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PD-AAF-924-61

CLASSIFICATION

PROJECT EVALUATION SUMMARY (PES) – PART I

Report Symbol U-447

1. PROJECT TITLE	2. PROJECT NUMBER	3. MISSION/AID/W OFFICE
Remote Sensing Pilot Project.	515-0144	USAID/Costa Rica

4. EVALUATION NUMBER (Enter the number maintained by the reporting unit e.g., Country or AID/W Administrative Code, Fiscal Year, Serial No. beginning with No. 1 each FY) 80-3

☑ REGULAR EVALUATION ☐ SPECIAL EVALUATION

5. KEY PROJECT IMPLEMENTATION DATES			6. ESTIMATED PROJECT FUNDING	7. PERIOD COVERED BY EVALUATION
A. First PRO-AG or Equivalent FY 78	B. Final Obligation Expected FY 78	C. Final Input Delivery FY 80	A. Total $ 610,000 B. U.S. $ 250,000	From (month/yr.) 1/1978 To (month/yr.) 8/1979 Date of Evaluation Review

8. ACTION DECISIONS APPROVED BY MISSION OR AID/W OFFICE DIRECTOR

A. List decisions and/or unresolved issues; cite those items needing further study. (NOTE: Mission decisions which anticipate AID/W or regional office action should specify type of document, e.g., airgram, SPAR, PIO, which will present detailed request.)	B. NAME OF OFFICER RESPONSIBLE FOR ACTION	C. DATE ACTION TO BE COMPLETED
This is a final evaluation carried out to identify strengths and weaknesses of the second stage (the Pilot Project) of a three-phase program, and to make recommendations to guarantee the most effective utilization of the information and new knowledge generated. Some of the findings and recommendations are also relevant to any future plans to implement the third stage (the National Project) of the Program.		

9. INVENTORY OF DOCUMENTS TO BE REVISED PER ABOVE DECISIONS

- ☐ Project Paper
- ☐ Financial Plan
- ☐ Logical Framework
- ☐ Project Agreement
- ☐ Implementation Plan e.g., CPI Network
- ☐ PIO/T
- ☐ PIO/C
- ☐ PIO/P
- ☒ Other (Specify) see above
- ☐ Other (Specify)

10. ALTERNATIVE DECISIONS ON FUTURE OF PROJECT

- A. ☒ Continue Project Without Change
- B. ☐ Change Project Design and/or ☐ Change Implementation Plan
- C. ☐ Discontinue Project

11. PROJECT OFFICER AND HOST COUNTRY OR OTHER RANKING PARTICIPANTS AS APPROPRIATE (Names and Titles)

Heriberto Rodríguez, General Engineer (USAID)
Fernando M. Rudín, Director National Geographic Institute.

Clearance: HRodríguez
GDaniels
MKilgour, AD

12. Mission/AID/W Office Director Approval

Signature

Typed Name Steve Knaebel, Director

Date

AID 1330-15 (3-78)

13. Summary

The Costa Rica Pilot Project represented the second stage of a three phase program (demonstration, pilot, and national) to develop the use of remote sensing and mapping techniques in connection with Costa Rica's resource inventory and mapping requirements. This evaluation is for work conducted during the project implementation period (January 1978 to August 1979) and includes several suggestions for the third stage --The National Program.

The purpose of this project was "to cooperate with the Government of Costa Rica in the execution of a pilot project concerned with mapping natural resources and monitoring urban expansion." Primary project emphasis was placed on 1) training personnel in data collection and analysis, 2) conducting a forestry inventory, and 3) monitoring the growth of the San José metropolitan area. The project was conducted by Resource Development Associates (RDA) of Los Altos, California, under contract to USAID.

As documented in several sections of the Morain/Wagner evaluation report, the evaluation team was impressed with the detail and comprehensiveness of the work performed for this Remote Sensing Pilot Project and especially with the extensive documentation available for review. The team also agreed on the following conclusions:

1. Technically, color-infrared, aerial photography may be the best imagery for supporting natural vegetation inventories in Costa Rica, but panchromatic or perhaps untested black and white infrared photography is generally more useful, since the film is more easily processed and reproduced.

2. Digital analysis of Landsat multispectral scanner data (MSS) did not prove successful either in accuracy or in the range of features that are needed for discrimination. The evaluation team can not recommend establishment of a digital analysis capability in Costa Rica on an operational basis.

3. In general the technical quality of the map products was good, although several maps are of doubtful utility due to the limitations of the data upon which the maps were based.

4. Current reproduction and distribution prices charged by the Instituto Geográfico Nacional (IGN) to users of remote sensing data in Costa Rica are below the acquisition cost and make the data highly cost-effective for various uses. We believe the value of remote sensing data in Costa Rica far exceeds the cost of collecting and analyzing such data although detailed cost benefit analyses for each user or for Costa Rica as a whole are not available.

5. There are many current and potential users for remote sensing data in Costa Rica. The Project did little to identify and work with Costa Rican users other than the trainees from five national organizations.

6. It appears that conventional wisdom and some previous RDA experience led to the decision on what data should be collected and analized. Costs for either data collection or analysis did not appear to limit the decision, but it was unfortunate that neither black and white IR photography nor good-quality Landsat imagery were obtained.

7. Much of the information that was collected and/or mapped under this pilot project appears useful for the GOCR agencies but few had had an opportunity to inspect the actual products. Several products were not considered useful.

8. The GOCR has taken steps to increase its programs to collect and update information needed by various user agencies. In particular, the Inter-American Development Bank has agreed to help support the use of remote sensing in Costa Rica and the GOCR itself is developing programs that require increasing the amount of available resource information.

14. Evaluation Methodology

A two-man team of outside specialists was formed in early September 1979 to review and evaluate the Pilot Project and to make recommendations concerning possible AID support for the follow-on activities envisioned under the National Program. This team conducted its review in Costa Rica in late September 1979 and in the U.S. in mid-September and early October. This report was prepared in December 1979 and revised in February 1980.

The Pilot Project evaluation was conducted by Dr. Stanley Morain, Director of NASA's Technology Application Center (TAC) at the University of New Mexico, Albuquerque, New Mexico, and Mr. Thomas Wagner, Applications Specialist at the Environmental Research Institute of Michigan (ERIM), Ann Arbor, Michigan. The team relied greatly on the cooperation and assistance of Ing. Heriberto Rodríguez, General Engineer at the USAID Mission in Costa Rica and Ing. Fernando M. Rudín, Director of Costa Rica's Instituto Geográfico Nacional. Ing. Rodríguez had served as AID liaison Officer for the Project and Ing. Rudín was the principal GOCR liaison Officer. The team also interviewed officials of the Oficina de Planificación Nacional y Política Económica (OFIPLAN), the Agriculture Sector Planning Office (OPSA), and the Dirección General Forestal of the Ministry of Agriculture and Livestock (MAG).

The project evaluation team chose to document its project review under two main headings: 1) project technical results and 2) GOCR institutional perspectives (See Section II of the Morain/Wagner Report).

The technical results were derived primarily from a careful study of available reports and documents, in particular the comprehensive final project report and several map products. The team evaluated the procedures in terms of their quality. Table 1 lists the reports that were available to the review team.

Somewhat more difficult was the attempt to determine what the precise GOCR user information needs are and whether the types of products generated are likely to meet those needs. For this purpose a number of interviews were held in Costa Rica with various personnel from agencies identified as users or potential users of the products or project methodology, and with USAID and Inter-American Development Bank personnel. Although few of these people had as yet had a good opportunity to inspect the products, the interviews attempted to determine the possible roles of the GOCR agencies in helping to identify the project requirements and their contributions (if any) to the pilot project. Equally important was their interest in continuing involvement in the proposed National Program, and their needs for the various products that would result from such a program.

The Mission has carefully reviewed the Morain/Wagner Report and concurs with its general findings, conclusions and recommendations.

EVALUATION REPORT

COSTA RICA PILOT PROJECT FOR NATURAL RESOURCE INVENTORY AND INFORMATION SYSTEM

PROJECT NO. 515-0144

(Morain/Wagner Report)

EVALUATION REPORT

Costa Rica Pilot Project for Natural Resource
Inventory and Information System
Project No. 515-0144

INTRODUCTION AND BACKGROUND

The Costa Rica Pilot Project represented the second stage of a three phase program (demonstration, pilot, and national) to develop the use of remote sensing and mapping techniques in connection with Costa Rica's resource inventory and mapping requirements. This evaluation is for work conducted during the project implementation period (January 1978 to August 1979) and includes several suggestions for the third stage -- the National Program.

The purpose of this project was "to cooperate with the Government of Costa Rica in the execution of a pilot project concerned with mapping natural resources and monitoring urban expansion." Primary project emphasis was placed on 1) training personnel in data collection and analysis, 2) conducting a forestry inventory, and 3) monitoring the growth of the San Jose metropolitan area. The project was conducted by Resource Development Associates (RDA) of Los Altos, California, under contract to USAID.

1.1 CONDUCT OF THE PROJECT EVALUATION

A two-man team of outside specialists was formed in early September 1979 to review and evaluate the Pilot Project and to make recommendations concerning possible AID support for the follow-on activities envisioned under the National Program. This team conducted its review in Costa Rica in late September 1979 and in the U.S. in mid-September and early October. This report was prepared in December 1979 and revised in February 1980.

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in Costa Rica and Ing. Fernando M. Rudin, Director of Costa Rica's Instituto Geografico Nacional. Ing. Rodriquez had served as AID Liaison Officer for the project and Ing. Rudin was the principal GOCR Liaison Officer.[7] The evaluation team is grateful for their unremitting support, advice and suggestions during the review process. Also we most gratefully acknowledge the time and interest of the many other AID and GOCR personnel for frank and thoughtful comments and discussion. The latter included officials from the following GOCR agencies:

- Instituto Geografico Nacional (IGN)
- Oficina de Planificacion Nacional y Politica Economica (OFIPLAN)
- Agricultural Planning Sector Office (OPSA)
- Direccion General Forestal, Ministerio de Agricultura y Ganaderia (MAG)

Team Directives

The evaluation team was directed to review the Pilot Project in terms of the way it was conducted and to identify additional opportunities for future AID-financed applications of remote sensing in Costa Rica, including Phase 3 - the National Program. The team was specifically directed to look at the following issues:

1) the relative utility of panchromatic, color, color infrared, and multispectral imagery;
2) the need for a digital analysis capability in Costa Rica;
3) the technical quality and utility of the various maps that were produce
4) cost information associated with various uses such as forestry, agricultural development, and urban planning;
5) methods used to identify the various GOCR data needs and possible new uses and user requirements;
6) the criteria (including costs) which were used to determine what data should be collected and analyzed;
7) the use and adequacy of the information generated by the Pilot Project for the GOCR agencies;
8) the arrangements (including budgets) used by the GOCR to continue to collect and update information needed by various user agencies.

The evaluation team was specifically directed to identify "the needs and special opportunities" for future AID-financed applications of remote sensing in Costa Rica. To do this we must state explicity the technical and institutional framework within which remote sensing can most effectively function.

Remote sensing is an information gathering technology that provides detail concerning the location, condition, and distribution of land resources. The technology is most useful in providing information about renewable resources at or near the surface of the earth (vegetation, soils, surface water), but the data can be used to assist in making subsurface interpretations as well.

For this project remote sensing technology was divided between aerial photography and satellite data. Applications of aerial photography and satellite data are generally complimentary rather than competitive-each does a somewhat different job. Aerial photography provides detailed coverage of relatively small areas at small scales, normally 1:5,000 to 1:50,000 for most purposes. Such scale allows identification of surface features of less than one meter in size. Aerial photography also provides vital topographic information through viewing of stereoscopic photo pairs-a type of information currently not available from satellite.

Satellites, on the other hand, provide repetitive coverage of very large areas at large scales, 1:1 million to 1:100,000. Such scales allow general observations of vegetation, soil, and surface water patterns at minimum resolutions of about 50 to 80 meters. Obviously, satellite images cannot provide the same type of detail that aerial photographs provide, but they have the advantage of being repetitively and cheaply obtained.

Remote sensing is simply one tool that aids in the collection and documentation of resource and environmental information. While it can provide some information by itself, the real utility of remote sensing is in combination with a variety of other resource inventory or environmental monitoring tools. Remote sensing data is especially valuable when combined with conventional field survey techniques. Field observations provide valuable site-specific information that cannot be identified reliably from aircraft or space, while the remote sensing images give spatial (areal) significance to the detailed site observations.

The evaluation sought to explore and document these issues within the constraints of time and available information. This report attempts to summarize these findings as concisely as possible. Limitations due to lack of time, insufficient familiarity of the Costa Rica environment, and with subtleties of the Spanish language meant that some of the issues necessarily were treated in a somewhat superficial manner -- especially those relating to the information requirements of GOCR agencies and other organizations.

Review Procedure

It is always difficult to develop a short-term evaluation of the results of a project to provide useful information to a number of agencies and organizations. Are the various types of output information of a nature and accuracy as to be generally useful - and will such information, in fact, be used? Are the proposed methodologies truly feasible in the Costa Rican environment? The answers to these questions are both technical and institutional in nature. Thus the project evaluation team chose to document its project review under two main headings: 1) project technical results and 2) GOCR institutional perspectives (See Section II).

The technical results were derived primarily from a careful study of available reports and documents, in particular the comprehensive final project report and several map products. The team evaluated the procedures in terms of their quality. Table 1 lists the reports that were available to the revi team.

Somewhat more difficult was the attempt to determine what the precise GOCR user information needs are and whether the types of products generated are likely to meet those needs. For this purpose a number of interviews were held in Costa Rica with various personnel from agencies identified as users or potential users of the products or project methodology, and with USAID and Inter-American Development Bank personnel. Although few of these people had as yet had a good opportunity to inspect the products, the interviews attempted to determine the possible roles of the GOCR agencies in helping to identify the project requirements and their contributions (if any) to the pilot project. Equally important was their interest in continuing involvement in the proposed National Program, and their needs for the various products that would result from such a program.

TABLE 1

LIST OF DOCUMENTS

Resource Development Associates "The Utility, Cost, and Effectiveness of Remote Sensing for Forest and Urban Sector Assessment in Costa Rica," Report for Contract AID/afr-C-1135, 9-10; March 1978, 146 p.

Resource Development Associates, "Design of a Natural Resources Inventory and Information System for Costa Rica: The Pilot Project Report," Report for Contract AID/la-C-1253; June 1979, 279 p.

U.S. Agency for International Development Project Paper: Costa Rica Remote Sensing Pilot Project: Project No. 515-0144, November 1977, 45 p.

U.S. Agency for International Development "Project Evaluation Summary (PES)-PA-Remote Sensing Pilot Project," December 1978, p. 7.

Blutstein, H.I. et al Area Handbook for Costa Rica, U.S. Government Printing Office 1970 p. 324.

OFIPLAN, "Plan Nacional de Desarrollo Forestal 1979-1982," Government of Costa Rica, June 1979, p. 201.

United Nations Development Programme; Country Programme for Costa Rica: UNDP assistance requested by the Government of Costa Rica for the period 1977-1981, 1975, 48 p.

Elizondo, C.L., et al., Guia Para Investigadores de Costa Rica, Instituto Geografico Nacional, 1977, p. 138.

Summary Conclusions

As documented in subsequent sections of this report, the evaluation team was impressed with the detail and comprehensiveness of the work performed for this Remote Sensing Pilot Project and especially with the extensive documentation available for review. In terms of our conclusions are as follows:

1. Technically, color-infrared, aerial photography may be the best imagery for supporting natural vegetation inventories in Costa Rica, but panchromatic or perhaps untested black and white infrared photography are generally more useful, since the film is more easily processed and reproduced.

2. Digital analysis of Landsat multispectral scanner data (MSS) did not prove successful either in accuracy or in the range of features that are needed for discrimination. The evaluation team can not recommend establishment of a digital analysis capability in Costa Rica on an operational basis.

3. In general the technical quality of the map products was good, although several maps are of doubtful utility due to the limitations of the data upon which the maps were based.

4. Current reproduction and distribution prices charged by IGN to users of remote sensing data in Costa Rica are below the acquisition cost and make the data highly cost-effective for various uses. We believe the value of remote sensing data in Costa Rica far exceeds the cost of collecting and analyzing such data although detailed cost benefit analyses for each user or for Costa Rica as a whole are not available.

5. There are many current and potential users for remote sensing data in Costa Rica. The Project did little to identify and work with Costa Rician users other than the trainees from five national organizations.

6. It appears that conventional wisdom and some previous RDA experience led to the decision on what data should be collected and analyzed. Costs for either data collection or analysis did not appear to limit the decision, but it was unfortunate that neither black and white IR photography nor good-quality Landsat imagery were obtained.

7. Much of the information that was collected and/or mapped under this pilot project appears useful for the GOCR agencies but few had had an opportunity to inspect the actual products. Several products were not considered useful.

8. The GOCR has taken steps to increase its programs to collect and update information needed by various user agencies. In particular, the Inter-American Development Bank has agreed to help support the use of remote sensing in Costa Rica and the GOCR itself is developing programs that require increasing the amount of available resource information.

Summary Recommendations

While the team endorses the rational, objectives, and basic conduct of the pilot project, it questions several of the technical conclusions and, therefore, the recommendations drawn from these conclusions. In other words, we believe the project provided a good basis for judging the utility of remote sensing data and techniques in Costa Rica, but we disagree with several of the RDA report recommendations.

1. RDA states "the Remote Sensing Pilot Project in Costa Rica has demonstrated operational procedures for a natural resources inventory and information system that meets the current requirements of the Government of Costa Rica and can be both implemented and maintained by Costa Rican professional personnel."

The evaluation team considers this statement to be only partially true. The utility of aerial photography has been demonstrated, but it is not clear what the GOCR's current requirements are, nor can one say exactly how useful satellite data will be to ongoing programs and projects.

RDA recommends "as a first step, a multidisciplinary, multiagency project team should be formed to complete a resources inventory of the country at mapping scales of 1:50,000 and 1:200,000, utilizing a combination

of CIR [color infrared] photography and Landsat digital data."

While we concur with the desirability of a country-wide resources inventory at the scales indicated, we believe that black-and-white photography (either panchromatic or IR) and good-quality Landsat images will provide a more practical data base. In particular, we believe that the results of this project clearly show that digital categorization of Landsat data is not currently feasible -- Costa Rica does not have a digital processing capability to handle Landsat tapes nor has the value of such data to operational programs been demonstrated.

3. "A single organization within the GOCR should be given clear administrative responsibility for this [country-wide resources inventory] project." We believe the IGN should have a clear mandate and adequate budget to prepare maps relating to the distribution of natural and cultural resources - but in addition, the other GOCR agencies should also have complete access to remote sensing imagery in order to carry out their inventory and monitoring responsibilities. For this purpose IGN should continue to reproduce and disseminate maps, aerial photos, and satellite images and provide to the wide variety of users, both public and private, information and facilities to make use of such data in Costa Rica.

4. RDA recommends "This [country-wide resources] inventory should be combined with existing resources data in map and tabular form into a manual geo-based information system." We concur with this recommendation but belive <u>much</u> more thinking needs to be done concerning the use of this information who should collect this information, what the system should include, and how it can be best used.

5. RDA recommends "A continuing training program should be established in Costa Rica to familiarize resources managers and data users with the techniques and applications of remote sensing. A research program should similarly be initiated...." The evaluation team believes there is indeed a need for continued training in remote sensing techniques and applications, but that the trained Costa Rican remote sensing professionals should be the ones primarily responsible for "familiarizing resource managers and data users with the techniques and applications of remote sensing". A modest research program conducted in cooperation with a U.S. counter-part organization also would be most desirable. The focus of such research should be clearly directed at local information needs.

The evaluation team sees remote sensing data as a source for many types of current information for a wide range of users. Therefore, we recommend that IGN work with and make remote sensing data available to GOCR agencies, donor assistance agencies, private and semi-private companies and individuals.

6. Processing of color films and making color prints is an exacting and costly process. We believe that careful study should be undertaken both to document the need for such color products in Costa Rica and to determine the cost of building a color facility. Currently, new aerial photography should be limited primarily to black and white until such time as color data can be processed and reproduced in-country.

7. A remote sensing center or office should be set up in IGN for the purpose of organizing the collection, reproduction, and dissemination of remote sensing data in a timely and user-responsive manner.

8. Satellite remote sensing is a rapidly developing field in terms of both the technology and its applications. The team recommends that close ties be developed and maintained with the "international remote sensing community." In time new French and Japanese satellite systems, as well as those of the U.S., will provide opportunities for obtaining useful imagery of Costa Rica. Many other countries, in Central and South America are actively developing remote sensing applications. Costa Rica should maintain cooperative contacts with the individuals and agencies of other countries that are using satellite data.

9. In many respects remote sensing is a U.S.-invented and subsidized technology, and for many years to come the U.S. will be the principle source of satellite imagery of Costa Rica. While the satellite systems and their reception stations represent "high technology," the adaptation and practical use of satellite products is intermediate and often low technology; that is the products can be effectively employed in regional or local situations with little capital investment or training. USAID should continue to support the <u>application</u> of this U.S. technology in Costa Rica. Specifically AID should provide a modest grant to ensure that both training and the national inventory process continue.

1.2 PROJECT HISTORY

In 1977 the Costa Rican Ministry of Agriculture indicated a concern over the rapid rate of national deforestation. At that time estimates suggested an average annual cut more than four times greater than that needed for domestic timber production. Since there is no on-going timber or forest inventory program in Costa Rica, the Department of Forests sought an approach for annually updating the location and area of forested lands. Traditional techniques for a complete national inventory were estimated at the time to cost $20 million and require 25 years to complete (RDA, 1979, p. 1).[1] The question of whether satellite or aerial remote sensing might represent more cost effective approaches to traditional techniques of inventory was discussed between AID and GOCR. It was decided that a preliminary investigation and cost effectiveness analysis should be made, and if the results warranted, a pilot project undertaken.

Phase I: Demonstration

By March 1977, Resources Development Associates (RDA) had completed the first of two preliminary investigations assessing resource inventory and environmental problems in Costa Rica. A randomly selected area of 200 sq km in the province of Puntarenas was chosen for a two-a-date map comparison of forested area (1968 and 1976). The result showed that about 5000 ha of land had been cleared in less than 10 years - a cutting rate equivalent to 2.5 times the assumed national average. Figure 1 (taken from another source) indicates the seriousness of the problem.

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[1] This estimate should be regarded with caution since we have no data on the unit costs involved or any understanding of the detail of the output product. An inventory of forest area and location would undoubtedly cost much less and take less time than one designed to provide volume estimates, stand conditions, etc. The assumption throughout the RDA pilot project has been that the $20-25 million year estimate would have provided a comparable product to that generated by a more sophisticated remote sensing inventory. While this may not be entirely true, we can safely agree that any inventory by traditional techniques would be costly and time consuming.

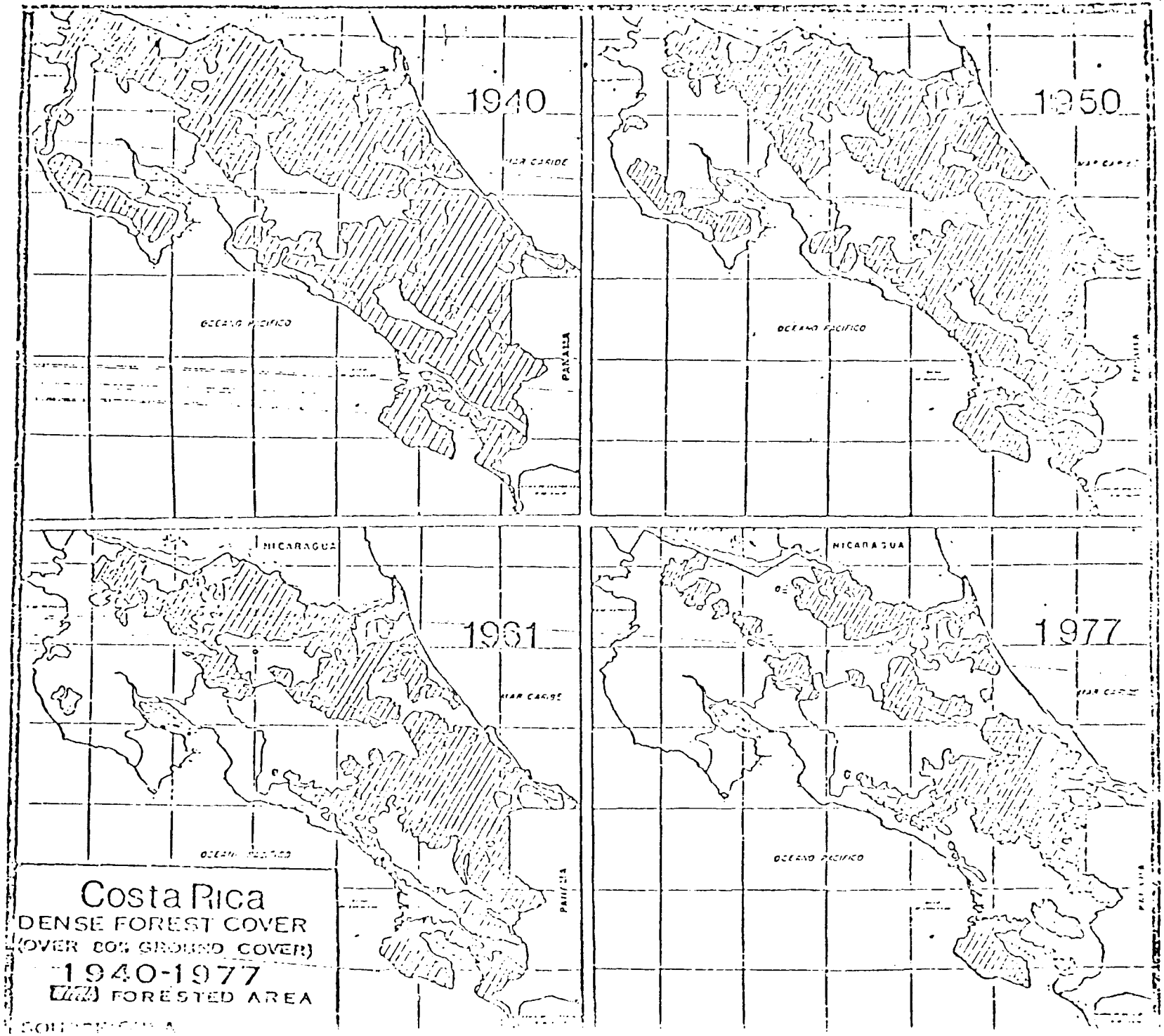

Figure 1

EXHIBIT NO. 1

A companion study was produced in June, 1977 assessing the potential application of remote sensing technology and metropolitan land use in San Jose. This showed rapid expansion of the urban fringe into surrounding agricultural lands and suggested that a more systematic approach to monitoring might substantially aid land-use planners and policy makers.

Based on the results of these two preliminary studies RDA undertook a cost effectiveness analysis of remote sensors and platforms[2]. Apparently it had apparently already been concluded that some type of remote sensing technology would provide the best approach, but there was some question about the utility of Landsat imagery compared to various forms of aerial photography[3]. Our findings, as elaborated in Section 2.1, confirm that this is probably true. The institutional base to support the routine collection of national inventory data appears to be negligible; and almost all natural resource data having a spatial dimension are currently derived by the Instituto Geographic Nacional (IGN) from black and white aerial photography at scales of 1:40,000 or 1:60,000.

In the cost effectiveness study, 1:20,000-scale, panchromatic, black-and-white photography was compared against color, color-infrared, and multispectral photography at the same or larger scales. Elements in the comparison included information content, ease of interpretation, cost of acquisition and processing, data collection time, and map production time when applied to the two questions of forestland survey and urban/rural land use conversions. Our summary conclusions for each application are reiterated below and further discussed in Section 2.1 of this report.

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[2] RDA 1978. "The Utility, Cost and Effectiveness of Remote Sensing for Forest and Urban Sector Assessment in Costa Rica," AID/Afr-C-1135, 9-10, 128 pp.

[3] The bases for this conclusion are not clear. There are no data presented in support of it and apparently no inquiries were made that would have led to its a priori adoption at this stage in the investigation. If we bear in mind, however, that there are few, if any, routine resource inventory programs underway, we can intuitively agree that there would be no basis for comparing the cost effectiveness of traditional versus remote sensing techniques.

a. Forestry Sector:

"....digitally analyzed Landsat data appears to be the most cost effective alternative for preparation of Level I forest cover maps at 1:200,000 scale. Color infrared aerial photography at an acquisition scale of 1:40,000 would appear to be the most cost effective tool for development of Level II and III forest use maps (RDA, 1978, p. 4)."

b. Urban Sector:

"....if the urban sector must absorb the total minimum-job costs for computer processing, then digitally analyzed Landsat data will not be cost effective for typical urban application in Costa Rica. On the basis of currently available cost information, manual interpretation of color film at a scale of 1:20,000 would be the recommended alternative for the production of 1:50,000 scale Level I/II urban maps as well as for the more detailed 1:25,000 scale Level III/IV maps (RDA, 1978, p. 6,7)."

Phase II: Pilot Project

Following the completion of the cost effectiveness analysis RDA was awarded a contract to design a natural resources inventory and information system for Costa Rica (see Attachment #1). The pilot project report was completed in June 1979[4] and forms the basis of the current end-of-project review. Three activities were undertaken: 1) to complete a land-use inventory in the project area; 2) to develop an operational capability for using remote sensing technology in resource surveys; and, 3) to provide resources information to support GOCR management policy decisions in the project area. An oral presentation was made in Costa Rica in March 1979 to review the findings of the project but little information is available regarding the outcome of that meeting.

In support of the first goal an east-to-west transect from Puntarenas to Limon was defined as the project area. This 5000 sq km area (about 10% of the total national territory) is contained on two 1:200,000 map sheets and can be entirely imaged on two Landsat scenes (Path 15 and 16, Row 53). Within this area, eight 1:50,000 scale sheets were selected for more detailed land-use evaluation using color infrared photography. A series of map overlays from other sources showing geology, soils, slope, drainage and watersheds were also produced. The Landsat evaluation was based on analysis of one computer

[4] RDA, June 1979. "Design of a Natural Resources Inventory and Information System for Costa Rica: The Pilot Project Report." AID/LA-C-1253, 279 pp.

tape of the March 3, 1975 scene of Path 16, Row 53 (Puntarnas) and visual interpretation of Path 15, Row 52 (Limon).

The development of an operational capability was supported by a sequence of training activities. Pilots and aerial photographers from IGN were given a two-week course on aerial survey techniques and the handling of color infrared film. Almost all of the photography used in the project was obtained from the "training" flights conducted during the course. Five user agency staff members were also given instruction. A one-week course was organized at National Space Technology Lab (NSTL) at Bay St. Louis in Mississippi, followed by a three-week, more intensive course at San Jose State University in California. Field and on-the-job training completed the sequence for the project participants.

The third goal-providing resources information to support policy decisions-is regarded by the project review team as a desired natural outcome of the first two. It is this goal that forms the crux of our discussion in Section 2.2 of this report. Our recommendations for future activities stem largely from our discussions with potential users of the various types of information generated in the pilot project.

II. PROJECT REVIEW

Evaluation of the Remote Sensing Pilot Project centered on two aspects: 1) the technical procedures and results of the project and 2) the institutional aspects. The former is primarily concerned with how the project was carried out; the latter, with the organizational environment that the project is supposed to affect. For obvious reasons — including access to information and correct standards of comparison — we have much more confidence in our evaluation of the technical aspects of the project than in the institutional aspects. Nevertheless, we felt it was important to document our limited observations concerning the possible adoption and utilization of the demonstrated techniques and their products by the various government and other agencies in Costa Rica.

2.1 TECHNICAL ASPECTS

This section is concerned with a review of nine aspects of the technical procedures and objectives of this project.

Project Rationale

Several assumptions, constraints, and realities form the rationale behind RDA's inquiries into the use of remote sensing for natural resource inventories in Costa Rica. In a technical sense the review team finds no difficulty in adopting an equivalent stance. Obviously, resource planning and development will require a systematic approach to data collection using modern survey techniques. It is also quite apparent that urgently needed data are not currently being collected by user agencies in GOCR. These conditions, when combined with the constraints imposed by a limited number of people, the inaccessible terrain, climatic factors, and rapid land-cover conversion, certainly argue in favor of using aerial and possibly satellite data. Evidence from many similar projects in other parts of the world provides overwhelming support for the utility of the technology and the basic approach being pursued in Costa Rica.

Our primary concern with respect to the project rationale is that it appears to lack a clear perception that remote sensing is just one of several tools (or technologies) that are employed in conducting modern resource inventories. Many developed and developing country personnel have mistakenly assumed that remote sensing can replace the arduous and time-consuming process of field data collectionand laboratory analyses. In most instances this is not the case, and any project directed at institutionalizing.

the use of appropriate remote sensing techniques must eventually address the problem of integrating such techniques with on-the-ground survey procedures. If such procedures do not exist, a plan for developing them must be proposed. This concern is more fully developed in Section 2.2, Institutional Aspects.

Participating Training

In adopting the position that remote sensing technology can reduce the time and expense of gathering natural resource data, we recognize that the existing cadre of trained interpreters must be increased. The training program and the resulting quality of expertise acquired by the participants in this project seems to have established a sound foundation for continued growth in this area. The five trainees from participating organizations received an intensive four-week training program that spanned the use of cameras, film, and filters, photo mensuration Landsat design and operation, and a variety of interpretation techniques. Of the five, four are continuing to work with the map products generated during field and workshop activities. Presumably they may also make use of the mapping techniques that were demonstrated.

We believe the trainees from both the AID-supported pilot project and a previous IDB-funded project form an adequate personnal base for an expanded national remote sensing program. Future trainees, perhaps, should not be subjected to such intensive period of instruction for hands-on workshop activities. Such activities would relieve the pressure of constantly having to absorb new material without the time or opportunity to put previous ideas into practice. In this regard it might have been preferable for each of the participants to address a specific individual problem rather than have them all concerned with the same mapping effort. It might also have been useful, specially in the interpertationof the color infrared photography, to provide instruction and workshop activities on the creation of photo interpretation keys.

Future training efforts in Costa Rica should include increasing the expertise of those already introduced to the technology. In addition, as GOCR capabilities and needs become better defined, formal remote sensing training at the University of Costa Rica should be encouraged and selected individuals should be sent to foreign institutions for more extensive training.

A growth in the ranks of the trained interpreters should be matched by a growth in the numbers of management-level personnel being introduced to the technology. Efforts in the past two or more years in Costa Rica appear to have had moderate to good success, but unless the momentum is maintained there is always the danger that operational acceptance of the technology will never be achieved.

Data Collection

The project seems to have been successful in the acquisition of color infrared photography. IGN obtained excellent CIR 9 x 9 transparencies for about 75% of the project area. The difficulties encountered with cameras and cloud cover during the process are characteristic of those to be expected in humid tropical environments, and lead us to recommend that such data be acquired as necessary primarily on a project basis. Nevertheless, for current inventory purposes, we concur with the RDA recommendation that at least one complete set of new, good-quality, aerial photography be obtained for the entire country in as short a time as possible.

From a practical standpoint, new aerial photography should be obtained as close to the standard 1:50,000 IGN map scale as possible. This will facilitate the transfer of terrain information to the standard map and make comparisons between the two easier.

Color infrared photography (CIR) was selected as the best choice, over standard color and panchromatic images, primarily for reasons of its greater atmospheric transparency and interpretability. However, we consider the lack of black-and-white infrared photography (which has even better haze penetration capabilities than color IR) to be a serious omission in the project. For many data handling and reproduction purposes, color IR photography may be less desirable than black-and-white photos, as long as the information content on the black and white is adequate. (We note that RDA considered the panchromatic photography to be adequate for most purposes except in its haze penetration capabilities; adequate in its information content (especially for forestry); and much cheaper and easier to collect, reproduce, and use in the Costa Rican environment.*)

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*We regard as impractical the suggestion that portable light-tables can be installed in cars, for viewing CIR transparencies in the field.

As far as Landsat is concerned, data were obtained either in computer compatible tape (CCT) format or as standard-product color prints. Unfortunately the images, obtained in 1975 and 1976, were not good, primarily because of extensive cloud cover and haze.* (Much better Landsat data has since been obtained for most of Costa Rica.) For a manual image interpretation, exclusive use was made of standard EROS Data Center prints. In addition to being at a 1:250,000 scale, instead of the 1:200,000 scale required for standard IGN map purposes, the prints were substandard due to the use of an interim photographic process that now is no longer in use as EROS. For this pilot project, we believe that high-quality Landsat images produced directly from the CCTs should have been introduced. The poor quality EROS images probably resulted in an erroneous conclusion concerning the utility of standard image-interpretation techniques as applied to Landsat images. In many ways manual image interpretation (using good quality data) represents an inexpensive and more broadly applicable approach to Landsat data analysis than digital computer processing. For comparison purposes, Figure 2 compares a portion of standard EROS image that was used for this project with a high-quality version of the same image at the same scale that was produced later. Note that relatively high-quality images are now being produced as standard products by the EROS Data Center for the same price as the previous products -- $50 for a 29.2-inch color print.

Landsat Data Classification

The CCT for 3 March 1975 (Path 16, Row 53) was subjected to both supervised and unsupervised classification algorithms. The trainees selected some 20 classes of cover type. Following this the Electromagnetic Systems Laboratory created an 86-cluster, unsupervised classification based on 15% of the data. These were then condensed to 42 classes and, by a process of stratification and maximum likelihood classification, further reduced to 14 printed classes. Where the rationale becomes difficult to follow is in the relationship between:

1) the 20 classes identified by the trainees (page 56) and the 14 classes
2) finally printed (page 76);
3) the 14 printed classes and the 7 actually used in calculating identification accuracies (page 115); and
   the 14 classes from Landsat and the 59 categories apparently recognized on the CIR photography (page 51).

*Figure 5-16 of the RDA report, which compares forest area in 1944 and 1975 (using Landsat) is highly misleading, since clouds obscure substantial portions of the 1975 scene.

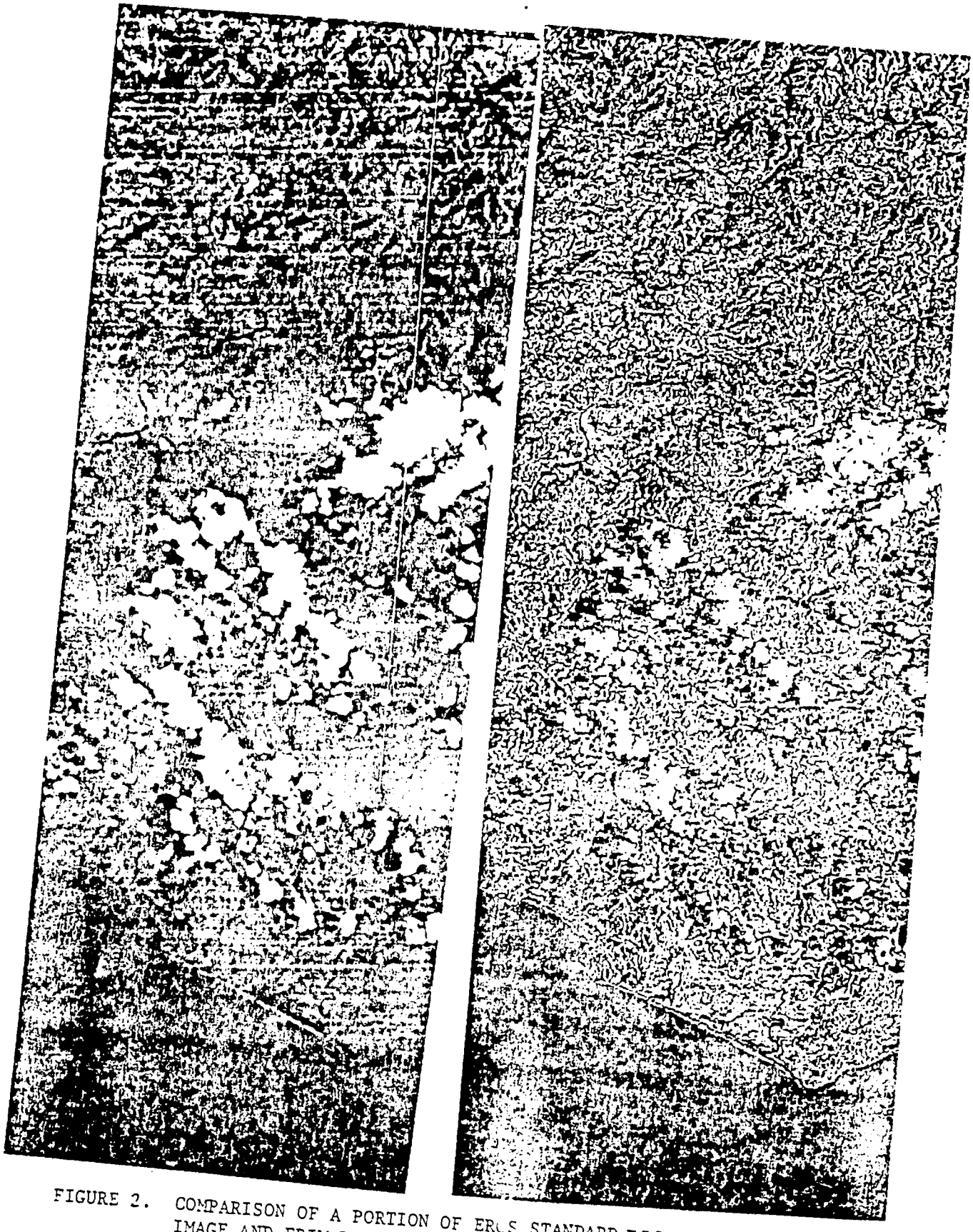

FIGURE 2. COMPARISON OF A PORTION OF ERTS STANDARD FCC LANDSAT IMAGE AND ERIM DIGITALLY ENHANCED LANDSAT IMAGE

It appears to us that the categories statistically separable in this one satellite scene contain a mixture of Level I, II, and III categories as defined in the classification for use with CIR photography. Of the 14 Landsat categories (Table 2), 8 have Level II designations but six of them are not identifiable in the full classification scheme. In addition there are two Level III classes and one Level IV class.

In summary this use of digital computers (HP 3000 and IBM 370) to classify Landsat data was not successful. Contrary to the RDA recommendations, the evaluation team believes that the results presented in the Pilot Project report provide sufficient evidence to recommend not using digital classification procedures in any operational program. A list of the terrain cover classes (RDA p. 65, Table 4-4) that could not be distinguished consistently contains all of the Level I categories and many of the categories at Levels 2 and 3. The detailed statistical test to determine classification accuracies indicated poor results for most major categories when compared with aerial photography; for example, only 57% of forest was correctly classified, brush was 26%, grass was 70%, and mangrove was 82% on the Tarcoles sheet. Accuracies were even lower for the Barranca sheet. While one can hypothesize about the reasons for these poor results, the fact is that the digital classification technology, considered to be among the best available, was not adequate for the purpose of consistent and reliable resource mapping in Costa Rica.

Overlays

The successive map overlay approach to ecological analysis is widely used in the planning professions. The overlay sets produced in the pilot project for eight 1:50,000-scale sheets are probable valuable for several agencies in GOCR, but that value will only be determined as resource questions are asked. Among the most useful and immediately valuable overlays in the series are the land-use maps produced from 1:40,000 scale color-infrared photos. These eight maps provide detailed information that has apparently never been available before, and agencies involved in their production can and probably will make use of them.

We regard the production of a "biophysical" map using various elements in the overlay series as an effective but not very useful demonstration of the versatility of geo-based information systems. Our use of the word "useful" is intended only to suggest that a higher degree of acceptance might have been reached if specific GOCR requirements had been sought out and one or

TABLE 2

Forest

Mangrove

Coffee

Grass 1 - Lush-growing, Green Grass

Grass 2 - Dominantly Dry Grass

Grass 3 - Dry Grass with Brush Component

Brush

Cane

Cut Cane

Bare Soil/Wet Soil

Urban 1 - Central City

Urban 2 - Commercial/Residential, Medium Density

Urban 3 - Commercial/Residential, Low Density

Other - Water, Clouds, Shadow

two specific cases addressed. As a matter of fact Sr. Fonseco, Director of CATIE in Terrialba has indicated a need for biphysical data in determining potential and optimal cropping patterns in Central America. His need for soil overlays, however, cannot be met with soil association maps; he needs more refined information about soil chemical and physical properties.

In general terms it seems to us that the adoption of a manual geo-based system (that is, one based on sets of overlays rather than computer-based digital data) has excellent potential for Costa Rica. However, we regard it as a separate question from that of determining land use from remote sensing data, and think it deserves a more comprehensive study to determine data inputs and expected outputs. The history of manual systems indicates a compelling urge on the part of their creators to continue input uniformity even when some of that input is found to be only marginally useful. Any decisions regarding source material, levels of data accuracy and reliability, and types of data should be based on a more careful examination than occurred in this project. In the meantime, we feel that land-use mapping from aerial photography should continue as one important input to any geographic information system developed for Costa Rica.

Map Production

The methods described in the report for map scribing and peel coat are straightforward and cost effective. It is the evaluation team's understanding that these techniques were already being employed by the IGN in Costa Rica prior to the Pilot Project. While we fully endorse their use, it is not clear why so much attention was apparently directed to these in what was a remote-sensing-oriented project. In particular, we do not feel that the Landsat results warranted the major investment in the production of high-quality maps based on digital processing.

Currently there are techniques that allow the geometric correction of Landsat images to almost any scale and map projection. The evaluation team suggests that cartographically acceptable image-map products (using Costa Rica's Lambert projection at IGN map scales of 1:200,000 and 1:50,000) would have been more appropriate and useful.

Classification Analysis

The statistical techniques employed in the project for assessing Landsat classification accuracy are widely recognized. The element that is most lacking, however, is actual ground truth or sample area enumerations. Throughout the analysis, classification accuracy is based on the comparison of Landsat digital categories with CIR photographic categories (used as ground truth). Since they were not the same categories identified earlier in the report, it is somewhat difficult to interpret the meaning of the values given. Only five of the 14 Landsat classes are compared, and one of these, bare soil, was previously shown to be easily confused with several other classes. Moreover, only data from the Tarcoles and Barranca sheets were analyzed and both of these were interpreted by RDA rather than GOCR personnel. We have no input regarding interpretation accuracies obtained by the Costa Rican participants.

The absence of ground truth is of more than passing concern. In its earlier cost effectiveness study, RDA reported that only 82% accuracy could be achieved for ten categories derived from CIR photography at 1:20,000 scale (RDA, 1978. p. 28). Using a scale of 1:40,000 one could expect even less accuracy, but we don't know in which categories. How can we, therefore, compare Landsat with photo-derived data and draw valid conclusions regarding the accuracy of the former?

Aside from the interpretation accuracy, we are given data comparing sensor measurements from Landsat and aerial photography. Here again, the results are difficult to assess. Of the twelve categories, a comparison could only be given for four (forest, brush, grass, and mangrove). It appears that "brush" is over-estimated on Landsat and forest is under-estimated, using CIR photography as the ground-truth base. Why bother to generate a 14-class digital map from Landsat if only five classes can be verified and only two can be fairly accurately measured?

Our criticism is not directed at RDA or its methodology, but is intended to endorse our conclusion that manual image analysis is best applied in Costa Rica at 1:200,000 scale, for Level I categories primarily. Clearly, additional work is required before the utility of Landsat data can be determined at 1:50,000.

Cost Analysis

In calculating cost effectiveness the Pilot Project considered the costs of data collection, processing, analysis, field checking, and map production for Level I forest-cover maps at 1:200,000; and Level II/III land-cover maps at 1:50,000. For mapping at 1:200,000 scale the following summary values are given (from RDA, 1978, p. 108).

	Landsat	Pan B&W	Color	CIR
		1:40,000	1:20,000	1:40,000
Total Cost (R)	8K	9.3K	32K	14.2K
Total Time (months)	1/2 mo.	6 mos.	19 mos.	6 mos.
Cost/Hour	$92.50	$9.00	$9.60	$13.65

These are reasonable numbers and on the surface it would seem cost-effective to proceed with a Level I Landsat digital mapping project for the entire country at 1:200,000. We do not recommend this, however, for the following reasons:

1. There is nothing to show that a digital analysis of enhanced Landsat images provides more accurate forest-area information than a visual analysis;
2. The difference between Landsat accuracy and that required by the user agencies has not been determined. Since no inventory of forest area currently exists, one can argue that any level of reliability above ambience is acceptable; if that is so, a visual analysis would be much less expensive and just as fast as a digital analysis;
3. It has not been determined that the 14 classes proposed in the digital analysis have any inherent value to GOCR users. A more exhaustive survey of user information needs is clearly warranted before a classification scheme for the 1:200,000-scale land-use maps is produced. This would best be done by IGN personnel.
4. It has not been demonstrated that GOCR's need for data has sufficient priority to warrant a $92/hr investment and two-week delivery. In view of the demonstrated value added by utilizing panchromatic and CIR photography, it seems more cost-effective to adopt one of those strategies at $9 or $14/hr.

The strongest argument we can make for Landsat data in a country the size of Costa Rica is that the data can be used relatively quickly once a suitable image has been obtained (cloud cover permitting). We strongly urge that the GOCR continue to request collections of Landsat data from NASA. There are already enough users and ongoing projects in the country to warrant new and better satellite coverage.

At 1:50,000 scale it has been shown that color and color-infrared photography is better than panchromatic black and white photography in terms of interpretability. We encourage the future collection of CIR data at 1:40,000 as a base for detailed resource analyses on a project basis, but not on a periodic national basis without in-country color processing facilities. The comparison of costs for Level II/III land cover mapping between CIR and Pan B&W are given below (RDA, 1979, p.176). While there is little difference in their costs per hour, we are skeptical about the time required to interpret the black and white photos as compared to the color infrared.

	Per Map Sheet	
	CIR (1:40,000)	B&W (1:30,000)
Total Cost (R)	$1,987	$3,782
Total Time (hours)	420	800
Cost/Hour	$4.70	$4.70

Many resource surveys are conducted using photographic prints in the field -- soil surveys, geologic surveys, forestry surveys, etc. Each of these has particular scale and format requirements. Often observations and mapping are recorded directly on the prints, which are used for later map drafting in the office. Therefore, photos should be cheap, accessible, and expendable. We believe that for many (but not all) purposes, black and white prints fit this description better than imported color transparencies or prints.

2.2 Institutional Perspectives

During its brief visit to San Jose, the evaluation team met with several user organizations of remote sensing derived information. There were many others that we did not have the opportunity to visit, but we were impressed by what we believe to be an urgent and broadly-based need for land resources information-a need not currently met by existing data or information systems. At many levels of society decisions concerning the exploitation and development of resources are being made -- and frequently made without access to information concerning the current environmental situation. In particular, alienation of land for grazing, timber cutting, crops and urban expansion seems to be occurring in an unplanned and haphazard fashion. Those individuals and organizations that are concerned with resource management and development and environmental protection are potential users of either the remote sensing data directly or of the information derived from remote sensing. Those organizations can be categorized as 1) private sector, 2) national government, and 3) international (donor) agencies.

Private Sector

Historically Costa Rica has developed under a decentralized system of decision-making and private investment that continues to this day. Out of a total investment of 3,446 million colons in construction, plant and equipment in 1978 more than 65% came from private rather than public sources. Much investment goes to agriculture and grazing which provides most of Costa Rica's foreign exchange. Thus the private sector is likely to be one of the major end-users of remote sensing products and information. For better or for worse, private individuals and companies will make use of aerial photographs for determining the best areas for forestry, agriculture or urban development. They will monitor their activities and investments with available imagery. Energy companies may make use of Landsat data for locating promising sites for mineral exploration or water resources. To the extent that such information allows development to progress in an enlightened manner, remote sensing products will be useful in promoting further economic development. Those that harvest resources illegally or destructively may fear that collection of current images will result in their discovery and reduce the scope of their activities.

National Government

National governments are the prime mobilizers of resources for national development and environmental monitoring. The GOCR has recently recognized the need for greater coordination of planning relating to land resource development and environmental protection. This recognition is implicit in the inititation of a national planning process -- with the establishment of a planning organization (OFIPLAN), and preparation of a national development plan as the first step. The national plan seeks to integrate into a coordinated framework the various projects relating to forest development, national parks and reserves, agricultural development, land use planning, transportation, hydroelectric energy, and economic and social concerns. For such a planning process to work, the GOCR needs to establish an accurate resource data base from which sound decisions can be made. In addition, it must convince the National Congress of the need for mechanisms to enforce resource regulation and monitoring. Remote sensing is clearly one of several tools that are properly directed at the need for current and accurate resources information.

A number of Costa Rican government institutions are either intermediate or end users of remote sensing data. As identified in Table 3, some 18 national agencies and educational institutions are potential users of remote sensing products. However, it should be noted that the products required by one agency may differ from those required by another. Therefore, it is important that the various agencies have access to either the remote sensing data per se and/or to map products derived from these data. Some will seek to use the images directly others will depend on IGN-developed maps.

In no area is land resource information more critical than in forestry. The evaluation team's visit to the Forestry Department indicated a pressing need for up-to-date information but almost no ability to obtain this information. The stated GOCR requirement for basic forest information provide one of the principle reasons for the Pilot Project. Sixty-six forest inspectors have the requirement to evaluate and approve permits for cutting timber and converting forest land to agricultural land. In Costa Rica some 200,000 people earn their living from forestry in all parts of the country -- far more than can possibly be monitored with the meager

TABLE 3.

Selected Remote Sensing User Organizations in Costa Rica

- Ministerio de Agricultura y Ganadería (MAG)
- Ministerio de Obras Públicas y Transportes (MOPT)
- Instituto de Tierras y Colonización (ITCO)
- Instituto de Fomento y Asesoría Municipal (IFAM)
- Instituto Nacional de Vivienda y Urbanismo (INVU)
- Instituto Costarricense de Electricidad (ICE)
- Instituto Nacional de Seguros (INS)
- Instituto Costarricense de Turismo (ICT)
- Instituto Costarricense de Acueductos y Alcantarillados (ICAA)
- Junta de Administración y Desarrollo de la Vertiente Atlántica (JAPDEVA)
- Oficina de Planificación Nacional y Política Económica (OFIPLAN)
- Servicio Nacional de Electricidad (SNE)
- Dirección de Geología, Minas y Petroleo (DGMP)
- Municipalidades
- Universidad de Costa Rica (UCR)
- Universidad Nacional (UNA)
- Instituto Tecnológico de Costa Rica (ITCR)
- Corporación Costarricense de Desarrollo (CODESA)
- Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)
- Centro Científico Tropical (CCT)
- Agencia para el Desarrollo Internacional (AID)
- Banco Interamericano de Desarrollo (BID)
- Compañía Bananera Atlántica, S.A. (COBAL)

foestry personnel and facilities. Ing. F. Ocampo C., sub-director of forestry, stated that remote sensing data could be used to demonstrate the extent and seriousness of the deforestation problem to the National Congress as a first step in obtaining the financial resources that are necessary to develop a system to monitor and regulate further forest exploitation. All but the most remote forest areas are under serious pressure and of his staff of 397, only four are currently trained to make use of remote sensing products. The evaluation team believes that both recent aerial photography and recent Landsat images can be of substantial help to the Forestry Department.

Another beneficiary of recent remote sensing data would be the Agricultural Sector Planning Office (OPSA) in their efforts to develop an area frame sampling strategy for annual crop inventories. Being developed in cooperation with the U.S. Department of Agriculture, the area frame requires aerial photography for stratifying the land surface. In Guanacasta, the first province to have a partial frame established, existing aerial photography is out of date and frequently of marginal quality. New photography would materially help this AID-supported activity.

Many other public agencies could also employ new remote sensing data or their derived products. The Ministry of Agriculture and Grazing could monitor rangeland conditions and be advised of the acceptance of certain conservation practices. The Ministry of Public Works and Transport could plan new routes; the Institute of Electricity (ICE) could monitor watershed conditions for their hydro-electric dams among others.

International Assistance Agencies

A number of foreign-funded agencies and organizations operating in Costa Rica seek to improve the economic well-being of the local population. Sometimes working relatively independently but often working in close cooperation with the GOCR, these agencies also have a basic need for resource and environmental information in planning and implementing there development projects. Two of many examples are the U.S. Agency for International Development (AID) and the Inter-American Development Bank (IDB).

As an example of requirements for resource and environmental information we cite AID's twenty-one million dollar Natural Resources Conservation Program. This program is directed at strengthening the technical and institutional mechanisms through which the GOCR manages the country's renewable natural resources. Over a five-year period a number of pilot watershed, reforestation, timber harvesting, range improvement and conservation education projects will be launched. At the outset the program recognizes that "information on resources and their uses in geographic areas requiring priority attention is not adequate" and identifies the IGN as providing crucial new resources information in concert with the Ministry of Agriculture and Livestock (MAG). Some $63,500 in loan funds have been identified for purchase of satellite imagery and aerial photography for "the plan areas". It is not clear whether this amount is intended for collection of data only or where it includes data interpretation and reproduction. In any event, this amount seems like a very conservative figure for the number and size of geographical areas that need to be recorded and monitored. Also, the conservation education projects should include instruction on the use of remote sensing images and cartographic products.

III. CONCLUSIONS AND RECOMMENDATIONS

The following discussion is based on Section II of this report.

3.1 Conclusions

The evaluation team was impressed with the quality and comprehensiveness of the work performed for the Remote Sensing Pilot Project and especially with the exhaustive documentation available for review. While the team basically agreed with the rational and conduct of the project, it disagreed with several of the technical conclusions that were drawn and, more particularly, with several of the recommendations. In disagreeing the team drew primarily on the project's own data but in several cases noted the omission of important data. These omissions included the use of black and white IR photography and high-quality enhanced Landsat images.

We believe that the project did not succeed in establishing precise user agency requirements for information, and that therefore the proposed follow-on program would be of somewhat uncertain utility. However, we also feel strongly that sufficient interest in and justification for a resource inventory and monitoring system exists in Costa Rica, and that AID should proceed with implementation of Phase 3 - the National Program in concert with the Inter-American Development Bank and the GOCR. To that end we have evaluated the need for implementing such a system and recommended a number of elements for the program. Remote sensing represents the most cost effective and, in most cases, the only rational means of obtaining large-area forest, agricultural, and urban resource information. Such a program should include the use of both satellite and aircraft imagery in a multistage approach, but should be largely independent of non-Costa Rican processing and analysis facilities. Training, data, and equipment support should represent the backbone of any U.S. assistance to Costa Rica for a national resources inventory program.

3.2 Recommendations

The evaluation team recommends that:

(1) the IGN bedesignated as the lead agency for carrying out a high-priority national resources inventory at map scales of 1:200,000 and 1:50,000;

(2) soils, forestry, agricultural crops, range condition, watershed characteristics, and urban planning be included in this inventory;

(3) high-quality digitally-enhanced Landsat imagery be used as a basis for the 1:200,000-scale inventory and 1:50,000 black and white photography be used for the 1:50,000-scale inventory;

(4) the 1:200,000 scale inventories be updated every two years with new Landsat data and the 1:50,000 scale inventories be update every five years with black and white photography;

(5) color or color infrared (CIR) photography be collected for specific projects and reproduced at a scale and in a format appropriate to the information needs of the project;

(6) the IGN seek to expand the base of users for both the project map and the photographic products by conducting training sessions;

(7) an experimental digital data-processing capability be developed in Costa Rica in cooperation with a U.S. institution, using existing computer hardware and personnel;

(8) AID continue to supply technical assistance in the area of remote sensing and geographic information systems (GIS) through one or more qualified U.S. contractors.

3.3 Suggestions for Follow-on Activities

Technical activities that would help support an eventual Phase 3 — operational program are the following:

Training. Both short term and long term training in remote sensing and resource inventory techniques are necessary. In particular, we believe that at least one person should pursue a 2-year graduate program in the U.S. directed at modern resource mensuration techniques emphasizing aircraft and satellite remote sensing. U.S universities that offer this type of Masters degree program include Pennsylvania State University, Cornell University, Purdue University, South Dakota State University, The University of Michigan, and the University of California.

Short-term training can and should be conducted in Costa Rica. USAID should contract with any of the above or other qualified institutions to prepare and conduct a one-to-two week seminar/workshop for Costa Rican resource surveyors and managers in cooperation with IGN. Such a seminar/workshop could acquaint a much larger number of Costa Ricans who are in a position to make use of available remote sensing products than if it were held in the U.S.

Data. It is essential that good quality aerial photography at a scale of approximately 1:50,000 be obtained as soon as possible. We believe this

will serve as a basis for much of the resource survey and monitoring requirements that are currently evident. Panchromatic photography should be suitable for this purpose.

Color infrared (CIR) photography should be obtained for project areas concerned specifically with renewable (vegetation and water) resources. The scale and season of the imagery should be consistent with the specific information requirements of the project.

High-quality Landsat images, geometrically corrected and scaled to the standard 1:200,000 IGN map sheets, should be obtained for the entire country (9 sheets).

Equipment. Equipment for analyzing and interpreting remote sensing data need not be sophisticated, but it must be available to those making use of remote sensing products. Specifically, hand and laboratory stereoscopes, zoom transfer scopes, light tables, planimeters, and annotation materials should be available to the (hopefully) many people who will make use of the photos and images. These can initially be made available through the facilities of IGN, but a number of agencies will eventually need some basic in-house equipment.

Facilities. IGN should provide facilities for using and distributing the remote sensing data products. This facility should include a public browse-file of data available, reference material, information on the various data products, and equipment to aid in the manual interpretation of such data. The facility should have staff that are responsive to user organization needs and requests. Other countries have established national remote sensing centers, with two or three staff members, to serve this purpose and we recommend Costa Rica do the same.

Research. A number of technical issues remain to be addressed in defining an operational survey program based on remote sensing. We believe further applications research should be conducted in the use of different aerial photographic film filter combinations. In particular, we would like to see black and white IR tested with color infrared film for economy and interpretability.

Also a number of multitemporal studies using current Landsat data are feasible and should be undertaken. These studies would be directed at quantifying land cover (especially forest) changes recorded between 1975 and 1979. Both digital and photographic techniques can be employed.

If Costa Rica has a suitable digital computer system available, a research-oriented digital data processing capability should be developed. Such a low-cost capability will allow quantitative analysis and testing of Landsat data at its full 80 meter resolution. Several organizations in the U.S. offer Landsat data processing software packages for free or at nominal prices — including software provided under AID support for other countries.

For this research it is advisable that cooperative institution-to-institution ties be developed with a U.S. counterpart. A number of educational or non-profit organizations in the U.S. are qualified and willing to provide this type of arrangement under AID sponsorship.

ANNEX I

Life of Project
From FY 78 to FY 79
Total U.S. Funding [illegible]
Date Prepared: 11/23/77

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Project Title & Number: REMOTE SENSING PILOT PROJECT 515-[illegible]

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: The goal of the Remote Sensing Pilot Project is to protect the natural resource base so that its long-term contribution to economic development can be maximized.	Measures of Goal Achievement: Rate of deforestation and environmental damage slowed.	1. Remote Sensing Monitoring 2. Ground Surveys	Assumptions for achieving goal targets: That Costa Rica maintain its interest in resources conservation.
Project Purpose: The purpose of the Pilot Project is to show that the application of Remote Sensing aerial photography technology to natural resource information gathering and analysis can yield useful results in Costa Rica.	Conditions that will indicate purpose has been achieved: End of project status: 1. System for continual identification of data needs is providing information to public and private entities. 2. Land uses and resource maps are being used by Government and private entities in land management planning.	1. Contractor reports, day to day project monitoring, user reports. 2. Project monitoring, user reports.	Assumptions for achieving purpose: 1. That data obtained will be perceived as useful in resource planning by the Government.
1. Training a. Costa Rican technicians trained in Remote Sensing technology. b. IGN personnel trained in aerial photographic data collection. 2. Data Collection a. Data collected and interpreted using optical and computer-aided imagery analysis techniques. b. Maps prepared. c. Information evaluated and converted to useable formats at district level. d. Final results evaluated with cost breakdown. 3. Data Utilization Data analyzed by users (OTSA, Natural Resource Institute, DGU, U. of Costa Rica Geography Dept., Instituto Tecnológico de Costa Rica, Inter-regional Institute for Agricultural Sciences) and adapted for specific needs.	Magnitude of Outputs: 1.a. 5 Costa Rican technicians received 4-week EROS training course and 8-week on-the-job training at contractor's U.S. facility. b. IGN personnel received 2-week training program in aerial photographic techniques, aircraft operations, and color infrared photography. 2.a. Data available on 10,000 km^2 project area and interpreted. b. Detailed maps of 10,000 km^2 project area. c. Forest and land use formats at district level. d. Completed in-depth evaluation. 3. At least three entities have, by the end of the project, adapted information to specific needs and used it in resource planning.	1.a. Project Monitoring b. Project Monitoring 2.a. Data available to users in useable form. b. Appropriate maps available to users. c. Formats available to users. d. Evaluation available. 3. User reports and Project Monitoring.	Assumptions for achieving outputs: 1. That qualified applicants are available for training and are nominated in time. 2. That weather conditions will allow for timely data collection. 3. That entities will recognize usefulness of remote sensing information in their specific interest areas.
Inputs: 1. Technical Assistance 2. Training 3. Evaluation	Implementation Target (Type and Quantity): 1. $200,000 for assistance in Remote Sensing Technology. 2. $35,000 for technician. 3. $5,000 for in-depth evaluation, in preparation for National Program.	Project Monitoring and Evaluation Reports.	Assumptions for providing inputs: That counterpart funds are made available for items budgeted.

Attachment #2

September 25, 1979

Ing. Fernando M. Rudín
Director
Instituto Geográfico Nacional
San José

Dear Sir:

To better evaluate the results of the Remote Sensing Pilot Project, for which you acted as principal Government of Costa Rica Liaison Officer, and to prepare recommendations for continuing remote sensing work, the AID Evaluation team respectfully requests brief answers to the following questions concerning the Project:

(1) What products, supplies and materials were supplied to you for this project, either through the AID Mission or from Resource Development Associates directly? These materials may include film, data analysis equipment, photographs, satellite images, maps and map materials.

(2) What government and private organizations are users or are likely to be users of the products generated by this project?

(3) What mechanisms are being used or are planned to help make potential users aware of the availability and nature of the map or photo products? How soon will these mechanisms be implemented?

(4) What types of uses might you anticipate will be made of the products? Which products (maps and photographs) are likely to be the most generally useful?

(5) Approximately what was the value of IGN contribution to the implementation of this project-including the value of all salaries and facilities use? What was the value of the contribution from other agencies such as MAG, INVU, OFIPLAN, and UCR?

(6) How helpful was the project training program for your aircraft facility staff and your image analysis staff? Was there need for more or less training or training of a different types?

(7) Much of the project was concerned with developing a methodology for geographic information data base based on a series of transparent overlays. Is this approach appropriate for Costa Rica? Will you be implementing such a system in the Phase 3 - National Project?

(8) As a result of this project, what plans or activities do you think the GOCR will undertake-including the National Program?

(9) What is IGN's annual budget and how many personnel are on your staff?

(10) How many maps (1:200,000 and 1:50,000) does IGN provide to users each year? What is the cost of reproducing 6 & w aerial photography?

As you know, your prompt answers to these questions will help us evaluate the success of the Pilot Project and recommend additional activities in the future. Please feel free to answer either in English or Spanish.

Sincerely,

Tom Wagner
Stan Morain
(AID Evaluation Team)

TW:mps

cc: Ing. Heriberto Rodríguez - AID

Mr. Tom Wagner and Stan Morain
AID Evaluation Team

Dear Sirs:

In answer to your letter of the 25th of September about the activities developed by this institution for the AID Pilot Project in Remote Sensing and about the plans for utilization of obtained data, permit me to inform you that:

1. The products supplied were the following:

   a. two computer compatible tapes (CCT)
   b. 252 color infrared aerial photographs
   c. theme maps (drainage, soil, slope, geology, waterways, land use) (these are topographic maps of a scale of 1:50,000) of Rio Grande, Naranjo, Barva, Tarcoles, Golfo, Matina, Barranca and Abra, and topographic maps of a scale of 1:200,000 of San Jose and the city of Limon (material on negatives and slides).

2. Governmental institutions and private organizations that use products of remote sensing and could utilize product generated by this project:

   - The Ministry of Agriculture and Cattle (MAC)
   - The Ministry of Public Works and Transport (MOPT)
   - The Institute of Lands and Colinization (ITCO)
   - The Institute of Development and Municipal Assessment (IFAM)
   - National Institute of Housing and Urbanism (INVU)
   - The Costa Rican Institute of Electricity (ICE)
   - The National Insurance Institute (INS)
   - The Costa Rican Institute of Waterways and Sewage (ICAA)
   - The Costa Rican Institute of Tourism
   - The Administrative and Development Council for the Atlantic Watershed (TAPDEVA)
   - Office of National Planification and Political Economy (OFIPLAN)
   - The National Service for Electricity (SNE)
   - The Office of Geology, Mines and Petroleum (DGMP)
   - Municipalities
   - The University of Costa Rica (UCR)
   - The National University (UNA)
   - The Technological Institute of Costa Rica (ITCR)
   - The Costa Rican Corporation for Development (CODESA)
   - The Tropical Agricultural Research and Training Center (CATLE)
   - The Tropical Science Center (CCT)
   - The Agency for International Development (AID)
   - The Interamerican Development Bank (BID)
   - The Atlantic Banama Company Inc. (COBAL)

3. All photographic and cartographic products are available for those interested in the Geographic Section of this Institute. All of the material is filed and will serve as a resource for all types of investigations.

4. The principal type of use of this information is for integrative analysis of resources in any physiographic or socioeconomic region in the study area. The maps will serve as a basis for carrying out reconnaissance in these areas and the interpretation in detail of the aerial photographs will facilitate study of the resources in these same areas.

5. A) Contribution of the National Geographic Institute (IGN):

- Taking of infrared, color, and black and white aerial photographs
- Field work and transportation
- Laboratory work: photinterpretation and cartography
- Materials: theme and topographic maps, materials for drawing and photointerpretation
- Basic photogrammetry equipment
- Technical specialists
- Elaboration of slope maps, 1:50,000

B) Contribution of other institutions (MAG, INVU, OFIPLAN, UCR and ITCR)

- Field work
- Laboratory work: photointerpretation
- Specialized technicians (from each agency)

C) Approximate costs (US $)

	IGN	MAG	INVU	OFIPLAN	UCR	ITCR
Salaries	9,500	2,400	2,100	2,100	2,500	2,500
Per diem	850	400	200	200	300	100
Vehicles	3,500	2,300	1,400	1,500	1,500	1,300
Aerial Photos	55,000	----	-----	-----	-----	-----
Materials	4,500	50	50	50	50	50
Equipment & other facilities	5,000	300	300	300	350	300
TOTAL	78,350	5,450	4,050	4,150	4,700	4,250

6. The National Geographic Institute will not participate directly in the training program of the aforementioned project, however, the acquisition and interpretation of infrared aerial photographs permitted the understanding of this remote sensing technique on the part of personnel of this institute. Training was necessary owing to the fact that no one had worked before with photographs of this nature.

7. There does not exist in this country a system of geographic information. Because of this the series of transparent overlays will serve as a base for a data bank to be implemented in the third stage.

8. The national stage will include an inventory and control of the forests of the country, as well as a more effective program of control of cultivation in the most appropriate zone for each crop (potential use).

9. National Geographic Institute:

a. Annual Budget:

1. National: 7.821.747.00 (US$ 909,505.46)
2. Topographic: 1.236.705.00 (US$ 143,802.90)
9.058.452.00 (US$ 1,053,308.30)

b. Personnel:

1.	Technical	86
2.	Administrative	59
	TOTAL	145

.0. Products of the IGN

a. Average of maps sold each year:

1. scale 1:200,000: 4,250
2. scale 1:50,000: 42,000

b. Cost of reproductions (black and white):

1. aerial photographs:
   a) standard size = 30,00 ($3.48)
   b) amplification 20" x 20" = 130,00 ($15.11)
   c) amplification 40" x 40" = 620,00 (72.09)

2. Landsat Images:

   a) scale 1: 1,000,000 = 30.00 (3.48)
   b) scale 1:500,000 = 130.00 (15.11)
   c) scale 1:250,000 = 620.00 (72.09)

Sincerely,

National Geographic Institute
Ing. Fernando M. Rudin Rodriquez
Director General