and low river terraces, old and more recent, partly alluvial in origin. For the most part they form flat, low plains in the center of the area; of volcanic origin, deep; and there are also some hills with long slopes and potential erosion problems.

T.S.C. Classification

Limiting Factors:

- Limited drainage and a high phreatic level on flat land.
- Low fertility - clay on hills, low pH in some subareas.
- Road's effect on drainage.

Technology:

- New cacao and corn technology has advanced
- Traditional for subsistence crops; for practical purposes there is none in the case of old cacao

Potential Land Use:

- Cacao: Old : 20 percent
- Cacao: New : 15 percent
- Agriculture : 30 percent
  Pepper 15 percent
- Livestock : 20 percent
- Forestry/Others : 15 percent
  Laurel (5 percent)
  Cacao

General recommendations: The area must be carefully managed, bearing in mind soil protection and improvement with legumes and agro-forestry systems. Livestock management should be extensive but care should be taken on sloping land, perhaps with silvo-pastoral (agro-forestry) systems. The management of old cacao must include drainage, shade and probably grafts.

Projection for this area: The projected surface area is some 4000 has, over which nontraditional crops could be developed together with basic grains and cacao, if steps are taken to improve drainage and the drying and processing infrastructure in the zone. The area has potential for pepper production in zones to the right of the Rio Guacalito.

Area No. 9
Chart No. 9
Land Use

	CROP	% (HA)
A.	CACAO:	
	Old/New/laurel	500
	New	300
B.	PEPPER	300
C.	Other crops	

AREA NO. 10

Surface Area: 5000 Ha.

Centers of Population: San Isidro/Aguas Claras; Colonia Blanca; La Libertad

Specific Areas: The area includes several microclimates and certain soil variation within those microclimates.

- Area of rolling hills to flat land: San Isidro/Rio Negro
- Area with steep slopes: near San Isidro, high part of the Blanca and La Libertad Colonies
- Area with gentler slopes: the Libertad and Colonia Blanca colonies
- Hilly Area: Shallow soils, low fertility and the risk of erosion due to the soil/rain combination.

Watershed:
Rio Negro
Guacalito
Frijoles
Raudales

Present Use:

Livestock	: 45 percent
Extensive	: 25 percent
Intensive	: 15 percent
Agriculture	: 35 percent
Traditional:	: 10 percent
Nontraditional:	: 25 percent
Forestry, Charral, Others	: 20 percent

Classification:
Life zones:
bmh - T

Soils:

Soil use Capability: The soils in the zone could mainly (70 percent) be considered as suitable for agricultural use with limitations due to the slope (40 percent) or the clayey texture (50 percent). We have divided the area into four zones, taking considerations of slope into account: Less than 30 percent, steep slopes in the area around San Isidro. Gentle slopes of 10 percent to 30 percent in Las Colonias and zones that range from rolling/flat to hills ranging from 5 percent to 10 percent in the vicinity of San Isidro and in Las Colonias, in the area adjoining the Rio Negro.

Origin and Topography: Due to their origin the soils may be considered as mostly exhibiting a rolling to strongly rolling topography. Formed by the recent depositing of volcanic ashes that form low or irregular ridges and hills.

T.S.C. Classification

Limiting Factors:

- In areas with steep slopes and hills the soil should be protected with a vegetative covering.
- The area requires the organizing of the communities involved for the heart of palm and maracuya markets.
- The priorities as far as limiting factors in the zone are concerned are: fertility and soil texture.

Technology: Advanced in regard to intensive grazing, dairy production and nontraditional crops such as: heart of palm, macadamia, maracuya.

RECOMMENDATIONS:

Land Use:

- Livestock: : 20 percent
- Agriculture : 20 percent
  Traditional
  Potential for Pepper 15 percent and
  Maracuya 5 percent
- Heart of palm : 30 percent
- Macadamia : 15 percent
- Forestry/Protection : 15 percent
  Peach palm/cacao/laurel

Systems: The peach palm/heart of palm or cacao/laurel system is recommended in sloping areas for protection or grazing. It is also recommended that soils be protected with crops providing soil cover such as forage legumes.

General: To define subfocuses of development:

- One around Las Harmonias/Canalete based on heart of palm
- Another around Las Colonias with macadamia, potentially forming a larger area with area #13
- Another: silvo-pastoral (agro-forestry -- livestock and peach palm) around San Isidro and Rio Negro and silvo-pastoral systems that include legumes, peach palm and grazing with intensive management.

Projection for this area: The area has great potential as a focus of development for any of the crops analyzed -- but there have been prior experiences or large investments in heart of palm in the area. Pepper, macadamia and plantain are also important as well as intensive livestock activities. The zone could be representative of some 2000 has. in the surrounding areas.

Area No. 10
Chart No. 10
Land Use

	C R O P		% (HA)
A.	HEART OF PALM		1500
	MACADAMIA		750
B.	PEPPER		250
	MARACUYA		250
	Systems:	Cacao	400
		Peach palm/laurel	
C.	Other crops		

AREA NO. 11

Surface Area: 1700 Ha.

Centers of Population: Cuatro Bocas, El Porvenir, Los Cartagos

Specific areas:

- Area near the Cuatro Bocas river
- El Porvenir Area
- Los Cartagos Area

Watershed: Nino (Pizote) River

Present Use:

Livestock	: 45 percent
Extensive Grazing	
Agriculture	: 20 percent
Old Cacao	: 15 percent
Forestry, Others, Charral	: 20 percent

Classification:

Life zones:

bmh - P

Soils:

Soil use Capability: The soils in the area are mostly suitable for agricultural use or for the crops selected in this assessment but with limitations of slope and fertility. A limited area (15 percent) is formed of soils which flood temporarily once a year; sandy and shallow.

Origin and Topography: The origin of these soils is mostly volcanic or developed on high and low river terraces, old and more recent.

T.S.C. Classification

Limiting Factors:

- The area near the river floods every year
- Clayey and shallow soils in the El Porvenir area.
- Pronounced slopes up to 40 percent in the Los Cartagos zone.

Technology: Traditional for old cacao. Quite advanced technology for rice crops.

RECOMMENDATIONS:

Land Use:

- Agriculture : 20 percent
  Rice, plantains
- Livestock : 25 percent
- Cacao: : 25 percent
  New
  Old 20 percent
- Pepper : 10 percent
- Forestry/protection : 20 percent
  Heart of Palm/Peach Palm 10 percent

Systems:

- Agro-forestry systems are recommended based on peach palm and cacao/laurel.
- Soil cover systems are required on the hills.

General Recommendations:

- Pepper: This is recommended as a socioeconomic alternative for small farmers and in very small areas where soil drainage and texture will be improved.

- Heart of palm/peach palm are an alternative for this group of small farmers and thus would improve extensive livestock use, for a more efficient crop.

- Cacao also permits a cacao/laurel/cedar system on land with new cacao.

- The boundaries of the area are now defined so as to achieve greater influence for San Jose and moving away from the land that floods; near the river toward the hills of La Chepa.

Projection for this area: The area is redefined in an attempt to avoid the land that floods. The area should be developed taking San Jose de Upala as its center.

Area No. 11
Chart No. 11
Land Use

	C R O P	% (HA)
A.	CACAO:	250
	Old (15%)	170
	New (10%)	
B.	PEPPER (10%)	170
	Heart of palm/ Peach palm systems	170
C.	Other crops	

AREA NO. 12

Surface Area: 1800 Ha. (It is recommended that it be reduced to 1200 Ha.)

Centers of Population: Villanueva, Fatima, El Delirio

Specific areas:

- Hills to the west of the road
- Marshes or land that floods to the east of the road.

Watershed: Rivers: Hacienda, Los Canos and Pantano, to the right of the access road

Present Use:

Agriculture	: 15 percent
Livestock (seasonal use)	: 30 percent
Cacao	: 20 percent
Old Forestry	: 20 percent
Flooded Charral	: 15 percent

Classification:

Life zones:
ph - T

Soils:

Soil use Capability: This is the area with the greatest limitations as far as soils are concerned: phreatic level of less than 60 cm, more than 40 percent of the area is made up of hills with clayey, shallow soils (30-40 cm), potential erosion problems on the hills and in the low-lying areas (land that floods and remains waterlogged for most of the year).

Origin and Topography: Ridges of structural origin, eroded and forming a mountain range in the area. As well as low plains that form marshes in those that are alluvial or lacustrine in origin, flat areas ranging from moderately drained to marsh. The hills range from rolling to very rolling.

T.S.C. Classification

Limiting Factors: Limiting factors include slope, fertility and erosion on the hills over more than 25 percent of the area and drainage in the flat areas, phreatic level less than 60 cm in over 30 percent of the area. These characteristics, together with problems regarding immigration status and ownership make this one of the areas of greatest conflict.

Technology: Traditional for basic grains and cacao

RECOMMENDATIONS:

Land Use:

- Agriculture: : 15 percent
  Rice, Corn, fruit trees
- Pepper : 5 percent
- Livestock: (seasonal) : 20 percent
- Cacao/New : 10 percent
- Cacao/Old : 10 percent
- Forestry protection : 40 percent
  Laurel/Cacao
  Heart of Palm/Peach Palm 20 percent

Systems:

- To define systems:
  cacao/laurel/cedar
  Heart of palm/peach palm

- Define: an annual system for cattle with rotation from hills to waterlogged land, improving grazing on the hills.
  A system of heart of palm/peach palm, that permits rotation with legumes and the use of peach palm as feed for pigs and cattle.

General:

- Relocate farmers in other places

- Carefully select areas for pepper - on the hills

- Eliminate some 800 has. of waterlogged land and eroded/clayey hills.

Projection for this area: The area is perhaps the one with the greatest limitations -- fortunately it is not representative of a high percentage of the land included in the project. One solution for this area is the relocation of some farmers on the surrounding hills or on land more suitable for the crops selected.

Area No. 12
Chart No. 12
Land Use

	C R O P	% (HA)
A.	CACAO: OLD	120
	NEW	120
B.	PEPPER	120
	Systems:	
	Heart of palm/peach palm	120
	Laurel/Cacao	120
C.	Other crops	

AREA NO. 13

Surface Area: 2400 ha

Centers of Population: San Luis, Cooperativa, Buenos Aires, San Jeronimo

Specific areas:
- Area above 400m
- Buenos Aires/Argelia Area
- San Luis and Cooperativa Area

Watershed: River Cucaracho and tributaries: Negro, Blanco, Azul, Francia and the Quebrada Penjamo

Present Use:

Agriculture	: 25 percent
Livestock	: 40 percent
Cacao, Plantains, other fruits	: 10 percent
Forestry/Charral/Protection	: 25 percent

Classification:

Life zones:
bh - T

Soils:

Soil use Capability: Around 80 percent of the soils in this area could be considered for use with the crops selected for this assessment, incorporating annual crops into the systems proposed; the area has limitations in regard to texture and erosion over approximately 15 percent of its surface area (area with an altitude of over 400 m).

Origin and Topography: The topography of the area is influenced by the nearby volcanoes and is characterized by steep slopes over a small part of the area. Although it is of volcanic origin, the rest of the zone is flatter with low-lying ridges with rolling-to-very-rolling topography (area around San Luis and La Cooperativa).

T.S.C. Classification

Limiting Factors:
- Water: for irrigation and human consumption in the central part of the area.
- Soil: slopes of up to 50 percent and visible or potential erosion over more than 30 percent of the area. Rocky outcrops or volcanic clustered fragments that occur in layers at different depths.
- Climate: Precipitation of > 3000 mm/year/average
  These two factors, soil and climate, mean that there should be careful soil and vegetation management in over 50 percent of the area.

Technology: Traditional and subsistence (agriculture). Improvement of small areas with cacao, pineapple, coffee and rice.

RECOMMENDATIONS:

Land Use:

- Livestock: : 20 percent
- Agriculture: traditional, pineapple, corn, plantains : 15 percent
- Macadamia: : 30 percent
- Maracuya: : 15 percent
- Forestry/protection : 20 percent
  Cacao/Laurel 10 percent

Systems: It is essential to incorporate legumes as vegetative cover for the soil. Windbreaks, agro-forestry (silvo-pastoral) systems are necessary in a large part of the area.

General:

- The area lends itself to the development of macadamia as a priority crop although this requires systems or associations with crops such as coffee, windbreaks and legumes that protect the soil and allow for grazing by animals such as sheep.

- Maracuya and pepper in small areas are a socioeconomic alternative for the "parcel" owners on the settlements in the area and the cacao/laurel system could also be viable in lower areas with more rugged terrain.

Projection for this area: The area could be developed -- if the road towards Liberia is improved -- underpinning it with industrialization or processing in Guanacaste.

Area No. 13
Chart No. 13
Crops selected and surface areas

	CROP	% (HA)
A.	MACADAMIA	720
B.	MARACUYA	360
C.	Other crops CACAO/LAUREL	240

AREA NO. 14

Surface area: 2100 Has.

Centers of Population: El Encanto, La Jabalina and La Lucha

Specific areas:
- Area near to production of citrus fruits: El Encanto and La Jabalina
- Area near La Jabalina towards the Pizote River and towards El Ensayo

Watershed: Cucaracho and Pizote Rivers

Present Use:
- Livestock : 50 percent
- Agriculture : 20 percent
- Forestry and Charral : 20 percent
- Not suitable and protection: 10 percent

Classification:
Life zones:
bmho

Soils:

Soil use Capability: Shallow, heavy soils with problems regarding slope and erosion. Moderate to low fertility in a large part of the area. However, there are areas near to the Pizote river, alluvial, deep, that would permit pepper production.

Origin and Topography: For the most part rolling flatlands formed by very meteorized volcanic materials, deep, and very small areas formed by recent volcanic ashes.

T.S.C. Classification

Limiting Factors:

- Irrigation and potable water over 70 percent of the area
- Slopes of up to 30 percent in 10-20 percent of the zone
- pH acid clayey texture, low fertility
- Shallow soils on the hilly areas

Technology:

- The area has potential for advanced technology on El Ensayo and the farms producing citrus fruits.

- The technology for subsistence crops is traditional.

RECOMMENDATIONS:

Land Use:

- Agriculture: basic grains
  citrus fruits, pineapple : 40 percent
- Livestock: : 20 percent
- Maracuya, Macadamia : 20 percent
- Forestry protection : 20 percent
  A cacao/laurel system may be introduced on 200 has of this category

Systems: Cacao/laurel in the fragile areas, forestry

General:

- This area should be incorporated into the agro-industrial development of citrus fruits, maracuya, and pineapple of zone #15, since there are over 400 has. in the "agricultural" category suitable for the cultivation of citrus fruits and pineapple.

- The farmers in the vicinity of El Encanto are familiar with coffee-growing and the zone offers the ecological conditions for this activity.

- There are deep soils in areas near to the River Pizote where the growing of black pepper could be encouraged.

Projection for this area: This area forms part of the "area of influence" of cultivation of citrus fruits: Santa Cecilia, Birmania and Brasilia. It also possesses information and technology validated for the area on the El Ensayo farm.

Area No. 14
Chart No.14
Land Use

	CROP	% (HA)
A.	MARACUYA	420
B.	MACADAMIA	420
C.	Other crops CACAO/LAUREL	200

AREA NO. 15

Surface Area: 2900 Has.

Centers of Population: Santa Cecilia, Sta. Elena and La Virgen

Specific areas:

- Santa Cecilia
- La Virgen towards the border, northern section
- To the left of the road, west section of the area up to Rio Mena

Watershed: Watersheds of Rivers Mena and Orosi

Present Use:

Agriculture	: 25 percent
Cacao	
Fruit trees	: 20 percent
Others	
Livestock	: 40 percent
Forestry/protection/charral	: 15 percent

Classification:

Life zones:
bh-T; bh-T

Soils:

Soil use Capability: Soils with serious limitations due to slopes and potential and visible erosion, but are suitable for the crops selected under this study if measures are taken to cover and protect soil from the rain.

T.S.C. Classification: Classes IV and VI in the traditional management system

Origin and Topography: Low hills of structural origin and rolling flatlands formed mostly by soils originating from pyroclastics and other meteorized volcanic materials, rolling topography, deep, or as in the case of a small section, residual soils originating from meteorized sedimentary rocks "in situ", rolling-to-strongly-rolling.

Limiting Factors:

- Soil depth. Rocks in limited areas
- A slope of more than 30 percent over more than 40 percent of the area
- pH acid and clayey texture in over 40 percent of the area

Technology:

- Traditional for subsistence crops
- Advanced for the production of citrus fruits

RECOMMENDATIONS:

Land Use:

- Traditional Agriculture: : 15 percent
- Citrus fruits : 30 percent
- Maracuya : 15 percent
- Pepper : 5 percent
- Livestock: : 30 percent
- Forestry - protection and other : 5 percent

Systems: Systems are required that incorporate legumes to provide vegetative cover as well as nitrogen fixation.

General:

- Define socioeconomic aspects in the border zone
- Encourage agro-industrial development and processing of citrus fruits, maracuya and pineapple
- Incorporate private enterprise and farmers groups into this development

Projection for this area: The area is representative for zones such as Santa Cecilia, Birmania, Brasilia and El Ensayo as far as suitable crops and the development model that could be used; supported in the future by marketing, technology and processing of citrus fruits, maracuya and pineapple.

Area No. 15
Chart No.15
Land Use

	CROP	% (HA)
A.	MARACUYA	400
	PEPPER	150
B.	_____	
C.	Other crops	
	CITRUS FRUITS	750

3.4 Analysis of Table 3.

3.4.1. Total surface area by crop/area

CACAO: 6500 Ha.

System: cacao/laurel: 1100 Ha.

HEART OF PALM: <4000 Ha.

System: Heart of palm/peach palm: 1400 ha.

MACADAMIA: 3800/3600 Ha.

System: macadamia/pulses/grazing or macadamia/coffee. This is proposed specifically in zones 2 and 14 but a vegetative cover should be included, preferably a legume (ARAQUIS), as soil cover in other zones.

MARACUYA: 2500/2700 Ha.

BLACK PEPPER: 3000 Ha.

This is included as an alternative solution for social and economic reasons in zones #4, 5, and 12; as the main crop in zones #8, 9 and 11; and as a very good alternative in areas $14, 10, 7, 3.

3.4.2. Projections/Area of Influence:

Each area is surrounded by a certain number of hectares with similar characteristics that could be incorporated into the production of the crops selected.

An area of "influence" is estimated here, subject to more careful analysis of soil, micro-climates and especially farmers that are not "parcel"-owners and bearing in mind that the zone could have greater potential for development by incorporating independent farmers, associations, CAC's and private companies into a concept of sustained development, but with more of an entrepreneurial emphasis, taking into account aspects such as potential for processing, markets, and the participation of farmers in problem-solving.

3.4.3 Crops selected in the zone: Location

HEART OF PALM:

Dos Rios area

TABLE 3

AREAS AND TOTAL SURFACE AREAS
(Summary: areas, crops, and surface areas)

		HECTARES / CROPS					
Areas	Systems	Maca-demia	Mara-cuya	Heart of Palm	Black Pepper	Cacao	Projections (Ha*)
1	200	400-600		200-400			2000
2	P/P=500 M/P/L=400 C/L=200	400		500		200	>2000
3		450	450		450	1150	>5000
4	C/L=175				350	1225	>1500 (DRAINAGE)*
5	C/L=150 P/P=150				450	750	>2000 (DRAINAGE)*
6		1000	150	300			>1000
7	P/P=250		550	1800	500	500	>2000
8	P/P=200				250	800	
9					300	800	
10	400 VARIOUS	750 M/L/P	250 P/P	1500	250		>2000
11	P/P=170				170	420	>1500
12	P/P=120 C/L=120				120	240	>500
13	C/L=240 M/CAF	720	360				>1500
14	C/L=200 M/C	300	400		100		>1500
15			200-400			50-100	>2000
TOTALS	P/P 1500 C/L 1200 M/L/P VARIOUS 400	3600/3800	2500/2700	<4000	3000	6500	

*, If the limited drainage is corrected
P/P Heart of Palm/Peach Palm
M/L/P Macademia/Legumes/Grazing
C/L Cacao/Laurel
M/CAF Macademia/Coffee

MARACUYA:

Settlements in Guatusos, Aguas Claras, Colonia Blanca, Bijagua and Upala

BLACK PEPPER:

- Upala/Sta. Clara, Colonia Puntarenas
- Settlements in Guatusos
- Sta. Cecilia
- Aguas Claras

MACADAMIA:

- Sta. Cecilia
- Colonia Libertad
- Guatusos
- Bijagua

CACAO:

In almost the entire zone

3.5. Clarifications/Recommendations by Area:

Area No. 3:

- Two crops - cacao and maracuyá - are also given as alternatives as they grow well in the zone.

Area No. 6:

- If the good performance of the Sta. Isabel variety continues, Maracuyá could take over part of the land used for macadamia.
- Heart of palm is included as a viable alternative on land that presents greater problems of wind and precipitation.

Area No. 7:

- Priorities in heart of palm and maracuyá.
- Some old cacao should be managed and pepper is an alternative in areas with good drainage and good farmers.

Area No. 9:

- Managed old cacao and cacao/laurel systems.
- 15 percent new cacao.

Area No. 10:

- Priorities heart of palm and macadamia.
- Maracuya and black pepper could complement a change by small cattle-farmers to an agricultural activity.
- The development of agro-forestry or silvo-pastoral systems is recommended for land with a greater likelihood of erosion due to its soil characteristics.

Area No. 11:

- The area should be analyzed with great care in order to choose the best farmers and land.

Area No. 12:

- Reduced to 1200 has.
- Careful selection of farmer and land

Area No. 13:

- The area has potential for the development of agro-silvo-pastoral systems based on macadamia, laurel and cacao.

Area No. 14:

- The area could be incorporated into production of citrus fruits on over 30 percent of the surface area.

Area No. 15:

- Area ready for work with citrus fruits. The project should involve other state organizations: MAG, IDA, Banking System, or if not, promote the integration of NGO's into the development of this area in regard to the processing of citrus fruits, pineapple and maracuya.

3.6. Development Areas

Here we highlight the characteristics of areas that are considered priorities in the development process.

3.6.1. Border area:

The situation of the inhabitants vis-a-vis their immigration status must be defined. As far as the selected crops are concerned it is recommended that:

- Pepper be grown, though the area is not the most suitable because of its drainage characteristics - in order to provide the inhabitants of the area with an alternative crop, in small areas and with a high labor input.
- As for cacao in this area, there are more than 300 has. of unmanaged old cacao with low yields that is not a source of income, work or stability for families.

3.6.2. Areas with potential for fruit processing

Pineapple, citrus fruits and maracuyá.

It is necessary to define the processing infrastructure and the development of producer associations.

3.6.3. Areas with potential for cacao storage:

- Upala, San Jose and Las Delicias

It is necessary to define a storage and marketing mechanism.

3.6.4. Areas with erosion problems:

- Cabanga and the Indian Reservation
- Sta. Cecilia
- Buenos Aires, Dos Rios
- Aguas Claras and San Isidro
- Canalete, Chimurria
- Bijagua

They require systems that incorporate legumes and soil protection.

3.6.5. Areas with drainage problems:

- Border Area

These two areas require an analysis at the individual farm level to recommend specific practices and systems.

CHAPTER FOUR

ENVIRONMENTAL MANAGEMENT OF POTABLE WATER PROJECTS

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4.1 Introduction

The Northern Zone Consolidation Project (NZCD) intends to increase opportunities for productive and sustainable development of the Northern Zone of Costa Rica. Development activities are based on increasing non-traditional export-oriented crop production, consolidating current settlement activities in the region through titling services to land holders, developing a self-financed system for road maintenance and rehabilitation, and supporting basic social infrastructure improvements. As part of these basic social improvements, funds and technical assistance are being made available to rural communities for the design and construction of potable water systems.

A tremendous need presently exists in the Northern Zone for safe potable water systems that can provide water of adequate quantity and quality to rural communities. Many communities are presently without piped water supplies, and endure poor health conditions, time consuming water collection tasks, or both on a regular basis.

The Northern Zone Consolidation Project, primarily through Direccion Nacional de Desarrollo de la Comunidad (DINADECO), has carried out a program over the past four years which has created the basis for the organizational and administrative strengthening of community organizations throughout the project area. With the assistance of DINADECO staff, communities have defined local problems and identified opportunities for action. Training seminars in community organization, accounting, budgeting, legal and administrative procedures have been conducted.

4.2 Environmental Protection for Potable Water Projects

In order to apply for financial assistance to proposed projects a community must prepare a letter of intent, accompanied by documents which demonstrate commitment of labor and time for project completion. Potable water projects must also include a completed form which identifies provisions which will be taken to protect the quantity and quality of the source of water. A copy of the present version of this form is included in Appendix C.

In general, this environmental protection form is intended to both assure that the natural resource base in the project area is managed on a sustainable basis, and to provide an opportunity for project staff to transfer knowledge and skills in environmental management to rural residents. In completing the document rural communities should develop a greater awareness of the hydrologic cycle and the causes of key environmental changes which could affect the long-term usefulness of the project, including:

- factors which can result in seasonal changes in water yields from ground and surface water supplies
- environmental factors affecting local or downstream flooding
- chemical characteristics of water supplies
- the relationships between water quality and biologic health.

4.3 Existing or Proposed Project Activities

Project staff have received requests from fifteen communities for technical assistance in potable water projects. These communities include the following:

Association	Contact Person
Birmania de Upala	Vidal Fernadez Quintana
San Jorge de Upala	Juan Barrios/Alfonso Lopez Sandoval
Los Cartagos	Omar Villalobos
El Salto de Upala	Jorge Murillo Alfaro
Colonia Blanca de Upala	Rosalba Espinoza
Santo Domingo Upala	Mayra Somarribas
San Isidro-Aguas Claras	Daniel Murillo/Juan Vicente
Brasilia de Upala	Manuel Gonzalez
Rio Negro-Aguas Claras	Raul Fallas
San Jose Upala	Gustabo Hernandez Espinoza
Buena Vista Upala	Veronica Lezama Lezama
Katira Guatuso	Manuel Corea Chavarria/Rafael Lopez
Puerto Nuevo de Guatuso	Juan Maria Ulate Espinoza
Las Armenias	Gerardo Quiros Ramirez

4.4 Field Activities Conducted as Part of the Short-Term Assistance

As a plan of action, the short-term technical advisor in Support to Community Development visited each of these communities accompanied by staff from DINADECO. We met with community leaders, families, and other key contacts, and did on-the-ground investigations of existing conditions affecting the quantity and quality of water available for development of a potable community system. Specifically, the field work attempted to provide detailed observations for each proposed water system on present water quality and quality. The effort was intended to provide answers to the following questions:

- Would the identified source of water provide sufficient supply to meet present and projected future needs?
- What environmental changes in the catchment area contributing to this water source might adversely alter the volume of this supply?
- Is the identified water supply of good enough quality to avoid any significant health problems? What environmental changes in the catchment area or immediately adjacent to the identified supply might adversely affect the quality of the water to be used?
- What specific management actions and agreements can the community make right now to guarantee that the present quantity and quality of water will be maintained on a sustainable basis into the future, to the best of their ability?

The intent of these village assessments was to use the interview process as an opportunity to establish among community residents a basic understanding of the hydrologic cycle and local environmental management needs.

At the project sites we initially met with the identified local contact for the proposed water system. After defining our interest as protection of the quality and quantity of water available from the source, we would initiate an open dialogue in an effort to answer all of the questions listed below.

Some questions were directed to the NZCP Project Staff. Others were for the villagers to answer, using their life experience as a guide. Finally, I would use my own resources to accumulate information which assisted my understanding of the local socio-ecological conditions. In all instances my intent was to demonstrate to village residents (and myself) how much they already understand about the hydrologic processes and environmental management needs facing each specific project being proposed.

In many cases, community members with whom we worked were very aware of the intricate physical and biological conditions which influence the quantity and quality of water available to them. In some instances, however, it was obvious that not all village residents saw watershed protection as a high priority in this stage of the project proposal. Especially in these instances, then, the village assessments served a role by establishing the importance of these factors in any overall project success.

In each site visited we would inspect the proposed water source, be it spring or well. In the process, we would do the following:

- use the physical setting of this water source as a field exercise to delineate the immediate catchment area for the source
- draw up a map to define the key portion of this catchment area which can be managed as a protection zone by the community
- define specific steps that can be taken to protect the quantity and quality of the source.

The end result of each visit was a completed Environmental Management form to accompany the community's application for financial and technical assistance for development of a potable water system.

A flow chart model of the methodology and process used to determine environmental management needs and promote greater environmental awareness for proposed potable water projects in the Northern Zone is included in Volume 2.

4.5 Community Assessment Topics

The specific questions which were presented in community visits included the following:

Questions Directed To Project Staff (DINADECO):

1. What data exist to estimate monthly/annual rainfall? temperature? variations in yields from springs and wells? variations in streamflow? basin sediment yield?
2. Which individuals from participating institutions can provide training and technical assistance to the communities in the monitoring of water quality from the surrounding watersheds? Will additional training be necessary for individuals from participating institutions so that they can provide this service? If so, how and when will this training be provided?

3. What data exist to estimate the following water quality parameters:

   pH

   fecal coliform count

   Total Dissolved Solids (tds)

   Sodium

   Potassium

   Calcium

   Magnesium

   Iron

   Hardness (Carbonate)

   Sulfate

   Nitrates

   Phosphates

4. What is the cost and availability of water quality testing services prior to the implementation of a community potable water project? as an on-going service to the community throughout the life of the water system? What parameters can be tested?

5. What additional technical assistance is available to rural communities for the design, implementation, and maintenance of potable water systems? How accessible is this assistance for rural community members?

Questions Directed To Community Residents:

1. From what source will you obtain the water supply for the proposed water system?

   a. mountain springs captured and delivered by gravity flow

   b. drilled or dug wells

   c. surface water diversions

   d. rainwater catchment

   e. combination of (a) - (d)

   How far away are these sources? What other sources are available? What sources have been used in the past to supply water for community needs?

2. a) What is the present yield from this spring (liters/minute)? Does this yield vary from month to month? wet season/dry season?

   b) How deep must you dig to obtain ground water? (for communities relying on dug or drilled wells)

3. What is the total area contributing to the flow of this spring or to the recharge of the water in the ground that supplies local wells? (e.g., delineate the catchment area or watershed which recharges your water supply)

4. Springs and wells are supplied with water from beneath the ground. How does the water from the surface (runoff, streams, rivers) affect this water from beneath the ground in your specific project area? (do springs get cloudy after major rainstorms, etc.)

5. What is the condition of the land area in this watershed? (amount of forest or other vegetative cover, exposed soils, average slope, geology, type of soils, amount of sediment in streams and rivers, stability of channels)

6. How do people use the land areas in this watershed above the source of water? (grazing of animals, cultivation of crops, roads and paths, etc.)

7. How often do floods occur which might affect the source of water to be used (spring or well)? Describe some of these flood conditions from the past.

8. What can be done to protect and/or improve the quantity of water available from the source to be used? (conservation of existing forested areas, natural regeneration of forest cover, reforestation, relocation of grazing animals, trail maintenance, etc.) Who will do this work? Who will monitor or supervise it?

9. How will you use the water from the proposed water system? (drinking, washing, animals, etc.) What other uses do you have for local water supplies? (e.g., rivers - fishing)

10. What are the major disease problems in your community? Which of these disease problems do you see being caused by the quality of the water you use?

Questions For the Short-Term Advisor to Resolve:

1. What qualities do people most value in their water supply? (e.g. taste, color, odor, convenience, reliability, perceived health value)

2. What are the local methods of excreta disposal? What are the general environmental sanitation conditions in the community?

3. What is the approximate distance to existing springs? Depth of existing wells?

4. What is the present population of the community? Dispersed or concentrated?

5. What types of organizations or committees exist in the community? How often do they meet?

6. What experience does the community have in self-help project maintenance efforts?

7. What does the community see as the real environmental concerns for their area?

8. What do people think of the national organizations available for technical assistance?

4.6 Summaries of Community Visits

4.6.1 Summary of Field Visits

Approximately 20 communities were visited one or more times to inspect existing water services, review plans and conduct a field study of the source for proposed new water systems. Many of these communities had some form of water supply service at present in the form of hand dug wells, drilled wells, or capped springs.

All of the communities visited, however, felt that their present service was inadequate. The communities of Santa Elena, Buena Vista, Rio Negro, and Colonia Blanca have access to capped springs with distribution lines in place. The distribution networks, however, do not meet all present or probable future water needs in these communities.

Most of these existing systems are also in need of significant repair. Mainline pipes have broken or are the wrong size to meet projected needs. Spring boxes need new covers or a better seal. A physician in San Isidro de Aguas Claras confirmed that more than 90 percent of the users of the present water supply source suffer from water borne intestinal parasites, primarily giardia and e.coli.

Lack of Available Data

Very little data now exist to measure local hydrologic conditions. Although some data were found to indicate precipitation and temperature patterns in the Northern Zone, the reliability of this data is uncertain. In addition, the more important data on variations in yields from springs and wells, variations in streamflow, and sediment yield from the higher watersheds are not available.

Water quality tests have been conducted for several of the springs to be used in the proposed water systems, but any existing copies of the results from these tests are apparently in the office of AyA in San Jose. No copies were available in the communities or in the Project office.

Local Preferences and Needs in Water Management

The quality most valued by community residents is taste and odor. If it tastes good and smells good, then people will use it. Convenience of supply was also rated

as important. Although the water supply presently used by much of the population of San Isidro de Aguas Claras is apparently contaminated and residents have been warned by the local doctor of the risks in drinking the water, the convenience of the supply results in continued use.

Every community visited appeared to have an active rural development committee or association, with a strong sense of cooperation and enthusiasm. Most communities reported some kind of past project effort which had been carried to completion by the local organization. Respect and support for the organizations involved in the NZCP was widespread in all of the communities visited. The field staff for DINADECO are especially noted in the comments of every community. Approximately one-half of the communities visited did not know the responsibilities of AyA, the national organization doing the technical work of rural water development.

Community members participating in the design, construction and maintenance of the proposed water system will need technical training and guidance in all phases of the project work. In specific reference to environmental protection, participating community members should receive training to include:

- techniques for delineating watersheds on a map and in the field
- general hydrologic principals to demonstrate how solutes move from the ground surface through underground water mediums, and the role of forest cover in the quality and quantity of water received at a spring source,
- techniques for collecting and conducting a simple analysis of a water quality sample using a portable testing kit.

It may be possible to accomplish this training through on-going community environmental education programs.

Watershed Delineation and Protection

The actual catchment area for each spring investigated was often difficult to determine. Groundwater flow directions do not always correspond to the surface contours of the land, and no data are available to check groundwater flow in specific sites. The location of impermeable layers which might obstruct or alter groundwater flow patterns is essentially unknown on a site specific basis. As a result, the catchment areas for all of the communities visited are approximate and based on reasonable field judgement.

In addition, in many cases it is not feasible to establish full protection for the entire watershed which contributes to a spring. Many of these watersheds are in private ownership and the cost for land purchase would be considerable. In each case we tried to include as much area above the spring as possible in the protected zone in order to improve our chances of protecting critical hydrologic regeneration areas and reducing the possibility of contamination.

The fragmented nature of the remaining natural forest cover throughout the Northern Zone made all protection efforts difficult. Communities using water sources situated in the midst of cultivated fields, pastures, or areas of active timber harvesting run a high risk of eventual contamination of the water source by agro-chemicals, animal feces, petroleum products, or other potentially harmful substances.

In all cases, every effort was made to locate a water source that is already well situated in a forested watershed. Of the 8 projects which have been approved, only the communities of Rio Negros and San Isidro de Aguas Claras will be required to reforest parts of their protection area. Even in both of these instances, the water sources are immediately adjacent to the Miravalles Forest Reserve, which ensures that most of the contributing watershed is well forested and fully protected.

Protection of Area Springs

There are many good springs located on the higher slopes of the volcanoes which form the southern boundary of the project area. Virtually all of the land above these springs is in natural forest and is legally protected as either a national forest preserve or parkland.

Efforts were made in Dos Rios, La Finca El Ensayo, Colonia Blanca, Aguas Claras, and Santo Domingo to identify the whereabouts and feasibility of using any of these springs sources in the future. Unfortunately, few people in these communities know precise locations for many of these springs, so very little on-the-ground information was compiled.

It would be worth the effort in the future to map the location of many of these existing, and potentially valuable, water supplies in the protected forests.

Communities with Completed Watershed Protection Plans

Every community visited took the time to show me one or more water sources for their proposed aqueduct. Several repeat visits were made to each community to confirm their interest in the project, to clarify project objectives, and to finalize all conditions to be met for completion of the Environmental Protection form and implementation of the project. The following communities completed the form, thus insuring that they will adopt strict conditions to protect the catchment area which influences the quality and quantity of water received at their spring source:

Community

Santo Domingo de Upala
Buena Vista de Upala
Birmania
Santa Elena
Colonia Blanca
La Armenias/San Isidro/Aguas Claras
Los Cartagos/San Pedro/Los Angeles/San Jose de Upala
Rio Negros

It is anticipated that funding and construction of aqueducts for these communities will begin immediately.

4.6.2 Community Project Notes

Community	Notes
Buena Vista	There are 2 springs which should be included in the aqueduct. Used together, they should adequately meet the needs of the community. 4 families live at a higher elevation than the spring source. A small booster pump will be needed to convey water to these families. An informal study of the proposed water system has been done, but no written information is presently available. The protection area is owned by community members, and is small enough in total area to be fenced for permanent protection. Crop cultivation is being done next to both springs, although not in the protection area. By protecting the existing forest cover above the springs the present quantity and quality of the water source should be secured.

Santo Domingo	A spring with a discharge rate of approximately 30 lpm is located in an area of dense natural forest cover. All of the areas immediately surrounding the spring are either in pasture or tree crops. Periodic monitoring of spring water quality should be done to assure that no contamination is entering from these outside areas. The protection area is owned by community members and is small enough in total area to be fenced for permanent protection.
Birmania	A spring with a discharge rate in excess of 30 lpm is situated on a steep forested hillside. Determination of actual groundwater flow direction is uncertain in this area, and adjacent hills are mostly in pasture. Although the community gave their assurance that no cattle would enter the protection area, it is recommended that periodic water quality testing be done. An engineering study of the proposed water system has been completed by AyA, with 1 copy in the office of DINADECO. The protection area is partially owned by an U.S. citizen with large landholdings in the area, and partly by another landowner residing in Liberia. It will be necessary to prepare a written agreement with both of these landowners to secure all protection measures for this water source. The protection area is probably too large for complete fencing, although the community should mark the boundaries of the protected zone and label it clearly.
Santa Elena	A very strong spring with a discharge rate in excess of 100 lpm is situated on a steep forested hillside, surrounded by inactive pastures. The upper boundary is very close to the boundary of the new national park unit on Volcan Orosi. Regular water quality testing should be conducted. The spring is probably capable of supplying more than 300 families. An engineering study of the proposed water system has been done by AyA, with copies in San Jose. The land is held by a private landowner. A written agreement should be prepared with this landowner to secure all protection measures. The protection area is probably too large for complete fencing, although the community should mark the boundaries of the protected zone and label it clearly.
Colonia Blanca	A diversion canal from a river sends a large volume of good quality surface water (in excess of 200 lpm) into an existing storage tank. There is no agricultural or grazing activity in the upper watershed, which originates in the national Forest Reserve on Volcan Miravalles. This river is probably capable of supplying more than 1,000 families. A water quality study has been done by AyA, with a copy available in the office in Liberia. The watershed area for this water source is very large, and cannot be adequately fenced or marked in the field. A small part of the catchment basin is under private ownership by a local ranch, and a written agreement for protection measures should be obtained from this ranch owner. Most of the catchment basin is in the Miravalles Forest Reserve and is presently managed as a protection forest.

Los Cartagos/San Jose	3 springs located approximately 10 km from the community of Los Cartagos are located in a dense tropical humid premontane forest. Access to the springs is very difficult, and the terrain is very steep. The combined discharge from all 3 springs is probably adequate to serve the 4 communities of Los Angeles, San Pedro, Los Cartagos, and San Jose de Upala. The land above the springs is owned by a family with a ranch residence in Aguas Claras. Some agreement about watershed protection will need to be confirmed with the owners of this ranch. An informal appraisal of the water system has been done by an engineer, but no formal design or water quality study yet exists. The protection area for all 3 springs is too large to be fenced, although it should be marked in the field by the community and labeled clearly.
San Isidro/Aguas Claras/La Armenias	The proposed water source is located in a small patch of remnant forest. Approximately 3 hectares of the protection area above the spring is presently in pasture and crop cultivation. The rural development association has negotiated to purchase this land from the owner and either reforest the entire area manually or allow the surrounding natural forest to recover the land. All of the land above this small 3 hectare patch is presently in complete natural forest cover and fully protected as part of the Miravalles Forest Reserve. The discharge rate from this spring is in excess of 80 lpm and should be adequate to meet the needs of as many as 1000 families. The community should mark with signs the boundary of the protected area that is not in the Forest Reserve. A water quality study is recommended before beginning any construction activities.
Rio Negros	A strong spring with a discharge rate in excess of 100 lpm is located in a small remnant patch of forest approximately 1 km from the edge of the Miravalles Forest Reserve. Most of the land surrounding the spring is in pasture. The terrain is rolling hills with many large volcanic rocks. The land is owned by a local coffee producer and cattle rancher. An agreement must be reached with this landowner to protect the area surrounding the spring and exclude cattle. The protected area is small enough to be fenced by the community. Approximately 4 hectares of the surrounding pasture land must be reforested by the community to improve protection conditions. A water quality test is recommended before beginning any construction activities.

Communities with Inadequate Available Sources

In instances where the quality of the available source is poor, it may be necessary to use one good source to supply several communities. The communities of El Salto and Brasilia were unable to demonstrate a water supply source which could ensure high quality water in the future. Both of these communities may want to join the water systems of other communities which do have access to water sources with better quality.

There are adequate water supply sources from rivers and springs located on or near the El Ensayo ranch which could serve Brasilia and nearby communities. The change in elevation from these sources to Brasilia is sufficient to use gravity flow for water transport. It is recommended that Project staff communicate with the ranch owners to determine the feasibility of using these water sources for a local water supply system.

During the time period of my visit I was unable to complete negotiations with the communities of Katira de Guatuso, San Jorge, and Puerto Nuevo. It is recommended that the staff of DINADECO in cooperation with the EMS continue this work in the immediate future.

4.7 Technical Observations and General Recommendations

4.7.1 Protection Activities for Potable Water Projects

For every community building a potable water system the following conditions should be included in all project work:

1. **Collect and analyze a water quality sample from the proposed water source prior to beginning any construction activity. The criteria to be evaluated should include, at a minimum, pH, fecal coliform count, total dissolved solids, $CaCO_3$, and nitrates. The results from each test should be evaluated by a qualified technician and kept on files in the local office of the Ministry of Health.**

2. **For springs located on steep, short hillsides, establish or maintain a dense forest cover to the top of the hill, at a minimum, with the width to correspond to the gradient pattern of the hill. For springs which are recharged by larger, less easily defined catchment areas, establish or maintain a dense forest cover of at least 4-5 hectares above the spring, with a width of at least 75 meters to each side of the spring, and a length at least 250 meters above the spring.**

3. **The participating community members should visually inspect the protected area in the field and agree to reforestation and long-term protection and maintenance programs.**

4. **Present uses and discharge rates should be recorded for each spring to be used in a project to determine the total number of families and services which can be included.**

5. **All crop cultivation, cattle grazing, timber harvesting, and fires must be eliminated from the protection area.**

6. **Protected areas which include private lands must obtain a written agreement from the landowner assuring compliance with the proposed protection measures.**

4.7.2 Investigation Procedures and Basic Data for Rural Water Supplies

The procedures used to successfully plan and implement a rural water supply project should include the following:

- initial community development work in the field
- determine the amount of water which must be supplied to meet the needs of the project
- locate and study the source of the water supply
- measure the quantity of water from the source
- conduct a water quality test, to include biological and chemical analysis
- establish a community mechanism and acceptable conditions to protect as large a percentage of the catchment area (watershed) as possible which delivers water to the source.

The text below is intended to provide general guidelines for organizing and conducting this initial project work.

Procedure of Initial Community Development Field Work

a. Request for assistance is submitted by community

b. Meeting organized by representative from DINADECO to define the process for technical and financial assistance and to arrange a field survey of the water source and proposed water system.

Determination of Specific Use

a. Collect information on present and projected population, present and planned infrastructure (roads, schools, markets, health centers, cooperatives, etc.)

b. establish specific consumption for community:

Location	Average Daily Consumption		
	Stage 1	Stage 2	
Rural Village	25	50	
Village with school, 20%	60	100	(Stage 1-private hook-ups Present Population)
Urban areas with 50% private hook-ups	100	200	
Primary School	10	10	(Stage 2 - Projected Pop.)
Hospital	200	200	

Location of Source

A field inspection of the proposed source, including an estimate of distance from the central populations to be served, and a rough map of the general landmarks identifying the location of the source should be conducted as soon after the initial meeting as possible. This inspection should be conducted by the specialist and/or representative responsible for completing the Environmental Protection form.

Measuring Quantity

Estimating water quantities of a stream:

(1) determine the cross-sectional area of the water flowing in a stream (average depth of water x width of stream)

(2) measure the velocity of the water by determining the distance that an orange (or something else round) will flow in one second; i.e, meters per second.

(3) Quantity = Area x Velocity

Example:

Average depth of water = 0.5m

Width of stream = 3m

Area = 1.5 square meters

Velocity = 2m/second

1.5 sq.meters x 2m/second = 3 cubic meters per second

1 cubic meter = 1000 liters

Measuring water quantities with a bucket:

(1) fit one or more pipes into a spring outlet

(2) calculate the volume of the bucket (or use a container for which you know the exact volume)

(3) measure the amount of time it takes to fill the bucket

Water Quality Tests

Every source should have a water quality test done before final project approval. Water quality tests should be repeated on at least an annual basis to determine if any contamination is occurring at the source.

Collecting and analyzing field samples can be difficult to accomplish. Many parameters, such as fecal coliform count, must be measured within an hour of the sample collection. As a result, laboratory tests will be impossible for many communities.

It is recommended that the project purchase at least one portable water quality testing kit that can measure bacteriological and chemical factors in the field. One kit available is produced by CD-SATA-Helvetas, Varnbuelstrabe 14, CH-9000, St. Gallen, Switzerland (telephone: 071-23-3481). The kit includes a membrane microfilter technique for detecting coliform bacteria and other bacterial organisms in water - the principal criterion of sanitary quality for public drinking water. The kit can also provide values for the following:

content of carbon dioxide (CO_2) in mg/l
content of dissolved oxygen in mg/l
hardness in grain $CaCO_3$/gallon
pH

Other similar kits may also be available. It is recommended that the EMS contact Dr. Alfonso Mata, Dean of Sciences at the University of Costa Rica for further information.

Protection of Catchment Area

The catchment area includes all of the land above the spring source which drains directly into the spring. As used here, "catchment area" is synonymous with the term "watershed". Springs and wells are both groundwater sources which have been diverted to the surface.

Unlike the watersheds for rivers, which can be delineated fairly easily by tracing all of the sloped land draining in a specific direction, the catchment basins for groundwater sources can be much more difficult to define. Groundwater flow to a source is influenced by a variety of factors, including direction and gradient of slope, permeability of the underground material (rock, soil), presence and extent of impermeable underground formations, and the dynamic viscosity of water at different temperatures.

Determining all of this information to define with any accuracy the total catchment area that contributes to the flow of a specific spring could be very costly and time consuming. Defining the body of underground water that contributes to a spring requires geologic maps showing the formations within which most of the flow is occurring. As an alternative, a study of drilling tests (from local wells, for example) could be used.

No information has been found to be available to define these geologic characteristics on a site-specific basis in the Northern Zone with any sense of accuracy. Using the limited geological analyses available, local experience, and field observations of gradient and aspect, rough estimates of the probable key catchment areas have been made for all of the communities intending to use springs for their community water supply. Periodic water quality testing will be essential to determine if these watershed delineations are providing all of the protection necessary to prevent contamination of the source.

As large a percentage of the catchment area as possible must be established as a protected zone to preserve the quality and quantity of water which drains into the spring. Protection areas less than 5 hectares in size should be fenced and labeled as protection forests. Protection areas greater than 5 hectares, but less than 100 hectares should be marked with signs or some other visible object to clearly delineate the boundaries for all local residents.

Wherever possible, local residents should delineate the boundary of the protection area on the ground with the field inspector, and make at least temporary marks on trees to define this boundary. It will be assumed that any protection area greater than 100 hectares is probably located within an existing reserve. If not, some technically feasible means of defining the total area and instructing people not to adversely affect the soil and plant resources should be done.

Within this protection area there can be no farming, no grazing of domestic animals, no fish ponds, no houses or other residences, and no trash disposal sites. No fires can be allowed to enter the catchment area. Surface water which flows through the protection area must be certain not to cause significant erosion to the spring or to cause the infiltration of substances which could degrade the water quality of the spring.

The area in the immediate vicinity of the spring (within a 5 meter radius) can be cleared of trees and kept in permanent grass to reduce evapotranspiration losses while preventing erosion. The grass cover should be kept cut short. All other lands in the protection area should be in forest cover. Wherever forest has been cleared in the protection area for pasture or agricultural land it must be re-established, either manually through the planting of trees, through artificial seeding of native forest trees species, or through natural seeding by the remaining native trees.

System Design, Construction and Maintenance

At this point sufficient information exists to bring in a qualified engineer to assist the community with the design and construction of the water system. All of the communities contacted requested some form of technical assistance during the construction phase of the water system to help them avoid costly technical mistakes.

This will represent both a financial and a social burden on the community, since few residents know of qualified technical specialists available to assist them. It is recommended that the EMS help each community make the necessary link to a qualified technician who can guide their construction efforts.

4.7.3 Community Watersheds, Regional Watershed Management, and Environmental Education

Protection of the catchment areas recharging local springs and wells to be used in community potable water projects must go hand in hand with a comprehensive watershed management effort for the entire project area. Community residents in the project area understand very well the need to protect the lands immediately above their water supply (springs and wells) to assure that these local supplies will continue to produce water of a sufficient quality and quantity to meet their needs.
Educational programs can expand this understanding to demonstrate how management of the watersheds which contribute to the flow of all of the rivers in the project area will affect the timing and quality of flow received downstream.

For example, serious flooding problems have been reported on numerous occasions for the Rio Zapote, Rio Guacalito, Rio Frio and others in the project area. A major cause of the increase in flooding incidents appears to be the conversion of primary rainforest to pasture and cultivated fields.

"High-grading" of remnant forest lands, or the removal of forest trees of highest commercial value, is also very prevalent in the project area and contributes to this degradation of river quality and rapid runoff.

Removal of forest cover can reduce the overall evapotranspiration rate and affects the infiltration rate of precipitation into the soil. Under a forest canopy, precipitation reaches the ground at a gradual rate by "trickling" through and down the branches of the trees. This water infiltrates slowly into the ground, with a great deal moving deep into the stratum and recharging local groundwater supplies.

Importance of Environmental Education

Environmental education efforts can establish for local community residents, not only a firm understanding of these hydrologic processes involved in the flooding problem, but also an indication of what they can do with their limited local resources to begin to correct the situation.

Community watersheds can serve as excellent training grounds for environmental education activities. Training activities which will ultimately enable community residents to delineate watersheds visually in the field and with topographic maps, and instruct in proper methods for collected and analyzing water quality samples can be conducted using the local water supply source as the model.

Environmental educational efforts must include local children in their outreach activities. If community watersheds are to be truly protected it will be essential for the next generation to know where and why these areas have been established. School programs that get students to plant trees in and around water sources, help construct fences to delineate the protected areas, and create "fun" activities teaching basic environmental management needs and opportunities should be included wherever possible.

Environmental education activities must also establish the importance of water conservation, even in the very humid environment of the Northern Zone. Rational use of the available water sources is essential as the population of the many rural communities continues to grow.

The considerable volume of potable water that is available in the many springs and rivers of the Northern Zone should never justify waste of this important resource. Rural water systems are often victim to leaking tap-stands, ruptured pipes and other poorly maintained services. Education programs should indicate where and why residents will want to control these problems and promote a more widespread sense of water conservation.

Education programs should also indicate some potential environmental changes which can result from community water projects. For example, most perennial springs being used to supply local water systems presently contribute to the creation of wetland areas and small streams below the spring. Trapping the water from the spring in a concrete box and transmitting it in an enclosed pipe to points farther downstream could significantly alter or eliminate these wetland biological communities. An understanding of the role of these communities in local ecological conditions, and opportunities to mitigate impacts by correctly sizing storage tanks and overflow/release tubes will be important.

Present Budget and Resources for Environmental Education

A budget of $300,000 has been established as part of the NZCP to assist with environmental education efforts in the Project area. At the present time no agency or organization has been identified to carry out this educational work.

There is at least one agency, however, that is already doing environmental education work in the Northern Zone. The Unidad Regional de Conservacion de Guanacaste (URCG), a consolidation of 3 national parks, a wildlife refuge, recreational area, and an agricultural experiment station, has been actively conducted environmental education programs in the Northern Zone for several years.

At present, URCG has a full-time biologist based in Santa Cecilia, a biological research station 8 km south of Santa Cecilia, and plans to place additional biologists in the communities of Dos Rios and Colonia Blanca. These staff and facilities are being used to conduct environmental education programs with local adults and school children.

In 1989 more than 200 students from the local schools in Santa Cecilia, Brasilia, El Ensayo, and Dos Rios, representing approximately 44 percent of the total student population, participated in environmental education programs through the URCG Programa de Educacion Biologica. Future programs will include a larger percentage of the total students, and incorporate additional geographic areas in the field activities.

It is recommended that the NZCP work in conjunction with the staff from the URCG in establishing a comprehensive environmental education program for the Northern Zone. The extensive experience, existing infrastructure, and excellent relations the URCG has with local communities makes them an appropriate choice for assisting project efforts. A meeting should be held between the URCG Director, Roger Morales, URCG Sub-Director, Randall Garcia, NZCP Director, and AID advisors to the Project to define the best opportunities for these agencies to cooperate on environmental education efforts.

4.7.4 Building a Water Resource Data Bank

In general, the data on water yield and water quality is not extensive and insufficient to be of much use in site specific analyses. This fact does not necessarily limit the ability or effectiveness of making sound environmental management programs for water projects, but is a point for the long-term Environmental Management Specialist (EMS) to keep in mind in supervising these projects in the future.

Water quality testing services are available, but many parameters may be difficult or impossible to quantify given the distances from the water source to the testing laboratory and the limited time in which a test must be completed. Some additional training for local community members in water quality monitoring and general system maintenance should be provided through the project, and could easily be fit into the scope of work for the EMS.

There are many excellent water supply sources, including springs and rivers, located on the perimeter of the Forest Reserves and National Parks throughout the Northern Zone. Unfortunately, the actual location of these sources is not well known, even by local residents. It is recommended that the EMS work with local residents to map as many of these water supply sources as possible. Protection strategies for these sources should also be developed with local residents, wherever possible. These water sources may prove to be invaluable in the future as the population continues to grow in this area.

The Project should develop a water resource data bank for the Northern Zone. This data bank should include all information that is collected on the location, yield and quality of surface and ground water resources in the zone, system designs, and operation and maintenance practices for community water systems. Efforts should be made to consolidate all existing hydrologic information about the Northern Zone, including topographic, geologic, meteorologic, well records, stream measurements, and related information.

CHAPTER FIVE

ENVIRONMENTAL MANAGEMENT STRATEGIES FOR THE SETTLEMENT AREAS

by Alberto Vega
Ecologist

EXECUTIVE SUMMARY

The fundamental purpose of this assessment was to provide the NZCP with the data to make it possible to determine on the ground whether the four campesino settlements founded by IDA are complying with the environmental regulations stipulated in the agreement.

The recommended criteria for preventing adverse effects are straightforward. (1) All areas with forest cover must be respected and conserved, (2) integrated water course management must be practiced, and (3) land-use must be tailored to its limitations.

The last of these criteria is probably the most complex, if all possible variables are considered. Nevertheless, it was assumed that the most feasible use, at least during the initial stage, and for an indefinite period of time, is that of cultivation of annual crops on cleared soil under traditional management.

This is almost invariably the use which the campesinos benefitting from the project will make of the land, regardless of its capability. Therefore, the land which may be assigned to the beneficiaries of the settlement programs should be, at most, of Type III according to the official Costa Rican classification system.

On the basis of these three criteria, the policy of conservation management of natural resources places emphasis on the most intensive use of those areas already degraded and which exhibit few limitations for agricultural use and low environmental deterioration risks. All other areas must be protected as a stabilizing factor and as a source of alternatives in the future.

The application of these criteria in the field gave varying percentages of land on each of the four farms which could be used for establishing campesino settlements. These percentages ranged from 74 percent for the Finca Argelia to 39 percent for Finca Alfonso Bustos. Intermediate situations occurred in the cases of Zapal and Argendora, where the results were 69 percent and 55 percent respectively.

The limitations encountered for sustainable agricultural use on the four farms under consideration are mainly associated with edaphic and climatic limitations. The most characteristic limitations of each farm may be used to complement the maps prepared. This will enable project managers to determine on the ground if the natural resources are being managed on a conservation basis, and if the environmental regulations in force are being complied with.

The areas which are not suitable for establishing settlements should be protected by the groups of beneficiaries themselves. The areas with potential for more limited economic uses such as cattle ranching, tree farming and forestry production, could be incorporated into production at a later date. This would be when the use designated for them is shown to be correct.

Environmental education for settlement members and the IDA personnel in direct contact with them, to make them aware of the risks of environmental degradation, could be very positive for the conservation of the northern zone's natural resources. In fact, these are the two groups of people who on a daily basis are transforming the environment through their activities and are, therefore, those who have a greater potential impact on its quality.

5.0 Scope of Work

The scope of work of the group of short-term experts in environmental management consists of four specific areas:

1. Campesino Settlements and Land Titling
2. Agricultural Diversification
3. Community Development
4. Road Rehabilitation and Improvement

This report is mainly concerned with the first of these areas. The most specific aspects of the scope of work as far as this activity is concerned indicate that: "The contractor shall assist IDA (Agricultural Development Institute) and the participating communities in a project area (Development Associations) in drawing up initial environmental evaluations ("IEE" in AID terminology) and/or environmental assessments ("EA"), as the case may be, for at least four (4) farms purchased under Project 041, including approval of a mechanism for the management of the areas identified as critical from a reforestation and communal watershed management standpoint."

The precise implementation of these terms of reference involved, therefore, a high degree of participation by IDA in order to comply with the specification of support for this institution. After the first week of this assessment it was felt that the scope of work for this component should be reviewed, given the fact that there was no active participation by IDA and no specific personnel counterparts were assigned. It was eventually agreed with the project director, the coordinator of the environmental work team and the AID advisor that the scope of work should to some extent exclude IDA given the latter's low level of participation.

Thus the original scope of work was given a new orientation. It was decided that the project director will be provided with the criteria necessary to be able to evaluate whether, in establishing campesino settlements, IDA is managing the environment adequately. This is one of the essential conditions with which IDA must comply in order for it to receive the funds designated under the project for this activity, as specified in the agreement between IDA and the Planning Ministry (MIDEPLAN) and in the agreement between AID and the Government of Costa Rica.

Adequate management of the environment is understood in this case to mean the rational utilization and conservation of natural resources in general, but it is specifically defined by the regulations laid down by AID in adherence to the mandate of the US Congress (Foreign Assistance Act). The most relevant aspects of these regulations refer mainly to the intention of promoting a) sustainable production, especially of agricultural produce, b) maintenance of natural ecosystems, and c) the explicit policy of conserving and protecting tropical rain forests and threatened and endangered species (AID, 1988). These last two areas are of special concern to the US Congress and also, therefore, to AID in its funding policy.

After a joint review and modification of the scope of work for this component, it was possible to define it in the following way: "The contractor shall draw up initial environmental evaluations ("IEE" in AID terminology) and/or environmental assessments ("EA"), as the case may be, for at least two (2) farms purchased under Project 041, including approval of a mechanism for the management of the different areas".

Zapal and Argendora were identified as being the farms with the highest priority as they have already been divided into parcels and the roads needed for the settlement have been mapped out. The Alfonso Bustos and Argelia farms were determined to be less important.

5.1 Establishing a General Frame of Reference

From the perspective of environmental protection, the fundamental purpose of the project in regard to the establishing of campesino settlements, is that this activity should not result in the destruction and/or deterioration of the natural resources of the region, especially soil and water resources, the remnant areas of tropical rain forest and the biological diversity associated with it.

In order to prevent the deterioration of these resources under the project, a global vision of the area is needed, since the effects of bad land management practices, besides having local effects on the degradation of the soils, will have even greater effects on other components of the system downstream.

The need for an environmental management unit capable of maintaining this integrated vision of natural resource conservation in the project area has already been pointed out (Gow et al., 1988). The individual environmental assessments to be conducted as part of this work should be consistent, therefore, with an overall vision of the region. In this context, it is advisable to consider the main risks of environmental degradation in humid tropic regions and how they can be avoided in the light of the knowledge available.

5.1.1 Environmental Considerations in the Development of the Humid Tropics

From the standpoint of the conservation of renewable natural resources, the general problems of humid tropical regions are similar to those of any other area of the world. The fundamental objective is to ensure that their use be sustainable. This means that an intensification in the use of these resources should not provide merely a short-term increase in economic and food production. Rather, resource use must be sustained over the long-term, for the benefit not only of this generation but also of the those to come.

The most accepted notion concerning the rational use of renewable natural resources suggests that the mechanisms for their use must harmonize with the patterns of nutrient circulation and the flow of energy which characterize a given region. In practical terms this means that the limitations imposed by the natural system should be respected. Two aspects are of great importance in this context: (1) matching land use to its sustainable capability and (2) maintaining the natural hydrological cycle.

In humid tropical ecosystems these two concepts are equally as important, or even more important, than in other areas, because the changes normally occur faster. A larger amount of water flowing through the system causes greater erosion and lixiviation, or the washing away of the nutrients. Deterioration occurs more rapidly, and is, generally speaking, irreversible.

The main problem in ecosystem management in the humid tropics is that we still do not know enough about them to be able to propose, with a great deal of certainty, mechanisms for the use of resources which are ecologically safe and reliable. However, there is sufficient information available to prevent large-scale ecological disasters in most cases. Therefore the adoption of a conservative decision-making philosophy is preferable.

Importance of Tropical Forest Cover

The presence of forests in these systems is no mere accident. Nature, through evolution and natural selection, has established this system as the most appropriate under the prevailing physical conditions.

Besides providing soil cover which protects it from erosion, the forest diminishes the amount of drainage, reducing these risks even further. Besides the flow which tree transpiration represents, a greater proportion of water returns to the atmosphere as a result of evaporation, which is increased by the large surface area of contact provided by the leaves, branches and trunks of the vegetation.

The volume of water which drains off immediately is reduced even further by the effect of a high rate of filtration favored by the presence of roots and the good physical characteristics of the soil. The water filtered in this way fills the aquifers and maintains the baseline flow of water channels during the periods of least precipitation.

The greater amount of water returned to the atmosphere also has a marked effect on maintaining fertility by reducing the intensity of the process of lixiviation. In addition to this reduction in the flow of water, the system has developed mechanisms to ensure that the nutrients remain linked to the living matter. In this way the nourishment cannot be removed by the flow of water through the system with the same rapidity with which they would be removed if they were in the form of inorganic compounds.

Thus we find in these ecosystems the presence of "mycorrhiza" which capture the nutrients in the organic matter which falls to the forest floor, before these are dissolved

and carried away by the movement of the water. For this reason, wet rain forest ecosystems are highly susceptible to rapid degradation when the vegetation on which they feed, and which provides most of these nutrients, is eliminated.

Under conditions of forest cover, the water is clean as it flows through the channels, with low sediment and nutrient loads, given that the latter remain in place since the erosion and lixiviation processes occur at low rates which maintain the balance. Aquatic communities have evolved under this pattern of flow, developing dependence mechanisms which are projected downstream.

We are normally able to identify three complementary segments in a water course. These segments exhibit different characteristics in relation to the regimes of water-flow, the structure of habitats and the quality of the water itself. Thus, first we find currents with a small, rapid flow in the highlands, channeled rivers at the foot of mountains, and, lastly, mature rivers on alluvial plains with their system of meanders. In each one of these segments of the water courses, the aquatic community has evolved in accordance with the particular characteristics of the segment. Any change in the flows of energy and materials will produce an effect both on that segment itself as well as the other sections of the river downstream.

When forest is eliminated and crops or pastures are established, there is a substantial reduction in the regulating effect of vegetation on the hydrological cycle. The increase in sediment loads and the change in the natural hydroperiod in the rivers, lagoons and swampy areas of the region, reduces the potential for navigation and increases the risk of floods which affect both communities and crops or livestock. The community of organisms connected with the aquatic environment is modified in response to the new flow-pattern of matter and energy and there is an interruption in the food chains whose final link is usually the human population.

The empirical information available indicates that when changes in land use get underway, the effects on the soil and the aquatic ecosystems are of relatively little importance. As a greater proportion of the watershed is affected, the effects become more noticeable. In large watersheds the critical point appears to be around 50 percent of the area under tree cover. If tree cover is greater than this, the effects on the quality of the water and the aquatic system in general are not very evident. However, once this limit is passed, changes occur very rapidly and both the aquatic system and the environment in general deteriorate very rapidly.

5.1.2 Current Alternatives for Management of the Humid Tropics

To a large degree, our lack of knowledge concerning the functioning of humid tropics ecosystems is due to their great internal variability. This variability is present in all components of the system. The great diversity of plants and animals is probably better known and better documented than the variation in other components such as soils.

In Costa Rica, the increase in the number of soil samples needed to provide sufficient information on this resource for forest development projects has been greater on the Atlantic side of the country (San Carlos) than on the Pacific (Guanacaste), due to this variability in the system (Sonia Torres, com. per.).

Given the present situation -- a lack of knowledge of these ecosystems combined with pressure from groups of inhabitants who need to make use of them as a means of survival -- three possible management models have been considered (National Research Council, 1982):

1. The conservation, more or less intact, of considerable expanses of these ecosystems in the form of parks, reserves or any other type of protected area. The utilization of these resources is mainly for feeding local Indian groups, scientific research, nature germ plasm banks, and maintenance of water quality and control over erosion. This configuration is obviously of limited economic benefit in the short-term but is ecologically very stable in the long-term.

2. The use of large areas of tropical wet forest ecosystems for the production of timber for construction, firewood or wood pulp, using existing conservationist technologies for the extraction and management of the resource.

3. The utilization of the areas which have already been deforested in order to intensify the production of foodstuffs and other goods of economic value, with technologies developed for agricultural production in the humid tropics. This is the model which offers greater short-term economic benefits but its ecological stability will depend on the efficacy with which rational management programs are implemented, especially those relating to protection of soils against erosion and maintaining their fertility.

It would probably not be possible to apply any of these three models alone in any region or country in the humid tropics. Nevertheless, the principles on which they are based are valid and it is possible to implement a mixture of them. Thus, it is possible to a) solve the problems of food and the quality of life of the inhabitants who require immediate assistance, b) continue the search for alternatives for the sustainable use of these ecosystems, and c) preserve part of the resources in a more or less untouched state for the future.

The combination of these three methods is more easy to implement in those regions of the humid tropics where demographic pressure is still not excessive. This seems to be the case in the Northern Zone of Costa Rica.

5.1.3 Selection of Criteria for the Assessment

The arguments discussed in the previous paragraphs demonstrate that in order to avoid a manifestation of negative effects on the environment, it is necessary to work in several directions at the same time. Most of the recommendations were provided previously in the evaluation by Gow et al. (1988). The measures recommended complement each other, and therefore should be applied in their entirety so as to efficiently avoid negative effects on the environment. These measures include:

- The protection of forested areas ("montana") and the associated biological diversity;
- The matching of land use to land use capabilities; and
- Integrated management of water courses

Protection of Forests and Biological Diversity

First, it is essential to protect the remnant forests which still exist in the area. This measure will help to preserve the biological diversity of plant and animal species, since their habitat is preserved. In this context it is important to mention the fact that there are practically no areas of primary forest which remain untouched by man. Nevertheless, there are forested areas from which the most valuable woods have been extracted, albeit on a selective basis. The forest as a system has not been destroyed in its entirety in order to establish pasture or crops.

In these areas the forest's main properties for protecting soil and water resources against the processes of erosion and lixiviation are still present. The existence of a large amount of biomass, great diversity of species, soil covering, the presence of a well-developed root system and good physical characteristics for water filtration, make the conservation of these areas worthwhile. Moreover, they are to be found mainly in areas with difficult access and uneven topography.

There is no doubt that the climatic characteristics of the zone have contributed to the preservation of these remnants of forest vegetation. The short dry season does not afford favorable conditions for fires to develop in these forested areas; conditions

severe enough to permit the forest to burn probably never arise in spite of the fact that burning is used to clear agricultural areas, to control weeds and in field management just as in other areas of migratory agriculture and extensive cattle ranching.

Matching of Land Use to its Sustainable Capability

In 1987 Costa Rica was able to establish a single system for the classification of Potential Land-Use Capability. This system is based on Dr Leslie R. Holdridge's system of Life Zones and has been developed by the Tropical Science Center There is no question that this methodology, which has been developed and validated in Costa Rica and other tropical regions of the world, is an appropriate tool for land-use planning in the region.

The types of potential use proposed under this methodology are given in Appendix D of this report, as well as the keys to the parameters for the predominant Life Zones in the project area.

From the standpoint of land use, the non-traditional crops which are being encouraged under the project are perennial ones, and mostly involve tree species. Therefore, they can be established in areas with serious limitations. Rather more care must be taken with non-tree crops such as maracuya and black pepper, especially the latter.

The problem of land use has more to do with the method of cropping which the recipients of parcels are likely to introduce on their plots. IDA is trying to guide such use through the support and follow-up program -- including credit and technical assistance, which have now been included as conditions of the agreement. Nevertheless, the resulting pattern of use depends on a series of variables which include marketing conditions, the price structure for agricultural produce, and the customs and traditions of the recipients.

Therefore, under these conditions it is almost certain that each farmer is going to exert the greatest possible pressure on the parcel for the production of annual crops such as corn and beans, at least for some time, until erosion and soil exhaustion make such activities uneconomic. When this happens the situation is virtually irreversible as the nutrients have disappeared from the system and the regeneration of natural vegetation takes place very slowly. Thus, areas suitable for sustainable economic activities such as tree crops, intensive dairy farming or semi-permanent crops, will have been lost unnecessarily.

This situation is more likely to occur in areas with more fertile soils where the limiting factor is the slope and therefore the risk of erosion is greatest. For some years the production of these crops may generate good profits which stimulate their implementation. In areas limited by acidity and low fertility this is less likely because the farmer is conscious of the low initial yield.

Given these considerations, it is wise to be conservative in regard to land-use capability. We can only be fairly certain that there will not be adverse effects on the environment if the parcels granted to the beneficiaries of IDA's settlement program include the areas with fewest limitations as far as agricultural use is concerned. It is felt, therefore, that it would be appropriate to include land which fits into the first three categories of the methodology legally adopted in Costa Rica.

Although these categories include land which, by the nature of its limitations, limits the diversity of the annual crops which may be planted and/or reduces yield, it is felt that its use for such purposes is possible without degrading the resource's productive capability. This limiting of the land to the first three categories in the system should be continued until the conditions prevalent in the zone guarantee correct initial utilization of the land with greatest limitations.

At this point it is worth pointing out that such an approach of limiting the land used for establishing settlements of campesinos is entirely consistent with the model mentioned previously for the immediate use of humid tropic ecosystems. We are intensifying the use of those lands with a high capability for economic production without substantial risks of deterioration, and at the same time preserving the areas with greater limitations for future economic development, when market and technological conditions are appropriate for their rational incorporation into the productive system.

An additional factor which could affect land use is the economic stability of the permanent crops recommended. These are crops intended for export and therefore subject to price fluctuations on the international market. Falls in prices or the absolute concentration of marketing channels in a few hands could reduce the utility margin of such produce for the farmer, ultimately prompting a change in land use to the production of grains in a short-cycle, annual agricultural regime.

An essential element in guaranteeing the zone's environmental stability and sustained development is the continuous generation of alternative methods of economic use. This will enable the regional system to respond to changing situations concerning

price conditions and marketing, which restrict crop utility for producers, without bringing about a drastic change in land use.

It is important to note that the continual generation of new alternatives is a normal mechanism in the ecological system in the humid tropics. It is precisely this which provides the evolutionary advantage of the great diversity of species which exist in these ecosystems. When the edaphic or biological climatic conditions become adverse for the populations of dominant species, others may quickly take their place because they are already present.

One mechanism which would duplicate this behavior of the natural system to some extent would be the development of a system of ongoing research, adaptation and validation of new crops and production systems. This mechanism is probably as, or more, important than the construction and maintenance of roads and other works which provide social benefits for the population.

Integrated Management of Water Courses

The programs for soil conservation, protection against erosion and protection of the uplands in watersheds will have little effect on the conservation of the quality of water and the aquatic environment in general if there is no integrated management of water courses of all sizes. Rivers, streams and brooks must be viewed as corridors which include not only the channels along which the water flows but also the riparian vegetation. It is this which determines the magnitude and periodicity of the flow of water, sediments and organic material. Protection of the water courses' riparian vegetation has proved to be a very efficient means of controlling the main disorders caused by bad natural resource management in the hydrological cycle and maintaining the quality of the aquatic habitat (Dickinson, 1985). The presence of these buffer strips at the water-land interface brings about:

- Filtration of a high proportion of the sediments dragged along by the runoff from agricultural land,
- Reduction in the erosion of river banks and sides,
- Buffering of the peak freshets which cause flooding,
- Control of accelerated eutrophication in bodies of water,
- Safeguarding of the productivity of fishing activities down river, and
- Maintenance of high biological diversity in the corridor, both in its aquatic and terrestrial components, due to the intrinsic diversity of habitats which characterizes interfacing ecosystems.

In Costa Rica there are regulations (Ley Forestal de 1986), which establish that between 10 and 15 meters of protective vegetation must be preserved along the sides of all water courses for the purpose of maintaining the stability of streambanks and reducing the load of sediments from them. The widest measurement applies to steep zones. In general terms, this is the case of the farms which were assessed.

The effect of such protection is probably more efficient when the diversity of species is greatest, characteristic of undegraded systems. This is because the diversity of growth habits and root systems produces an effective filtration effect, while at the same time increasing biological diversity. Compliance with these regulations will have a big impact on the preservation of biological diversity and the reduction of negative environmental effects in the Northern Zone.

The combination of these strips of protective riparian vegetation, connecting other areas which because of very strong limitations to agricultural development or because they currently have forest cover must be protected, affords a very valuable opportunity for maintaining biological diversity in the project zone as well as on individual campesino settlements.

5.2 Finca ZAPAL

The Finca Zapal has a surface area of 526.15 hectares and is, presently, according to IDA criteria, almost ready for the recipients to be settled on their parcels. The parcels, lots for housing and roads, have been delineated on the plans and marked out on the ground.

5.2.1 Location

The farm in question is located in the province of Alajuela, Upala canton, San Isidro de Aguas Claras district, next to the village of Colonia Blanca. Cartographically speaking, parts of it are to be found on four of the cartographic sections of the 1:50,000 scale map. These are sections 3148 I (UPALA), II (MIRAVALLES), III (CURRUBANDE) and IV (CACAO). A more precise location is defined by the grid references 398-402 and 309-314 (Lambert Projection).

5.2.2 Aspects of the Natural Environment

Unfortunately, the recent aerial photographs which cover the area of the Zapal farm are affected by the presence of a large amount of cloud cover, which makes their use impossible as a tool for the assessment of the opportunities and limitations for the agricultural use of this farm. For this reason the conclusion and recommendations set out in this report have been based on field observations carried out during a four-day tour of the farm with the help of:

- 1:5,000-scale plan of the farm with the delineation of the parcels and roads proposed by IDA,
- Topographic section enlarged to an approximate scale of 1:25,000 with the contours for most of the farm,
- Field tools: machete, clinometer, compass and borer.

Other available information which was very useful included the preliminary studies of the agrologic classifications on a scale of 1:20,000, and the land/man ratio carried out by IDA for the farm.

5.2.3 Climate and Life Zone

The Finca Zapal is located in the Very Wet Premontane Forest Life Zone. No meteorological stations exist nearby but on the basis of the isohyet and isotherm maps, the average annual temperature can be estimated at 22 C and average annual precipitation at around 3500 mm. The wind does not seem to be so strong as to limit crops in this region and no modifications were observed in the vegetation induced by this variable.

According to the map for dry months prepared by the Tropical Science Center (1985), there is, on average, only one month or less during which the soil condition is effectively dry. Although the presence of mist is common in the zone, it does not appear to limit the cropping alternatives, to judge from the abundance of mosses observed on the bark and branches of the oldest trees.

5.2.4 Hydrography

The farm forms part of the high watershed of the Rio Nino or Pizote. Two rivers of moderate importance, tributaries of the Rio Cano Negro which in turn joins

the Rio Pizote, run through the property. These are the Rio Aguas Verdes and the Rio Pirineas. Other important water courses are the Quebradas Monos and Argentina which join the Rio Pirineas at the same point in the south-east corner of the farm, and the Quebrada Los Cochinos which is located in the extreme north and flows into the Rio Jalapiedras, also a tributary of the Rio Cano Negro.

5.2.5 Topographic Conditions

The elevation of the future Zapal settlement ranges from some 500 meters above sea level in the extreme northeast to some 300 meters above sea level in the Colonia Blanca community in the extreme southeast of the farm. The shortest distance between the points of highest and lowest elevation is approximately 3 kilometers, along an approximate bearing of NW-SE. Therefore, the average slope of the property is approximately 7 percent. There are varying zones, however, of gentle and steep slopes. While not very great extensive, the latter limit land use for agricultural purposes.

The areas with the steepest slopes are the Quebrada Los Cochinos watershed and the upper reaches of the Rio Aguas Verdes in the far north and northwest of the farm, where the slope conditions can be as high as 90 percent. The slope conditions are gentle in the northeast section of the property, mostly less than 12 percent. Further south, especially south of the Rio Pirineas, the slopes begin to increase, being generally over 25 percent and reaching as much as 70 percent.

5.2.6 Soils

The soils on the northern part of the farm, especially to the north of the Rio Aguas Verdes are very deep and with a texture which ranges from loamy to loamy-clay. They are dark soils with a high organic material content and good drainage.

Further south, and especially south of the Rio Pirineas, the soils, though deeper, have a clayey texture, their coloring is brownish-yellow and drainage is slow. These soils have been used for cattle ranching and exhibit signs of compaction and mild symptoms of erosion.

Between the Rios Aguas Verdes and Pirineas, the soils have a high stone content, both in the cross-section and on the surface, which impedes the use of these soils for agricultural purposes over most of the area.

5.2.7 Vegetative Cover

There is no primary forest as such on the property. The Quebrada Los Cochinos watershed and the uppermost part of the Rio Aguas Verdes watershed, however, have good forest cover including essential forest elements which are valuable for the conservation of the quality of the water and control of erosion.

The rest of the section of the farm located north of the Rio Aguas Verdes has been planted previously with annual crops and now has secondary growth which ranges in height from less than one meter in the most recently planted areas, to four meters in the oldest section of the secondary growth. A similar situation is found in the intermediate area between the most important rivers.

The zone south of the Rio Pirineas has been mostly used for pasture, with the exception of a region towards the southwest which was planted with cocoa, mainly with laurel for shade. In the old pasture areas there is now a natural regeneration in large plants, some two to three meters in height. The area planted with cocoa still exists, although it lacks maintenance. The growth of the laurel trees used as shade in this plantation is adequate.

5.2.8 Wildlife

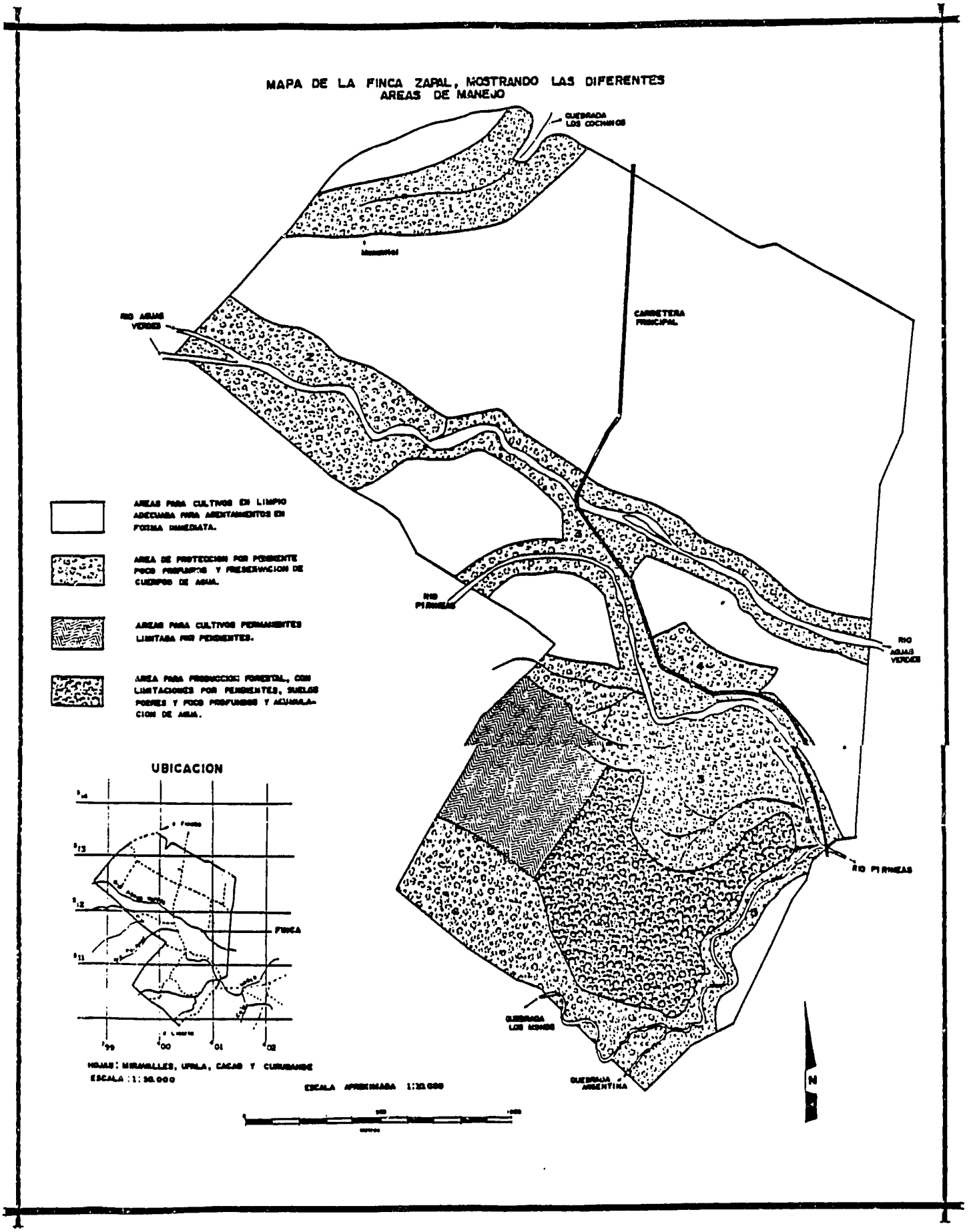
During the tour along the different paths which cross the farm, it was possible to observe indications of the presence of wild animals. The easily recognizable tracks indicated the presence of deer and especially of peccaries, tepezcuintles and armadillos. We even found a wild turkey feather and the tracks of a small cat. On one of the trails the characteristic smell of peccaries was very strong, indicating that these animals were present somewhere nearby.

The wildlife tracks detected were consistently more abundant in the areas of forest and secondary growth and along the banks of the rivers and streams.

5.2.9 Recommendations for Management

Based on field observations and with the help of the previously mentioned maps, a map (Figure 2) was drawn up on recommended uses for the different sectors of the farm. Four categories were established which include:

FIGURE 2


MAPA DE LA FINCA ZAPAL, MOSTRANDO LAS DIFERENTES AREAS DE MANEJO
QUEBRADA LOS COCHINOS
CARRETERA PRINCIPAL
RIO AGUAS VERDES
RIO PIRINEAS
RIO AGUAS VERDES
RIO PIRINEAS
QUEBRADA LOS MONOS
QUEBRADA ARGENTINA
AREAS PARA CULTIVOS EN LIMPIO ADECUADA PARA ASENTAMIENTOS EN FORMA INMEDIATA.
AREA DE PROTECCION POR PENDIENTE POCO PROFUNDO Y PRESERVACION DE CUERPOS DE AGUA.
AREAS PARA CULTIVOS PERMANENTES LIMITADA POR PENDIENTES.
AREA PARA PRODUCCION FORESTAL, CON LIMITACIONES POR PENDIENTES, SUELOS POBRES Y POCO PROFUNDOS Y ACUMULACION DE AGUA.
UBICACION
FINCA
HOJAS: MIRAMELLES, UPALA, CACAO Y CURUBANDE
ESCALA : 1: 50.000
ESCALA APROXIMADA 1:10.000
N

- Areas for protection;
- Areas for forestry plantations;
- Areas for tree crops; and
- Areas for crops on cleared soil.

Of these categories, only the last is recommended for the establishing of settlements due to the recommendations regarding the intensity of land use which were pointed out in the section above entitled, "Matching of Land Use to its Sustainable Capability". Only under these conditions can there be a high degree of certainty that the establishment of a campesino settlement will not have a negative effect on the quality of the environment and the conservation of the natural resources of this farm. When conditions change and respect for land-use capability can be guaranteed, the areas indicated for tree crops and forestry plantations could be included in the development of the settlement.

This obviously differs considerably from the parcel and road plans designed by IDA for the settlement which will established on this property. Nevertheless, even with these limitations, the usable area of the farm for the settlement is slightly over half, in the order of 55 percent.

Areas for Protection

The protected areas identified correspond to the banks of the rivers and streams and all the areas with slopes above 70 percent, regardless of the conditions of the other parameters of the natural environment. Five more or less separate areas are included, which have been numbered on the map. The total surface area of these units is around 175 ha, representing approximately 33 percent of the total surface area of the farm.

- **Area 1:** Quebrada Los Cochinos watershed (approximately 25 hectares):

  All this small watershed is included within the areas which should be protected, both because of its limitations and the present vegetative cover. An almost undegraded forest covers the whole area of this watershed within the farm boundaries. Moreover, it was in this watershed that the steepest slopes were observed, up to 90 percent.

  Apart from that, the area has great potential as a water source for present and future human settlements in the region. The stream disappears into the ground at a specific point and then reappears some 150 meters below with a considerably increased flow of water. Downriver, at the point where it leaves the farm, this stream is already being used as a water source for neighboring farms. The flow observed seems sufficient to provide water for medium-sized communities, therefore it could provide water for the

consumption of the future settlement as well as for the present inhabitants of Colonia Blanca and probably Colonia Libertad.

- **Area 2:** Upper Reaches of the Rio Aguas Verdes (30 ha. approximately):

  The reasons for the inclusion of this area in the protected category are very similar to the previous unit. The slopes near to the river's course are steep, in many cases above 70 percent. The whole area is covered by almost undegraded forest which preserves most of the characteristics of the original forest.

  Next to the area with the steepest slopes, contiguous to the river, a small plain with gentle slopes can be observed, but which besides having the same type of vegetative cover also has a high stone content on the surface.

- **Area 3:** Edges of the Main Rivers and Adjoining Areas (79 ha approximately):

  The reasons for the protection of these areas include, most importantly, the presence of the main water courses which must be protected with natural vegetation along their banks so as to preserve the biological diversity and the integrity of the aquatic community.

  Moreover, this unit includes the catchment area of two small, unnamed streams which flow into the Rio Pirineas and which are notable for their very rugged topography. Part of this unit is presently covered by secondary vegetation (charral) which is the result of regeneration on former pasture land.

- **Area 4:** Lagoons (approx. 6 ha):

  This unit has been included as a protected area as there are three small permanent lagoons located within it which account for approximately one quarter of the surface area of this unit. The slope around the lagoons is steep and the formation is such that the areas between them would make it very difficult to use it for agricultural purposes.

  Moreover, being so close to agricultural areas would cause the rapid eutrophication of these lagoons due to runoff with a high nutrient content. The same protection criteria for the aquatic community should be applied to the areas immediately adjacent to these bodies of water.

  Although there are fish (Tilapia) in these lagoons the local inhabitants do not take advantage of them. Some inhabitants of Colonia Blanca indicated that these fish have "worms" in their flesh. These "worms" are probably parasites which affect the fish population during one period of the year. Efforts should be made to define the quality of these fish for human consumption during various periods of the year.

  Should the quality be insufficient, or should the inhabitants continue to reject them, it would be possible to introduce other species native to the watershed such as guapotes and/or mojarras of the Cichlasoma genus, for example, which are the predominant icthyofauna in the Lake of Nicaragua or the Cano Negro laguna.

- **Area 5:** Upper Reaches and Banks of the Quebradas Mono and Argentina (approx. 35 ha):

This protected area is the one which lies farthest to the southwest on the farm. Although a greater number of trees are to be seen along the banks of these streams, in general terms this zone has less forest cover. The exception is the southwest corner where the slopes are, moreover, very steep. The strips of arboreal vegetation which exist along the banks of the streams do not meet the recommended width requirements and should be protected to ensure that these are achieved through natural regeneration.

Forestry Plantation Area

The forestry plantation area is covered by a secondary growth on an old area of pasture, due to the fact that it was previously used for grazing cattle. The surface area of this unit is approximately 40 ha, representing some 7.6 percent of the farm.

The soils, though deep, are also clayey and the slope conditions vary from 35-60 percent. One flat sector nearer to the Quebrada Monos of approximately some 5 hectares in area has additional drainage problems as a result of its position near the hillsides, with water accumulating on the surface during a considerable period of the year. It was covered with water when the farm was visited. Many species could be appropriate for the reforestation which is advisable for this unit. Laurel was observed to be developing very well in surrounding areas in climatic and edaphic conditions which are quite similar.

Tree Crops

The area for tree crops is partially covered by an old cocoa plantation with laurel for shade, and in part by secondary growth over areas previously used for pasture. The surface area of this unit represents only some 4.2 percent of the farm and takes in some 22 ha. The soil is less clayey than in the unit described previously and the slope conditions range from 20-35 percent approximately.

Annual Crops

Finally, the section for annual crops includes the rest of the farm, which accounts for approximately 55 percent of the total surface area. Practically all this area has been used previously for annual crops and/or pasture and therefore its present vegetative cover is a "tacotal" of varying age and height. Most of these units afford favorable conditions for annual crops on cleared soil, which could even be mechanized.

It is unfortunate, however, that according to IDA plans, part of this area will be used for establishing a community, when other areas exist that could be used for this purpose and which are not so valuable agriculturally. Part of the areas identified for forestry production, specifically the higher part of one of the hills, is considered adequate for this purpose and could permit better utilization of those areas with greater agricultural potential. Nevertheless, this does not constitute an environmental risk but is rather an appreciation of the efficiency with which it is possible to utilize resources which could in the future become progressively more scarce.

5.2.10 Conclusion and Recommendation

The setting-up of a campesino settlement, as designed by IDA, on the Finca Zapal could have negative environmental effects. Some of the parcels are located in areas with serious limitations for use, which could cause erosion and deterioration of the soils. Moreover, the delimitation of parcels which has taken place has not taken into account the buffer zone required by law for the protection of water courses.

The main limitations to sustainable agricultural production on the Finca Zapal are those associated with climate and soil. As far as climate is concerned, the limiting factor is the Life Zone itself, which due to the amount of rainfall it receives, excludes the presence of type I land (Annual Crops with Very High Yield). From the soil standpoint, the main factors are associated with slopes, texture, fertility and stone content.

Nevertheless, a campesino settlement could be established, preserving a balance with the environment, on approximately 55 percent of the property. In order to achieve this it is essential that the parcels and roads be compatible with the reality of the limiting factors observed on the ground.

The most important thing for this farm is to ensure that the buffer areas along the water channels are not included in the parcels and that the slopes on the parcels do not exceed 12 percent on loamy and clayey-loamy soils and 8 percent on the clayey soils. IDA should also offer guidance to the campesinos through their follow-up program so that they use simple soil conservation practices such as contour cultivation and alternate strips. This should apply especially to those parcels which approach the slope limits indicated.

It would also be advisable to seek another site which meets the conditions necessary for the location of the community in order to make efficient use of the best agricultural land. In the area appropriate for reforestation, excellent conditions exist for

this purpose and it would facilitate the initial protection and subsequent incorporation of these areas with limitations into the future development of the settlement.

5.3 Finca ARGENDORA

The Argendora farm has a surface area of 470.5 ha and, like Zapal, the parcels and roads for the future settlement have already been established on the ground. Housing lots have still not been marked out, though the site for the community has already been selected.

5.3.1 Location

Argendora is located along the boundary between the Dos Rios district in Upala Canton in the Province of Alajuela, and Santa Cecilia in the La Cruz Canton in the Province of Guanacaste, near to the village of Brasilia. The main road from Upala to Santa Cecilia crosses the farm along the Rio Las Haciendas.

Cartographically speaking it is to be found on section 3149 III (OROSI) the 1:50,000-scale map, between Lambert Projection grid references 386-390 and 331-336.

5.3.2 Aspects of the Natural Environment

The availability of aerial photographs for this farm is similar to that for Zapal. Only old photographs exist, in which land use does not reflect the reality observed on the ground. The recent aerial photographs covering the zone of the farm have a cloud cover which makes their use impossible.

For this reason the methodology for the reconnaissance carried out, on which the conclusions and recommendations of this report are based, was similar to that used in the case of Finca Zapal; it also included the same elements which facilitated the tour, observation and subsequent mapping. A three-day tour of the farm was conducted, along all the roads and most of the paths between the parcels, plus observations of slope conditions, depth and texture of the soil and vegetative cover were carried out.

5.3.3 Climate and Life Zone

The Argendora farm is located in the Tropical Wet Forest Life Zone. Though there are no meteorological stations nearby, the isohyet and isotherm maps indicate that annual average temperature and precipitation are around 24°C and 2,800 mm respectively.

No evidence was observed in the vegetation that the strong winds or the presence of mist are of such great intensity as to affect crop selection or yield. According to the Tropical Science Center map for dry months (1985), the farm is located in a zone where the soil remains in a condition of effectively dry humidity for vegetable growth for one to three months a year.

5.3.4 Hydrography

The Argendora farm is located in the central watershed of the Rio Colon or Rio Las Haciendas, flowing into the Lake of Nicaragua. This river forms most of the eastern boundary of the property, towards both the north and the south. The river runs through the central part of the farm in an almost south-north direction. On this part of the property, the eastern boundary is defined by the Rio Mechas which joins the Rio Haciendas roughly one kilometer downriver of the farm.

Besides these two major water courses, other streams exist in the area of the future settlement. The biggest of these is known as the Quebrada de Juan which joins the Rio Las Haciendas a little before this leaves the property. This stream drains most of the northern sector of the farm.

Another less important stream drains the southern part of the property and joins the Rio Las Haciendas near the bridge over the road to Santa Cecilia. This stream runs through most of the farm south of the main road and more or less follows the course of one of the roads planned by IDA, later turning away towards the east. Finally, an even less important stream joins the Rio Mechas in the eastern sector of the farm.

5.3.5 Topographic Conditions

The Argendora farm is located at an average elevation of roughly 330 meters above sea level. In the far south, according to the topographic map (1:50,000 scale) the elevation is 360 meters above sea level, falling to around 300 meters above sea level in the far north over a distance of some four kilometers, giving an average slope of approximately 1.5 percent.

Generally speaking, the slopes on this property are gentle, with the exception of the headwaters of the streams and the edges, both of these and of the main rivers which cross the farm. In these areas the slopes range from 25 percent to more than 60 percent. On the rest of the farm the slopes oscillate between 4 percent and 6 percent.

5.3.6 Soils

The soils of the Argendora farm are deep and have a clayey texture with a browny-reddish coloring. In the extreme south of the property there are areas with stones but these are not very abundant. The clay content is greater towards the western boundary of the farm. The stone content is high throughout most of the alluvial plain of the Rio Mechas. The clay content is less and the color darker, indicative of greater fertility in the soils located between the two main rivers in the eastern sector of the future settlement.

In the southern sector of the farm, the boundary of which is formed by the Rio Las Haciendas and the road to Santa Cecilia, there is an area of waterlogged soils, roughly in the central section of the area. This is a tract of some 13 ha which was completely flooded at the time of our visit and, according to the information provided by the prior administrator of the farm who acted as our guide during the tour, it remains in this condition for most of the year.

5.3.7 Vegetative Cover

Traditionally the farm has been used for extensive cattle ranching and therefore present cover is mainly a secondary growth of "tacotal" of varying height intermixed with patches of improved and natural pasture.

Forest cover exists in the areas with the steepest slopes, associated both with the main rivers and the streams. In these wooded areas the most commercially valuable timber has been extracted and, moreover, said areas have been used for extensive cattle grazing using the fenced grazing concept. That is, without establishing pasture or eliminating forest cover. The area of waterlogged soils mentioned in the previous section has also been preserved under this same type of cover.

Besides these areas with forest cover there are around five hectares of forest in similar conditions to those described above in an area of land with a gentle slope. This forest is located towards the eastern boundary of the farm and is linked to the area of forest along the edge of the Rio Mechas.

5.3.8 Wildlife

The presence of tracks and other evidence of the existence of wild animals was fairly scant in comparison with that observed on the Finca Zapal. According to our guide, it is still possible to find tepezcuintles and armadillos. But other species such as white-tailed deer or cats have not be seen on the property for years. During our tour we were able to observe two snakes, a fer-de-lance (Bothrops sp.) and a black racer (Chironius sp.).

5.3.9 Recommendations for Management

According to the distribution of the different parameters which define the environment of the Argendora farm which have been described in the previous paragraphs, it was possible to identify two types of area for the future settlement. These areas, marked on the map which was drawn up for this property (Figure 3.1.), include:

- Areas for protection and
- Areas for annual crops.

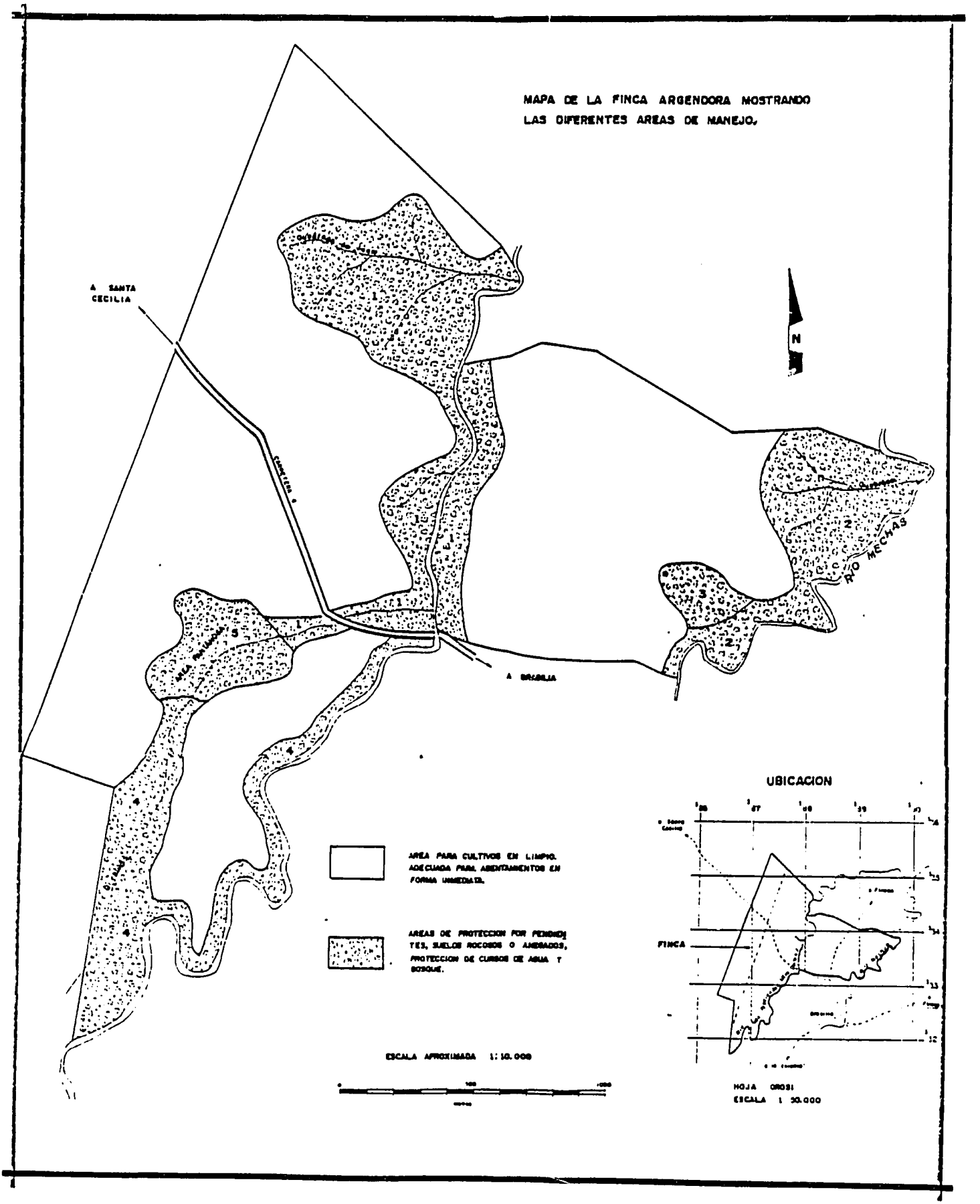
It is possible, therefore, to establish a campesino settlement in the areas indicated as suitable for annual crops, representing approximately 69 percent of the farm and covering an area of 323 ha.

Areas for Protection

The areas recommended for protection comprise 31 percent of the Argendora farm in broad terms. They have been included in this category mainly as they are situated near permanent water channels and because they have forest vegetation. Though the forest is not exactly primary forest, since it has been subjected to extensive cattle grazing and the most valuable forest species have been removed, it still retains elements of the original structure which are of great value in protecting the integrity of the aquatic environment and protection.

Five areas were identified which have been marked on the afore-mentioned map.

FIGURE 3


MAPA DE LA FINCA ARGENDORA MOSTRANDO
LAS DIFERENTES AREAS DE MANEJO.
A SANTA CECILIA
CARRETERA
A BRASILIA
RIO MECHAS
N
AREA PARA CULTIVOS EN LIMPIO. ADECUADA PARA ASENTAMIENTOS EN FORMA INMEDIATA.
AREAS DE PROTECCION POR PENDIENTES, SUELOS ROCOSOS O ANEGADOS, PROTECCION DE CURSOS DE AGUA Y BOSQUE.
ESCALA APROXIMADA 1:10.000
UBICACION
FINCA
HOJA OROSI
ESCALA 1:50.000

- **Area 1:** Catchment watershed of the Quebrada de Juan and banks of the Rio Las Haciendas north of the main road (approx. 64 ha):

  This is the largest of the areas recommended for protection in regard to the establishing of the future settlement. The main reason for its protection is its forest cover and the steep slope conditions associated with said area, which in some cases exceed 60 percent.

  It is very valuable from the standpoint of protecting the remnant forest areas and the high biological diversity associated with it and with the water-land interface, because it includes - besides the strip of protected vegetation - a wider bulge of land (the watershed of the Quebrada de Juan), which complements the protective action of the strip.

- **Area 2:** Strip of Protected Vegetation along the edge of the Rio Mechas (approx. 28 ha):

  The reason for protecting this area is the protection of the integrity of the aquatic environment indicated previously. The present cover of this unit is mainly forest.

- **Area 3:** Almost Undegraded Forest (5 ha. approx.):

  This unit represents one of the forest growths closest to primary forest on the whole property. Though the slopes and soils are suitable for annual crops, it would be advisable to protect it in spite of its small size as it is connected to similar vegetation in the protective strip of the Rio Mechas.

- **Area 4:** Watershed of the Quebrada in the south of the farm and the protective strip along the Rio Las Haciendas south of main road (approx. 37 ha):

  Once again, the reasons for the conservation of this unit are similar to those indicated previously: the protection of the integrity of the aquatic environment both in the main river and the stream which runs into it. Moreover, the highest part of the watershed of this stream has steep slopes of between 30 percent and 50 percent and its present cover is almost undegraded forest.

- **Area 5:** Zone Prone to Waterlogging (approx. 13 ha):

  This zone is not suitable for most economic uses due to the presence of water on the land for most of the year. It could only be of some value for extensive forest use, utilizing conservationist extraction techniques. On the other hand, it is presently covered by an almost undegraded forest which should be protected and which will contribute to the conservation of biological diversity in a very efficient fashion as it is connected to the protective corridor of the stream which forms it.

Areas for Annual Crops

Soil samples of these units should be taken to ensure that they meet the minimum accepted fertility conditions (PH 5.5) in order for them to be used for annual crop production. It is possible that some of them do not meet this criterion, especially

the units which lie farthest to the west on the property. Nevertheless, it is felt that the environmental risk of their use for the establishment of a settlement is low in these areas, since they have already been deprived of their forest cover and they are not situated in a highly erosive environment.

Moreover, the low yields with annual crops, should they be used for this purpose, will contribute to these areas being easily subjected to less intense uses in accordance with their capability, such as intensive dairy farming and the production of permanent crops and tree crops.

5.3.10 Conclusion and Recommendation

It is possible to predict the occurrence of negative environmental effects if a campesino settlement is set up on the Argendora farm which attempts to use the whole surface area of the property for such a purpose.

The most obvious limiting factors for the sustainable development of this property are associated with the soil. Among these, probably the most important is the slope conditions in the areas along the water channels. Secondly, we could point out limitations relating to texture, fertility and, to a lesser degree, the presence of stones and waterlogged soils.

The distribution of parcels and roads should be redesigned so that it matches the availability of suitable land, which includes roughly 69 percent of the property according to the indications on the map.

On this farm it is important to ensure that the areas presently covered with forest vegetation not be logged, that the parcels on these protected strips along the rivers and streams be excluded, and that areas with excessive stone content, waterlogged soil conditions or slopes over 8 percent also be excluded.

5.4 Finca de ALFONSO BUSTOS

The farm purchased from Mr Alfonso Bustos has a surface area of 90.8 hectares. This farm has not yet been divided into parcels nor have roads been planned for the establishment of a campesino settlement by IDA.

5.4.1 Location

The Alfonso Bustos farm is located in the Dos Rios district, Upala canton, in the Province of Alajuela. Cartographically speaking, it is to be found on topographic section 3148 IV (CACAO) of the 1:50,000 scale map, between Lambert Projection grid references 392-394 and 315-318.

5.4.2 Aspects of the Natural Environment

Besides the information similar to that available for the previous farms (ZAPAL and ARGENDORA), recent aerial photographs were also on hand in the case of this property. The 1:35,000 scale photographs were taken in May 1988 and were therefore very useful in tracing the vegetative cover and identifying the main physiographical zones of the property. This was useful on our tour and saved time in field observations.

5.4.3 Climate and Living Zone

The farm is located in the Premontane Very Wet Forest Living Zone. According to the isohyet and isotherm maps, precipitation and temperature for this locality are roughly 3,400 mm and 22°C respectively. In an attempt to correlate these values, the average values of the nearest station -- which is Finca El Ensayo -- were obtained. The latter is situated at a comparable elevation (610 meters above sea level) and has annual average rainfall and temperature statistics of 3,695 mm and 22.7°C respectively. Therefore, it may be concluded that the isoline maps coincide fairly well with the observations conducted at the station mentioned.

We did not observe indications in the vegetation of the presence of strong winds or situations which, due to the presence of mist, would imply limitations. According to the Tropical Science Center map for dry months (1985), on average there is a period of one month during which the soil is effectively dry for plant growth.

5.4.4 Hydrography

The Alfonso Bustos farm is situated in the upper watershed of the Rio Nino o Pizote, a little to the east of the Rio Penjamo before this joins the Rio Negro. No larger water course runs through the property, only two streams pass through it. The Quebrada Azufrada forms the far southeastern boundary and the Quebrada Guaracha performs the same function in a southwesterly-northeasterly direction.

5.4.5 Topographic Conditions

The farm in question is located between 800 meters above sea level in the far north and 550 meters above sea level in the southeast. The approximate distance between both points is roughly 1.5 kilometers, which gives us a general slope condition for the property in the order of 17 percent.

Generally speaking, the slopes are not very steep, 8 percent-15 percent or less, with the exception of a strip of land which forms the transition point between two terraces at different levels. On this strip of land the slope reaches gradients of over 45 percent and there are many rocky outcrops. The unit in the southwest corner has even gentler slopes of around 5 percent.

5.4.6 Soils

The soils on the Alfonso Bustos farm have a dark coloring, indicative of good fertility and they are of a loamy and loamy-clayey texture. They are, however, soils with little depth and for this reason agricultural use is limited on part of the farm.

There is also another soil unit which is characterized by a high phreatic level of between approximately 20 and 50 cms, at least during the period when our visit took place. This unit is to be found in the northwestern corner of the farm and could inhibit the cultivation of some annual crops during the wettest period of the year.

5.4.7 Vegetative Cover

Most of this farm has been used for cattle ranching or the cultivation of annual crops, especially beans. Therefore the present vegetative cover is a secondary growth of varying height. There is only a remnant forest which retains most of its original structure in the extreme south of the farm. The surface area of this forest is about 24 hectares.

5.4.8 Wildlife

No special element was observed which would indicate the presence of abundant wildlife. Our guide, a son of the former owner, pointed out that it was possible to find smaller animals such as armadillos and tepezcuintles.

5.4.9 Recommendations for Management

On the basis of the land use limitations observed on the farm purchased from Mr Alfonso Bustos, recommended areas were marked on a map of the farm (Figure 4.1.) as:

- Areas for Protection
- Areas for Cattle Ranching; and
- Areas for Annual Crops

It is recommended that a campesino settlement only be established in the areas designated for annual crops, as they are the only ones which could sustain, without deterioration, the degree of intensification to which they would be subjected once assigned. These areas include a total of 35 ha, comprising around 39 percent of the farm.

Areas for Protection

The areas recommended for protection on this farm total some 46 ha and represent approximately 61 percent of the farm. The reasons for which it has been recommended that these areas be protected include: the presence of forest cover, the conservation of the zone's biological diversity, protection of water courses, the presence of steep slopes and shallow soils. Two different areas are included on the map.

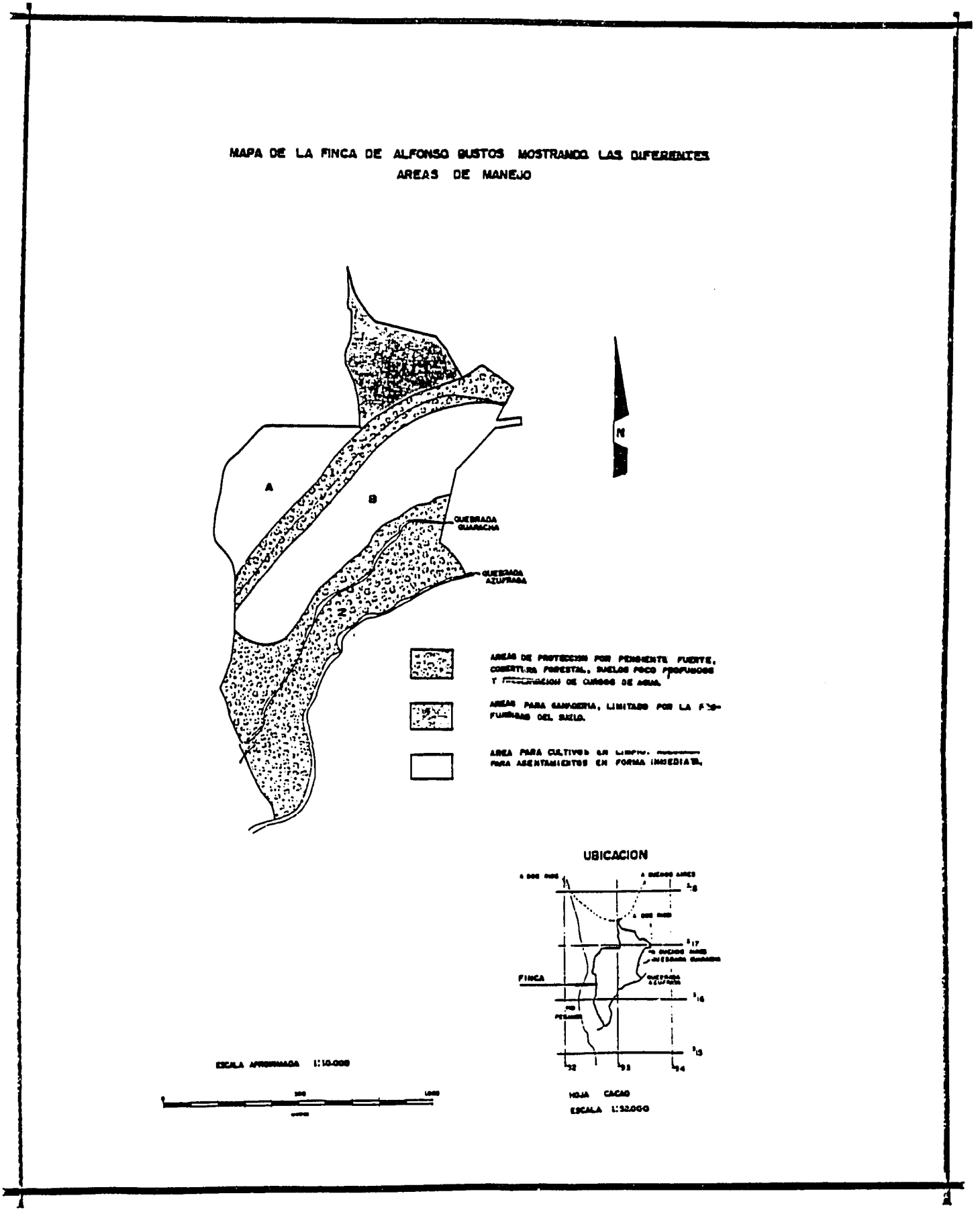
- **Area 1:** Slopes between Terraces (approx. 10 ha):

  This zone is very near the entrance to the farm and forms a strip running in more or less a northeasterly-southwesterly direction. The slopes on this unit are steep -- up to 45 percent and more -- combined with rocky outcrops on the surface.

- **Area 2:** Edges of the Guaracha and Azufrada streams (approx. 36 ha):

  The reasons for the protection of this area are the protection of a forested area of approximately 24 ha which still exists in the extreme south of the property. Also the protection of the integrity of the habitat in the streams mentioned and the protection of areas with shallow soil (less than 30 cms.).

FIGURE 4


MAPA DE LA FINCA DE ALFONSO BUSTOS MOSTRANDO LAS DIFERENTES AREAS DE MANEJO
N
A
B
QUEBRADA GUARACHA
QUEBRADA AZUFRAGA
UBICACION
FINCA
HOJA CACAO
ESCALA 1:32.000

Area for Cattle Ranching

This area is situated at the entrance to the farm. Although the topography is gentle in this unit, the test drillings conducted with the borer indicated the depth of the soil to be between 30 and 40 cms. Therefore this land could not tolerate the pressure of annual crops on a sustained basis. This unit comprises a surface area of approximately 10 ha, constituting 11 percent of the farm.

Annual Crops

Two different zones were marked on the map as potentially suitable for use in annual crops.

- **Area A:** Land with a high phreatic level (approx. 15 ha):

  This area is limited due to the presence of a high phreatic layer which is located at less than 50 cms. -- at least during the wet season when our visit took place. However, the cross-section was not observed to contain characteristics of the reduced compounds which are typical in waterlogged areas. It could probably sustain rice cultivation. During the final part of the rainy season it could be very useful for the cultivation of annual crops.

  Although this could be a serious limitation (depending on the duration of the period of this high phreatic level), this unit was included as suitable since the level of environmental deterioration which could be caused is relatively low, there being no forest vegetation and it is not a highly erosive environment. This lixiviation of the minerals is probably retarded due to the presence of the phreatic layer.

5.4.10 Conclusion and Recommendation

In order to avoid negative environmental problems in organizing a campesino settlement, it is necessary that the demarcation of parcels and the planning of roads be carried out in accordance with the limits to land use imposed by the natural environment on this property.

The most important limiting factors on this farm have to do with the soil. The most important of these is the effective depth of the soil, which is some cases reaches only 18 cms. The areas of moderately deep soils, over 60 cms., are fairly limited.

According to the borings carried out, it was possible to determine that the only the central area of the property, with an approximate surface area of 20 ha, and the northeast corner, an area of 16 ha, have soils deep enough for sustainable agricultural use.

Secondly, we found that the slope conditions also constitute a limiting factor on roughly 10 hectares of land which form a transition zone between two terraces with gentle slopes.

The third factor affecting the soil is the presence of a high phreatic layer which maintains high humidity in the soil of the 15 ha unit in the northwestern corner of the farm mentioned previously. Nevertheless, it is felt that this area could still be used for installing parcel owners given the fact that it has a very flat topography.

When the parcels are designated on the ground, these limitations should be taken into account so that they are not included in the parcels assigned to the recipients. The presence of the forest and the protection of the strips of protected vegetation should also be included in the criteria for the demarkation of the parcels.

5.5 Finca ARGELIA

The Finca Argelia comprises a total surface area of 370.8 ha and was acquired by IDA with Project 041 funds for the establishment of a campesino settlement. The parcels, roads, and the area for the community have yet to be decided.

5.5.1 Location

The Finca Argelia is located in the Dos Rios district of Upala canton in the Province of Alajuela. Said property can be found between Lambert Projection grid references 387-381 and 318-321 of cartographic section 3148 IV (CACAO) of the 1:50,000-scale topographic map.

5.5.2 Aspects of the Natural Environment

As in the case of the Finca Alfonso Bustos, it was possible to obtain very good quality, recent aerial photographs for the Finca Argelia (May 1988), which greatly facilitated the reconnaissance of this farm and simplified the task of obtaining measurements on the ground.

5.5.3 Climate and Life Zone

This farm is very near the Finca Alfonso Bustos and therefore is also situated in the same Premontane Very Wet Forest Life Zone. The information extracted from the

isohyet and isotherm maps is also similar -- 3,400 mm for the annual average precipitation and 22°C for the annual average temperature. The same considerations concerning the validation of this information with the station at Finca El Ensayo are also applicable to this locality.

There were no indications on the farm that mist is a serious problem. The same cannot be said be said for wind, however. There are deformations caused by wind in one sector of the farm situated in the northwest region. The area affected by this problem is the eastern hillside of the main elevation which exists on the farm. The windy area also has steep slopes for the most part.

The duration of the period during which the soil is effectively dry for the growth of vegetation is roughly one month according to the map prepared by the Tropical Science Center.

5.5.4 Hydrography

In the far northeast, the farm is flanked by the Rio Azul which later joins the Rio Penjamo and finally the Rio Pizote, via the Rio Cucaracho. The Rio Azul is striking for the color of its water and the high sulphur content of same. In passing through it, one can detect the strong smell characteristic of sulfuretted acid.

Other less important water sources are the Quebrada Gavilan which also acts as a partial boundary in the extreme southeast and the Quebrada La Vaca which forms a boundary in the extreme northwest. Another smaller stream enters the property in the south and forms a kind of lagoon roughly 8 hectares in size which later drains into the Quebrada La Vaca on the northern edge of the property. The water in both the Quebrada Gavilan and La Vaca is apparently of good quality.

5.5.5 Topographic Conditions

The Finca Argelia is located between 620 and 400 meters above sea level. The highest elevation is to be found towards the far southeast and the farm gradually slopes down in a northeasterly direction towards the Rio Azul. The average slope of the farm is around 6 percent. There are two intermediate hilltops on the property which give rise to the presence of steep slopes of over 70 percent.

The first of these is located towards the northeast of the entrance to the farm, coming from Dos Rios. This is the one which has really steeper slope conditions, above

70 percent. The other elevation is much more gradual and is to be found in the northern-central sector of the farm. The slopes in this sector are around 25 percent-30 percent.

On the rest of the farm the slopes are gentle, with the exception of a change of elevation between terraces in the southern sector. At this point the slopes are short but reach percentages similar to those described above.

5.5.6 Soils

The soils of the Finca Argelia are for the most part excellent. Generally speaking they are deep, darkish in color and of a loamy to loamy-clayey texture. It was possible to observe some deviations from this general condition. One of these involves brown/yellowish colored soils with a high clay content. This soil is to be found in the northeast region of the farm near the Rio Azul.

Another variation concerns the presence of stones in the form of outcrops in several parts of the farm. Most of these are small in area and do not represent a serious problem for the agricultural use of the soil. However, the largest of these affects a considerable area in the northern-central region of the farm and, combined with the moderate slopes which exist in that sector, they limit its use for the cultivation of annual crops.

Finally, there is an area of flooded or waterlogged soils due to the presence of a lagoon which permanently covers the surface with water. The water level is not very deep but enough to impede the use of this soil for economic purposes.

5.5.7 Vegetative Cover

Most of the farm is under a secondary growth of varying height. It is interesting to note that photographs from the year 1975 were also observed and land use was practically identical. Only small areas of forest exist near the streams, particularly in the southern part of Quebrada Gavilan.

5.5.8 Wildlife

In the area of the oldest secondary growth associated with the stony soils with moderate slopes in the center-north of the farm, it was possible to observe a very high density of armadillo tracks and signs that they had been feeding. It was also impressive

to observe in this area the density of a species of myriapod roughly 7-10 cm long, which apparently provide a source of food for the armadillos.

It was also possible to observe a snake of the "Mano de Piedra" species (Bothriechis sp.) near the Quebrada Gavilan.

5.5.9 Recommendations for Management

On the map of the Finca Argelia (Figure 5.1.), three types of area have been marked out on the basis of the observations carried out concerning the risks of deterioration to the farm's natural resources. These areas include:

- Areas for Protection
- Areas for Permanent Crops
- Areas for Annual Crops

The annual crop areas, which are the only ones recommended in this report for the establishment of a campesino settlement, account for roughly 74 percent of the surface area of this farm.

Areas for Protection

The recommended areas for protection on this farm include a total area of 66 ha comprising approximately 18 percent of it. On the corresponding map three types of protected areas have been indicated for different reasons, to wit:

- **Area 1:** Protection of Edges of Water Courses (approx. 49 ha):

  This is formed by the buffer strips along both sides of the water courses; for the most part these areas have tree cover, though this is not wide enough to provide them with adequate protection.

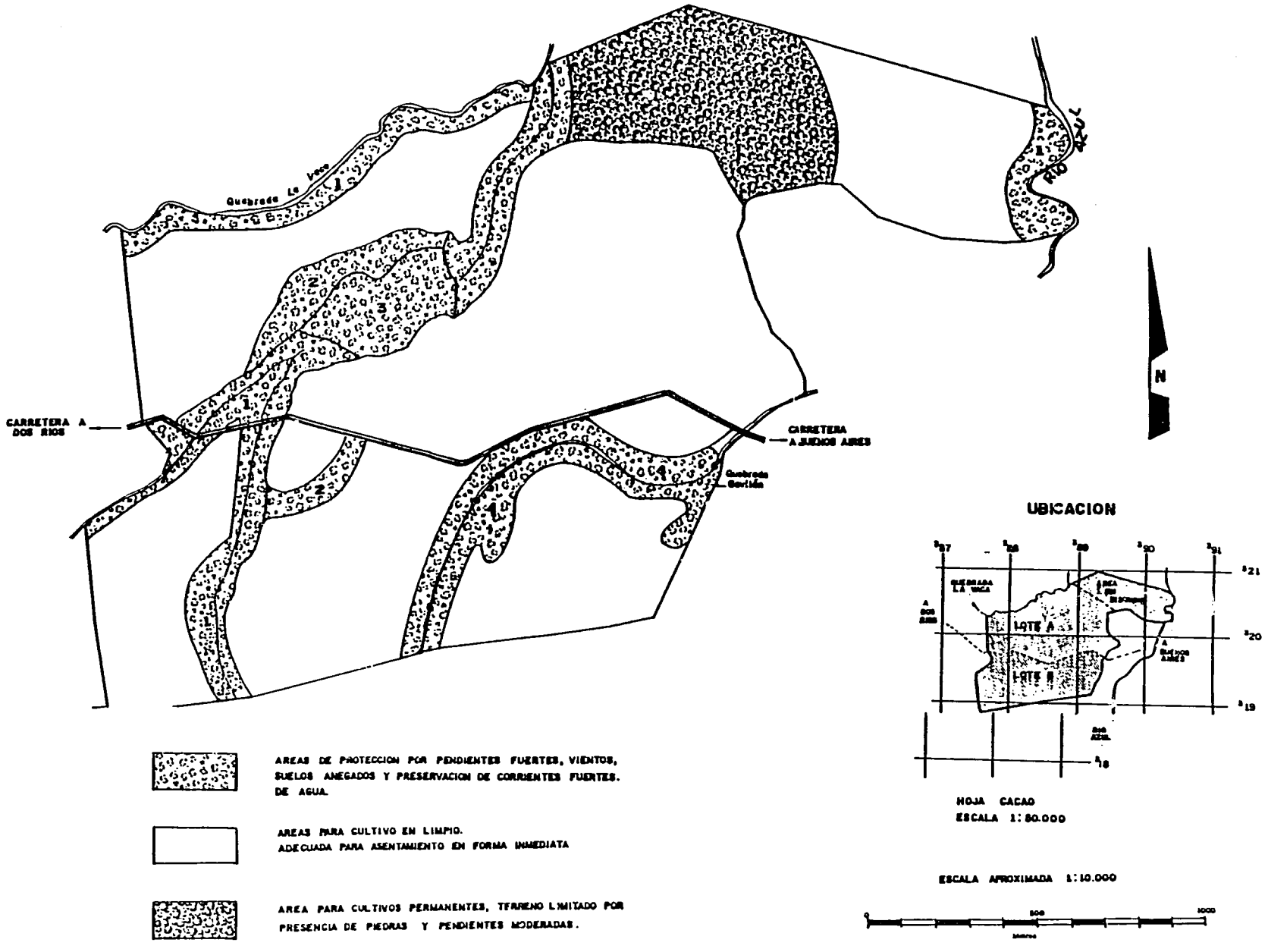
- **Area 2:** Area of Steep Slopes and Wind (approx. 9 ha):

  There are two units in this category, one to the north of the main road and the other to the south. In the first, combined with the steep slopes is the presence of strong winds which modify the shape of the trees which remain.

  The second unit involves a change of level between terraces with gentle slopes. While very small (approx. 2 ha), this change of elevation should be protected in order to recover the natural vegetation and to prevent it from becoming a source of sediment for the nearby streams.

FIGURE 5

MAPA DE LA FINCA ARGELIA, MOSTRANDO LAS DIFERENTES AREAS DE MANEJO



- **Area 3:** Lagoon (approx. 8 ha):

  This unit comprises an approximate surface area of 8 hectares and water covers the surface throughout the year, according to the guide who accompanied us during our tour and who was previously a worker on the property.

Permanent crops

The permanent crop area consists of the unit in the center-north of the property which was indicated as being characterized by moderate slopes in the order of 25 percent-30 percent, but with more or less significant rocky outcrops also being present. The estimated surface area of this section is approximately 30 ha, accounting for 8 percent of the total area of the farm.

Annual Crops

The area of annual crops suitable for the establishment of a campesino settlement on the farm covers an area of roughly 275 ha and represents 74 percent of the property. In this part of the farm there are rocky outcrops which vary in size and reduce the usable area, however they are not very big. Moreover, most of these areas are flat to slightly undulating, apparently very fertile. The only exception to this generalization could be the unit located further east near the Rio Azul. In this unit there is a soil which, though deep, is of a clayey texture and its coloring is browny-yellow, indicative of low fertility and acidity.

5.5.10 Conclusion and Recommendation

Of the four farms assessed, the Argelia farm is the one which offers the best conditions for the establishment of a campesino settlement. The area of the farm suitable for this activity includes some 74 percent.

Once again, the limiting factors for the agricultural use of this farm mainly involve the soil, excessive slopes limit one part of the farm, and the presence of stones, another. The distribution of parcels and roads should take into account the presence of these limiting factors, which at the same time constitute risks for environmental deterioration.

Besides these limitations associated with the soil, there is a limitation of an atmospheric nature which is the high winds on the eastern side of the hill near the lagoon formed north of the main road.

These limitations should very much be taken into account in dividing up the parcels on the ground, and the strips of protective vegetation along the edges of the streams and rivers should also be respected; it is also necessary to ensure that these areas are not included in the parcels so that tree cover can be reestablished through natural regeneration.

5.6 Final Considerations

The farms assessed display different degrees of environmental risks for the establishment of campesino settlements. This is especially true if the limitations of the environment are not taken into account in the demarkation of the parcels which will be given to the beneficiaries or when the routes of the roads are defined.

Nevertheless, if a conservationist policy is taken on board, parts of each one of them, of varying size, may be used with a high degree of certainty that there will be no adverse environmental effects. This conservationist policy is based on the identification of land use in the areas with less environmental risks and greater economical potential which have already been deforested, and in the protection and conservation of other areas with greater limitations for the future.

This plan for taking advantage of the resources currently available in Costa Rica's Northern Zone is possible given the abundance of land with a high agricultural potential and the relatively low density of the existing population. In order to achieve this, the most important thing is to apply these concepts as part of a development philosophy for the project. The combined effect of many small areas, like the four settlements proposed, managed in accordance with limitations imposed by the environment, will guarantee that resources are preserved throughout the area.

On the other hand, if it proves impossible to develop this philosophy, if only a few areas are established, in accordance with a set of regulations which are not entirely understood by officials and which cannot be put into practice by the beneficiaries due to the intrinsic limitations of the parcel they receive, then the effort will be in vain and the presence of negative impacts on the environment will without a doubt make themselves felt.

Environmental education can contribute, to a large extent, to a reduction in the risks of adverse environmental effects. Education should be directed mainly at those groups of people who have the greatest impact on the environment. These are rural

communities, the beneficiaries of the new IDA settlements, and the IDA technical personnel who are in daily contact with them. It is really these groups who with their activity are daily transforming the environment and using natural resources. The education of these persons, therefore, offers probably the best opportunity for preventing irreversible situations.

The exclusion of some areas of the farms as far as their use on the campesino settlements is concerned, brings with it the problem of what to do with those same areas. The greatest risk is that they may be invaded by squatters and mismanaged by some members of the settlement itself. It should be the responsibility of the associations or development committees themselves to ensure that this does not happen.

Among the areas which do not meet the criteria for being handed over to campesinos are areas in need of protection, reforestation, permanent crops and tree crops and cattle ranching. As their name suggests, the protected areas should be isolated from any economic use. Only moderate hunting and fishing should be permitted in these areas. If this is achieved it will be possible for natural regeneration to progressively reestablish tree cover in those areas which today do not have it.

The areas which can support less intensive economic uses than the cultivation of basic grains, such as cattle ranching, tree and permanent crops and forest use, should be protected in the same way until suitable conditions for their use exist. Meanwhile the community could benefit from the extraction of timber for community development projects, provided that conservationist management methods are used and the corresponding authorization is sought from the Direccion Forestal.

Subsequently, these areas could be exploited for the benefit of the community, either on a collective or individual basis when IDA and/or the settlement find a way to guarantee their correct use.

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APPENDIX A

ENVIRONMENTAL MANAGEMENT CONCERNS IN RURAL ROAD CONSTRUCTION (modified from Megehan, 1977 and Hudson, 1981)

by James Tolisano
Development Alternatives, Inc.
Washington, D.C.

Causes of Erosion

Accelerated erosion may occur during and after rural road construction from a variety of causes. Some possible causes could include the following:

- removal or reduction of protective cover
- degradation of natural soil structure or fertility
- increased slope gradients created by construction of cut and fill slopes
- decreased infiltration rates within or adjacent to the road
- interception of subsurface flow by the road cut slope
- concentration of generated and intercepted water
- decreased strength, increased shear stress, or both, on the road surface, cut and fill slopes, partly due to concentration of water and added weight to the slope in the embankment fill.

The results from project activities worldwide demonstrate that roads are frequently the major cause of erosion in rural development projects. Slope failures, landslides, slumps, and sheet erosion can result from poorly designed or maintained roads. In some project areas more than 50 percent of landslides and increased instream sedimentation can be attributed to road construction or maintenance activities.

Principles for Reducing Erosion From Roads

In order to minimize the amount of erosion which can result from road construction or rehabilitation, the following principles must be incorporated into work plans:

- Use land capability classifications to avoid road work in high erosion hazard areas
- Reduce the total road network in an area (i.e. the total length of roads within a defined geographic unit)
- Minimize the total area disturbed by any road work
- Minimize any off-site impacts of erosion by including drainage, revegetation, and planned slope gradients in road work.

Guidelines for Road Rehabilitation Activities

A number of field practices are appropriate to minimize or mitigate potential soil loss during road construction, rehabilitation, or maintenance. These practices assume that initial road activities are in compliance with land capabilities as established through thorough land use planning measures.

Route Reconnaissance and Location

- Avoid high erosion hazard sites
- Use natural terrain features (lower gradient slopes, benches, etc.) to reduce potential soil loss
- Short road segments with steeper gradients can take best advantage of natural terrain features and minimize local or total soil loss
- Situate roads on well-drained soils and rock formations that tend to dip <u>into</u> the slope.
- Do not undercut unstable, waterlogged toe slopes at valley bottoms
- Reduce concentrated flow in road drainage by varying road grades
- Position drainage of water and sediment to minimize stream loading and channel disturbance. Locate roads far enough above streams to allow buffer zones to filter out dislodged sediments moving downslope. Where possible, use sediment traps within drainage networks.

Road Design

- Use as narrow a road as possible, especially in high erosion hazard areas
- Balance the volume of cut and fill materials to minimize excavation. Place fills to ensure stability when wet or under pressure.
- Use retaining walls or, where possible, bench construction (no fill slope) to hold fill material.
- Use benches or terraces for proper drainage in areas of weak or erodible soils or bedrock.
- Road surfaces and grades should be designed in accordance with available local materials, type and volume of traffic, strength of subgrade, and planned service life of the road.
- Use open top culverts or road dips to direct road runoff onto sediment filter strips, rather than directly into streams.
- Use rip-rap, masonry headwalls, or other bank embankment protection at drainage structures.
- "Over-design" bridge and culvert structures to accommodate changes in sediment and water yields.

- Have roads climb away from channel crossings to reduce flow along or on the road surface.

- In areas of unstable fills, drainage can be sloped toward the uphill side of the road. Culverts should then be installed to carry the water under the road. Where this is not possible drainage can be sloped toward the downhill side of the road at a grade of 3-5 percent. Care must be made to assure that drainage will flow off of the road onto stable surfaces.

- Use cross drains (open-top culverts and intercepting dips) to reduce water concentrations in road ruts.

Road Construction

- Slope stabilization work should immediately follow road construction activities.

- Clear brush from fill areas to assure a solid base and compaction.

- Spread cleared, crushed vegetation beneath the toe of the road fill to enhance the buffering quality of the slope beneath the road.

- Install culverts to conform as closely as possible to natural stream channels. Compact fill material around all culverts to prevent seepage.

- Work during the driest weather conditions.

Slope Stabilization Measures

- Revegetation requirements: site preparation, species selection, seeding prior to mulching, fertilization

- Mulches will reduce surface soil temperatures, soil water losses, and soil crust formation. Where necessary, mulches can be anchored into the soil with woody vines and shrubs, netting, or stakes.

Road Maintenance

- Keep a maintenance record dating all activities performed

- Develop a regular schedule for cleaning culverts, cross drains, and dips, with greater attention given during wet seasons.

- Remove debris from drainage channels for a distance of 30 meters upstream from the inlet. Repair or replace cross drains and dips prior to the wet season onset, as needed.

- Avoid undercutting the roadcut when removing slide debris.

- Maintain a proper road grade at all times. Do not dump graded material over the fill slope.

- Haul and dispose of excess materials from maintenance operations in proper disposal areas.

- Patrol roads during significant storm or runoff events to confirm that drainage facilities are functioning properly.

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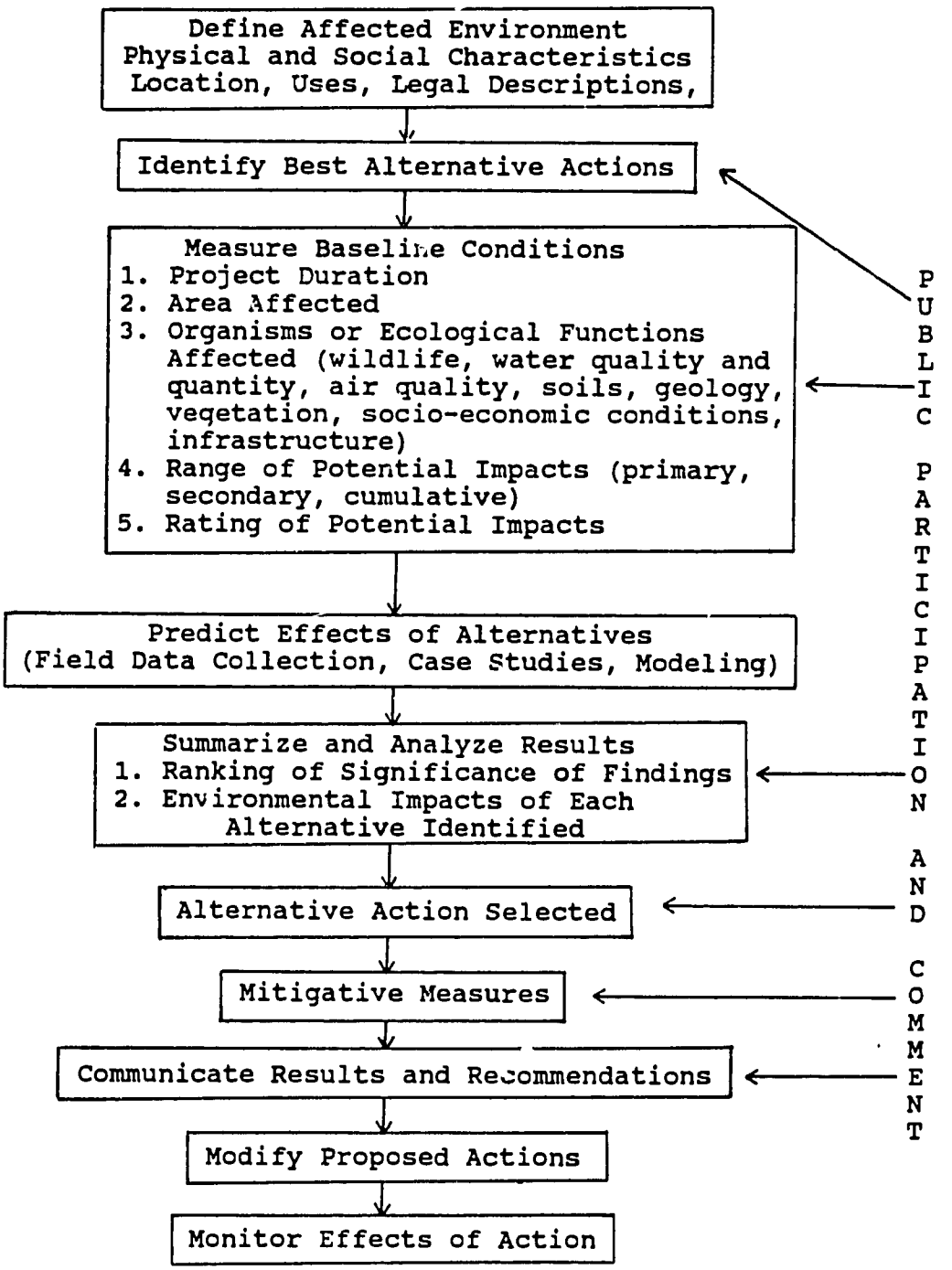
APPENDIX B

PLANNING AN ENVIRONMENTAL ASSESSMENT*

by James Tolisano
Watershed Management Specialist
and Raymond Douglas
Road Engineer



* Environmental Assessments for road, crop extension, potable water, settlement or other project activities should be prepared on an individual basis for specific actions in question. Checklist or "cookbook" approaches for EA work are available, but do not always target the correct criteria or concerns. Individually prepared EAs, relying on qualified technical expertise, and including aspects of the following criteria summarized in text, tables and graphs will produce the best results for long-term sustainable environmental management:

Criteria for Developing Environmental Investigations

* Environmental Assessments for road, crop extension, potable water, settlement or other project activities should be prepared on an individual basis for specific actions in question. Checklist or "cookbook" approaches for EA work are available, but do not always target the correct criteria or concerns. Individually prepared EAs, relying on qualified technical expertise, and including aspects of the following criteria summarized in text, tables and graphs will produce the best results for long-term sustainable environmental management:

Land Use

* Present and Projected Land Use Practices
* Changes in Human Population Characteristics
* Road Densities and Transport Networks
* Pest Control Conditions

Water Supply and Quality

* Basin Water Yields/Streamflow Characteristics
* Monthly and Annual Sediment Yield
* Well Yield Characteristics
* Biological and Chemical Constituents
* Changes in Channel Characteristics and Riparian Cover

Vegetation

* Type, Total Area Covered, Percent of Area Covered
* Productive Yields from Vegetative Types
* Unique Wildlife Habitat Communities
* Present and Project Sources of Stress (increased vegetation removal, fire, grazing, etc.)

Wildlife

* Current and Projected Fluctuations in Populations
* Impacts on Dominant Species in Maintenance of Ecosystem Processes
* Loss of Cover, Food Supply, or Other Habitat Disruptions

Soil

* Changes in Compaction, Soil Loss Rates, Subsurface Conditions, Soil Chemical Characteristics

Air Quality

* Changes in Levels of Chemical or other Constituents
* Noise Pollution

Socio-Economic

* Changes in Economic or Employment Patterns
* Changes in Human Population Characteristics
* Dilution of Cultural Traditions or Aesthetic Preferences
* Impacts on Community Facilties and Infrastructure (schools, recreation, health, water supply, solid waste, energy, transport)

ENVIRONMENTAL IMPACT IDENTIFICATION AND EVALUATION FORM

The following form may be useful in conducting quick analyses of localized project activities. The intent is to define a numerical ranking of probable environmental impacts from proposed field work. The score is summed and the user can then prepare an interpretation of the severity of the project on local and regional environmental conditions, and identification of specific areas in which mitigation or control is necessary.

Symbol Definitions	Numerical Ranking
N - NO environmental impact	0
L - LITTLE environmental impact	1-3
M - MODERATE environmental impact	4-6
H - HIGH environmental impact	7-10
U - UNKNOWN environmental impact	*

A. LAND USE

1. Changes in present and projected land use practices (define) _____
_____
_____

2. Changing the character of the land through:

   a. Increasing the population _____
   b. Extracting natural resources _____
   c. Land Clearing _____
   d. Changing soil character _____

3. Altering natural defenses _____

4. Foreclosing important uses _____

5. Jeopardizing man or his works _____

6. Changes in road grid densities _____

7. Other factors

_____ _____

_____ _____

D. NATURAL RESOURCES

Water Resources

1. Ecological balance _____
2. Diversion, altered use of water _____
3. Changes in stream channel characteristics or riparian (streamside) vegetation _____
4. Changes in surface water yields _____
5. Changes in ground water yields _____
6. Changes in surface or ground water quality _____
7. Changes in basin sediment yields _____

Wildlife Habitats

7. Adverse impacts on wildlife populations _____
8. Presence of threatened, endangered or sensitive plant or animal species _____
9. Adverse impacts on habitats _____

Vegetation

10. Changes in forest area or composition _____
11. Changes in vegetation type _____

Soils

12. Adverse impacts on soil structure, fertility _____
13. Adverse impacts on soil infiltration or erosion rates _____

Air Quality

1. Air additives _____
2. Air pollution _____
3. Noise pollution _____
4. Other factors

Short-term construction air pollution

_____ _____
_____ _____

Other Factors

14. Irreversible, inefficient commitments _____
15. Other factors

_____ _____
_____ _____

E. CULTURAL

1. Altering physical symbols _____
2. Dilution of cultural traditions _____
3. Other factors

_____ _____
_____ _____

F. SOCIO-ECONOMIC

1. Changes in economic/employment patterns _____
2. Changes in population _____
4. Changes in population densities _____
6. Changes in cultural patterns _____
7. Other factors

_____ _____
_____ _____

G. HEALTH

1. Changing a natural environment _____

2. Eliminating an ecosystem element _____

3. Other factors

_____ _____

_____ _____

H. GENERAL

1. International impacts _____

2. Controversial impacts _____

3. Larger program impacts _____

4. Other factors

_____ _____

_____ _____

I. OTHER POSSIBLE IMPACTS (not listed above)

_____ _____

_____ _____

_____ _____

_____ _____

APPENDIX C

SAMPLE FORM FOR CERTIFYING PROTECTION OF COMMUNITY WATERSHEDS

PROYECTO AGUA POTABLE/PROTECCION AMBIENTAL

by James Tolisano
Watershed Management Specialist

Asociacion de Desarrollo: _____

Canton de _____ Distrito de _____

Tipo de solucion: (a) captacion de un manantial y distribucion por gravedad (b) perforacion de pozo profundo y distribucion con una bomba (c) perforacion de pozo superficial con una bomba de mano (d) establecimiento de una red (e) captacion de lluvia y almacenaje en un tanque (f) proyecto multiple involucrando mas de un metodo o mas de una asociacion.

(tipo) _____

Incluya con este formulario un mapa mostrando: (a) el area que debe ser protegida para asegurar la calidad del agua en el futuro (b) tipo de vegetacion in el area de proteccion (c) la ubicacion de la fuente (manantial o pozo) (d) lugares de referencia

Evaluacion de la Fuente: (a) porcentaje del terreno en la cuenca que ya tiene bosque, natural o sembrado _____

(b) la descarga del manantial durante el verano _____

(c) problemas con inundaciones _____

(d) el uso actual del manantial _____

(e) principales problemas de enfermedades en la comunidad

Factores importante a considerar para la proteccion de la calidad y cantidad en un proyecto de agua potable.

1. La siembra de cultivos en el area de captacion del manantial podria producir la contaminacion de la fuente por infiltracion de pesticidos, etc.

2. Los pastos en el area de captacion del manantial podrian disminuir la infiltracion de agua a la fuente y, entonces, disminuir la descarga del manantial.

3. Los pastos en el area de captacion del manantial podrian ocasionar contaminacion proveniente del ganado.

4. Los incendios que pueden entrar el area de captacion podrian producir contaminacion, y disminuir la descarga del manantial.

5. Cortar los arboles en el area de captacion podria disminuir la descarga del manantial.

Otros: _____

_____

_____

_____

El compromiso de proteger la cantidad y calidad de agua incluye las siguentes regulaciones y actividades:

Regulaciones

1. No se deben sembrar cultivos en el area de proteccion del manantial.

2. No se debe permitir ganado en el area de proteccion del manantial. Tanto en bosque como en pastos, a fin de que la cobertura boscosa pueda reestablecerse.

3. No se debe permitir incendios en el area de proteccion del manantial.

4. No cortar arboles en el area de proteccion del manantial.

5. El area de proteccion debe ser no menos de _____ metros arriba del manantial y _____ metros cada lado.

6. El comite o la asociacion establecera el limite del area de proteccion con rotulos/alambre de puas.

7. El comite o la asociacion debe hacer una prueba de la calidad de agua, incluir pH, e. coli, STD, $CaCO_3$, y nitratos, por lo menos, antes de la construccion, y la inspeccion de la prueba debe tener el apoyo de un especialista calificado.

Otros: _____

_____

Certificado del Especialista en Manejo de Recursos Naturales:
"Considero que el cumplimieto de las previsiones indicades en este formulario son las mas apropiades para la proteccion de la calidad y cantidad de agua".

Firma: _____ Fecha: _____
(Especialista en Manejo R.N.)

Aprobacion de los Lideres de la Comunidad:
"Firmamos en constancia de nuestra conformidad y apoyo a las previsiones aqui senalades para la proteccion de la cantidad y calidad de agua potable de nuestra (s) comunidad (es).

Firma: _____ Fecha: _____

Firma: _____ Fecha: _____

Firma: _____ Fecha: _____
(Comentarios adicionales al otro lado)

APPENDIX D

DESCRIPTION OF CATEGORIES OF LAND USE CAPABILITY IN COSTA RICA

by Alberto Vega
Ecologist

TYPE I: Annual Crops (Very High Yield)

This is land which does not display any kind of agro-ecological limitations and therefore permit planting, cultivation and harvesting of all the annual crops ecologically suited to the site in question. They are areas which are either flat or have gentle slopes, without problems of erosion, depth, salinity or stone content, without phytotoxic elements, well-drained, easy to cultivate, with average textures, a good humidity-retention capability, fertile and not subject to waterlogging. Generally speaking, they are to be found in the wet life zones with a definite dry period of short-to-moderate duration.

TYPE II: Annual Crops (High Yield)

The land is this category has some limitations which may occur individually or in combinations, thus reducing crop selection, ease of cultivation and, in some cases, net yields. They may lie in areas with less favorable climatic conditions, such as dry life zones or very wet ones, with no dry period or one of very long duration. Some edaphic or topographic limitations may also be present, such as slightly heavy textures, minimal presence of stones, less depth and slightly pronounced slopes.

TYPE III: Annual Crops (Moderate Yield)

In this category the limitations are generally greater than for the previous one, but this land still permits economic production of selected annual crops without degrading the area's productive capability. These limitations may include steeper slopes, a broader range of soils textures, higher stone content, or they may be subject to frequent flooding and problems of wind or mist. The limitations may occur separately or in combinations, affecting crop management, productivity and yield to some extent.

TYPE IV: Permanent or Semi-permanent Crops

Included in this category are those areas which exhibit too many limitations for sustained production of annual crops but which permit the planting, cultivation and harvesting of herbaceous or bush crops with a moderate-to-long vegetative period (more than two years) and which do not require frequent turning of the soil nor do they leave it without dense protective vegetation except for brief and infrequent periods. Generally speaking, this category includes land in very wet and pluvial conditions susceptible to erosion under annual crops; the fertility of these areas can be limited. We could give as examples of this category: coffee without shade, pasture for cutting, banana, plantain and papaya, among others.

TYPE V: Intensive Grazing

Land with greater limitations which cannot be used for the aforementioned activities, but which may be used, without degrading the site, for high-yield grazing, capable of sustaining more than two head of beef cattle/Ha or more than 1.8 head\Ha of dairy cattle without any need for supplementary feed, except minerals. This category of land is mostly limited to wet or very wet zones, without a prolonged dry season, also including land with a great risk of erosion and whose fertility in general is slightly less than that required for crops.

TYPE VI: Extensive Grazing

Due to its greater limitations, this land permits low-yield grazing, less than two head/ha for beef cattle and 1.8 head/ha for dairy cattle, with a lower limit for both activities of approximately 0.5 head/ha, without any need for supplementary feed except minerals.

These areas are to be found in climatic conditions varying from dry to pluvial life zones, with variable dry seasons, affected by wind and/or mist. They may also have more severe edaphic or topographic limitations, such as restricted or excessive drainage, very heavy or light textures, high stone content, shallowness and low natural fertility.

TYPE VII: Tree Crops

In this category we find land which does not permit the crops or pasture described for the above types, but which may be used on a sustained basis for establishing species of trees which maintain a protective vegetative cover without any turning of the soil.

These areas are to be found on steeper slopes than the previous types of land and they require deep-to-moderately-deep soils without fertility problems. This category of land is also located in areas without wind or mist problems. Some examples of crops in this category include: cocoa, coffee with shade, citric trees, coconut, timber-producing species, maranon, etc.

TYPE VIII: Intensive Forestry Production

The land in this category permits sustained, intensive and permanent production of timber and other forest products from managed natural forests of this kind. They must allow rapid growth of the biomass. The conditions considered necessary for such activities include: hot or moderately hot (over 70°C), wet or very wet climates without prolonged dry periods or problems with wind or mist and deep soils without drainage or stone-content problems.

On some of this land it is possible to set up forestry plantations (preferably of native species), in areas whose fertility and other physical factors favor such use, though the establishment of such plantations is more advisable on Type VI land.

TYPE IX: Extensive Forestry Production

Included in this category is land with slope conditions steeper than the previous types and with varied climatic and edaphic conditions which are generally less favorable for the adequate development of the biomass, such as prolonged dry periods, cold climates, high cloud cover, strong winds, stony and shallow soils, very low fertility and high flood risk. The establishment of forestry plantations in this category can be very risky due to the limitations which exist. Therefore the establishment of such plantations should only be encouraged on a small scale and for the purpose of reestablishing the forest where it has been eliminated. Timber extraction on this land should be carried out more carefully than in the previous category in view of the risks of erosion which may exist in many of these areas.

TYPE X: Protection

To this class belong the land which does not meet the minimum conditions required for cultivation, pasture or forestry production. It is to be found in climatic and edaphic conditions so severe that they do not permit any direct economic use without the deterioration or degradation of the area. They include swampy and rugged land and other areas whose conditions indicate the need for them to be managed exclusively for the purpose of protecting watersheds, wildlife, scenic, scientific and recreational values, and even their absolute protection against any kind of invasion or economic or social use for the collective benefit of society.