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INVESTIGATION OF THE UTILITY OF ERTS-1 IMAGERY FOR UPDATING LAND USE AND RESOURCE DATA IN GUATEMALA

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15. Abstract

An intensive analysis of the imagery received to date has been completed and the findings are reported in this document. Our conclusions reported herein are restricted by receipt of only limited amounts of cloud-free coverage of our test areas. In most cases the interpretation findings are as anticipated from previous experience with multiband images. Band 7 provides promising indication of some conomically important environmental communities. It also permits viewing through thin cirrus cloud layers for features of medium to high contrast. Band 4 provides information of submerged reefs and of movement of suspended sediment bodies in water areas. ERTS 1 bulk images have positional mapping accuracy adequate for representation at 1:1,000,000 scale maps. Cloud cover is a true constraint to useable satellite coverage.

PREFACE

1. Objectives

The objectives of the investigation are:

a. To assess the utility of ERTS multispectral, synoptic, repetitive coverage for updating resource and land-use data, in a seasonally and secularly dynamic situation, for addressing a complex of ecologically interdependent variables in the hydrology, soils, vegetation and agricultural domains, in the geomorphically and climatologically diverse terrain of a developing country.

b. To demonstrate the utility of ERTS imagery for the delineation of tectonic structures and the extrapolation of geologic mapping beyond areas already mapped at reconnaissance and detail scales.

2. Scope of Activity

This report is concerned with the systematic use of ERTS-1 imagery for surveying the environmental conditions of the Guatemalan landscape. Attempts to use an integral approach for the utilization and behavior of the different land systems and units were carried out in 2 of the 3 main test sites. These attempts not only use the multiband imagery as illustration material, but involves the making of linear and areal measurements, and the identification, analysis and classification of the objects seen in the photoimage with a specific or practical scientific purpose, The multiband imagery that was analyzed covered parts of the Republic of Guatemala and the dates are:

August 21-23, 1972
November 2-3, 20 1972

Activities undertaken include the following:

a. Evaluation of image interpretability over proposed test sites selected for detailed study.

b. Selection of test sites for detailed analysis representing the following earth resource disciplines: Agriculture, geology, forestry and water resources. In addition, test areas will be subjected to mapping of environmental complexes and land use units, using a system approach to detail land systems and landscape units.

c. Compilation of other information to be used in support of ERTS image interpretation including existing maps and reports, aerial photographs and field data.

d. Preparation of enlargements and additive color images of ERTS photos.

e. Detailed interpretation of ERTS images making comparisons of image features and corresponding map types.

3. Significant Analysis, Findings and Techniques

A systems approach for the evaluation of the physical and cultural patterns of the landscape was used, and geomorphic-ecosystems and units, vegetation cover and land uses were identified. The data obtained from the initial identification of the landscape was tabulated and a classification scheme was compiled. The data obtained in a more detailed interpretation are being integrated into existing environmental mapping projects and regionalization schemes. By means of the information obtained we will try to manage the physical and biological resources in an integrated manner and with a socio-ecological philosophy and methodology.

Although cloud cover obscured great areas of the country, image interpretability was higher than expected, since in general, relatively small features such as urban areas, airport runways, agricultural plots and discreet forest units could be clearly identified. Sediment bodies and underwater reefs were also discernible. Tonal differentiations however, were difficult since the images available were taken at the end of the rainy season. Multi-seasonal coverage is needed.

Addcol and Diazo color combinations were essential in the progress made to date.

Mean error in positional mapping accuracy for one test of MSS bulk images was of the order of 170 meters, thus making ERTS-1 images suitable for 1:1 000 000 and 1:500 000 scale representations.

4. Conclusions and Reccomendations

a. In most cases ERTS image interpretation findings are as anticipated from previous experiences with multiband images.

b. The cartographic accuracy was surprisingly good from one test.

c. Options for more frequent overpasses would be desirable in the future.

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I. MAJOR ACCOMPLISHMENTS

A. Imagery Received from ERTS-1

Dates, Bands, Products and Date of Receipt

Data in the standing order for this investigation include coverage of the following area and the following product types:

Geographic Points

Latitude	Longitude
16°20' N	92°20' W
18°00' N	91°00' W
18°00' N	89°00' W
16°00' N	88°00' W
13°40' N	89°00' W
13°40' N	92°20' W

These points enclose Guatemala's boundaries, since it is needed to update resource and land-use for the entire country. Guatemala is covered in four successive ERTS-1 flight paths, numbered from 1 to 4 in an East to West direction, as shown on Figure 1. First coverage was on 21, 23 and 24 August 1972, for lines 1 to 4 respectively.

Imagery

Format	MSS Bands
M = 70 mm (-) transparencies	4 5 6 7
S = 70 mm (+) transparencies	4 5 6 7
T = 9.5" (+) transparencies	4 5 6 7
P = 9.5" (+) prints	5 7

FIGURE 1
ERTS-1 FLIGHT PATHS

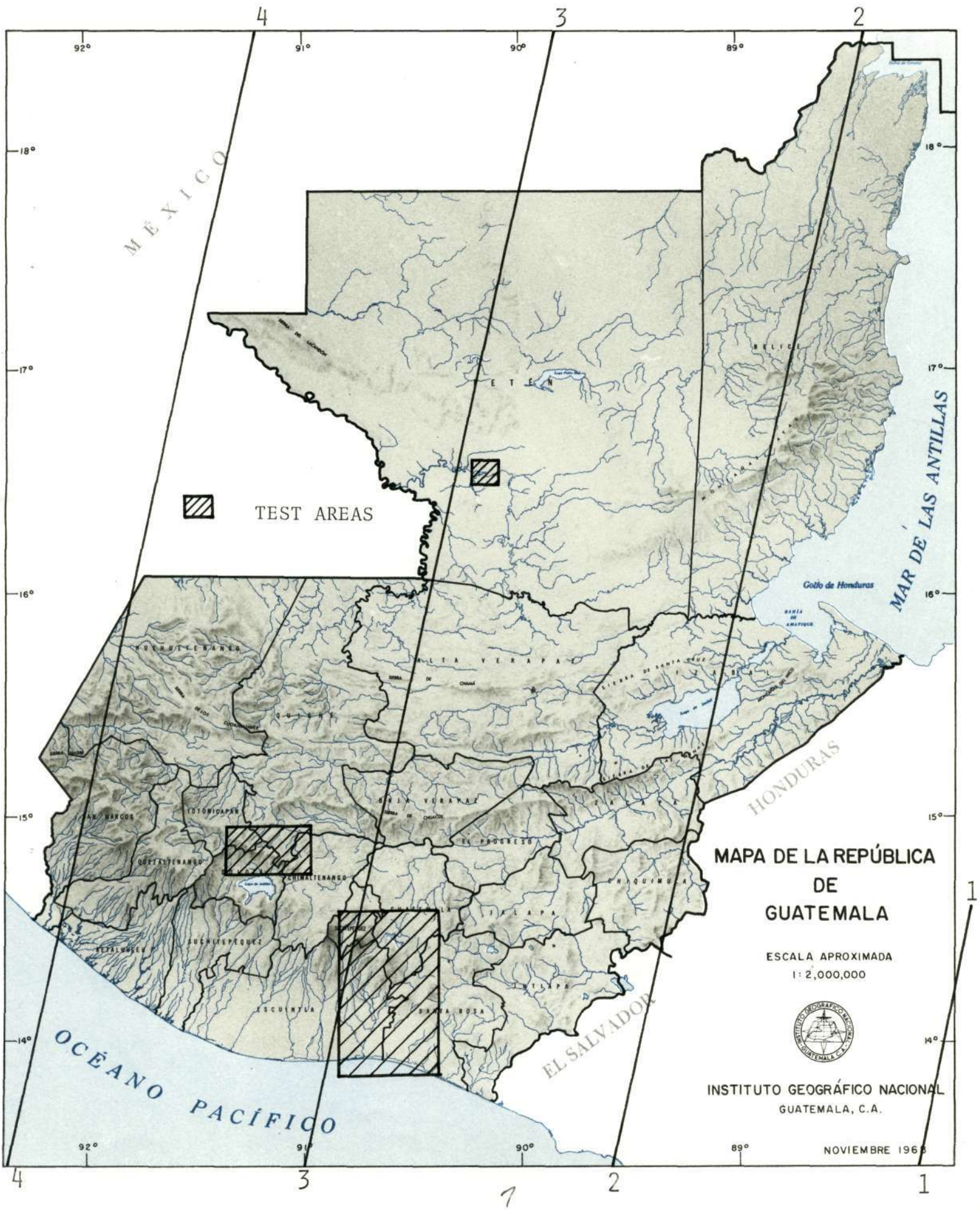

TABLE I

ERTS FLIGHT PATHS

Month	LINE NUMBER East 4	3	2	West 1
April	15	14	13	12
May	3	2	1	30
May	21	20	19	18
June	8	7	6	5
June	26	25	24	23
July	14	23	12	11
September	24	13	22	21
October	12	11	10	9
October	30	29	28	27
December	5	4	3	2
December	23	22	21	20
January	10	9	8	7
January	28	27	26	25
February	15	14	13	12
March	5	4	3	2
March	23	22	21	20
April	10	9	8	7

Dates enclosed in blocks indicate preferred cycles of ERTS coverage if cloud cover is minimal.

Imagery received to date is as follows:

Date of coverage	Product ID	Products not received		Date of Receipt
		Format	MSS Band	
21 Aug. 72	1029 - 15425	S	7	11/6/72
22 Aug. 72	1030 - 15481	T S	4 4	11/6/72
22 Aug. 72	1030 - 15484			11/6/72
23 Aug. 72	1031 - 15533			11/6/72
23 Aug. 72	1031 - 15540			11/6/72
23 Aug. 72	1031 - 15542			11/6/72
23 Aug. 72	1031 - 15545			11/6/72
24 Aug. 72	1032 - 15592	S M	7 7	11/6/72
24 Aug. 72	1032 - 15594	S	7	11/6/72
26 Sept. 72	1065 - 15425			11/30/72
2 Nov. 72	1102 - 15485	T	6	12/20/72
2 Nov. 72	1102 - 15492	T	5	12/20/72
2 Nov. 72	1102 - 15494			12/20/72
3 Nov. 72	1103 - 15544			12/20/72
3 Nov. 72	1103 - 15550			12/20/72
3 Nov. 72	1103 - 15553			12/20/72
20 Nov. 72	1120 - 15490			1/9/73
20 Nov. 72	1120 - 15493			1/9/73
20 Nov. 72	1120 - 15495			1/9/73
20 Nov. 72	1120 - 15502	T	7	1/9/73

B. Activities Undertaken

1. Quality of images and image interpretability over proposed test sites was evaluated for agriculture, forestry, geology, land cover, and water resources, on the basis of the goals set forth on Table 2. Not all of these goals could be evaluated though, since only a limited number of cloud-free images were available to date. We feel however, that significant results have nevertheless been obtained. These results are described in Secction I.C. for each one of the disciplines covered in the investigation.

2. Three test sites were selected for detailed analysis representing the above mentioned earth resource disciplines (See Figure 1). These sites, listed according to the area covered by each one (from largest to smallest), are:

1. María Linda - From Guatemala City in the Central Highlands to the Pacific Ocean. This will be the area subjected to more intensive investigation.

2. Altiplano Occidental.

3. Petén.

Based on the image-interpretability evaluations made and to be made in these test sites, resource and land-use data will be updated for the entire country.

TABLE 2

Goals for Evaluation of ERTS-1 Image Interpretability

Type	Priority	Area Unit	Existing Data and Sources
Agriculture			
Exploration for new crop bands	1	50 Has.	1954 Aerial Photography 1:60,000
Map crops that need protective shadow, such as coffee, etc.		50 Has.	"
Map areas of extensive crops such as cotton and sugar cane	3	50 Has.	"
Map cultivated pastures		50 Has.	"
Identification of humid zones for dry-season crops	2	50 Has.	"
Map abandoned farms	4	50 Has.	"
Forestry			
Map areas needing reforestation, and suitable for reforestation	1	2 $Kms.^2$	Land use map aerial photos

TABLE 2 (Cont.)

Goals for Evaluation of ERTS-1 Image Interpretability

Type	Priority	Area Unit	Existing Data and Sources
Map commercial forest land, range land and unstocked land.	2	2 Kms.2	Forest maps aerial photos some inventory records
Limits of vegetation as indicator of high annual rainfall (Hardwood) and low annual rainfall (Softwood)	3	10 Kms.	Ecological map
If it were possible, to determine limits between some conifer strata.	4	50 Hect.±	Ecological map
Evaluate existing forest vegetation maps	5	500 Hect.	Ecological map
Geology			
Geological Structures: folds, major faults	1	500 square kilometers	Regional Geologic maps 1:500,000 (surface), Air Photos Semidetailed Geologic maps 1:50,000 Topographic maps 1:50,000
Map Lithologic Zones	3	50 Kms.2	Geologic surface maps
Map Ground water indicators	2	5 Kms.2	
Map geothermal structure types	4	1 Km.2	

2/

TABLE 2 (Cont.)

Goals for Evaluation of ERTS-1 Image Interpretability

Type	Priority	Area Unit	Existing Data and Sources
Land Cover			
Urban-Industrial	1	Industrial (10 Km^2) Urban (100 Km^2)	Maps 1:50,000 1: 2,000
Horticultures	2	15-15 Km^2	Land Use Map 1: 1 000 000 1: 500 000
Agriculture			
Annual	1	1 Km^2	Land Use Maps 1:50 000 1: 1 000 000
3-Seasonal	1	1 Km^2	
Perennial	1	1 Km^2	
Grass-Lands, Pastures	2	3 Km^2	Land Use Maps 1:50 000
Range Lands	3	10 Km^2	Land Use Maps 1:50 000
Forest			
Deciduos	2	6 Km^2	Forestry Land-Use Maps 1:250 000 1:50 000
Coniferous	2	6 Km^2	
Fallow Lands	3	5 Km^2	Land Use Maps 1: 50 000

TABLE 2 (Cont.)

Goals for Evaluation of ERTS-1 Image Interpretability

Type	Priority	Area Unit	Existing Data and Sources
Iddle Lands	2	5 Km^2	
Eroded Lands	1	2 Km^2	No data
Wetlands	1	2 Km^2	Land Use Maps
Transportation	2	10 meters	Topographic Maps
Recreation	3	10	No data
Conservation	1	50	No data
Rural Settlements	2	?	Topographic Maps
Water Resources			
Define limits of watershed regions for Planning & manag. purposes	1	50 $Kms.^2$	Maps, aerial photos
Evaluate existing surface water inventory maps	1	50 Hect.	Maps, aerial photos
Delimite potential underground water sources	2	1 $Km.^2$	Maps, aerial photos
Delimite (stratify) zones of danger from erosion, by silt patterns, flooding sedimentation	3	50 $Kms.^2$	Maps, aerial photos

TABLE 2 (Cont.)

Goals for Evaluation of ERTS-1 Image Interpretability

Type	Priority	Area Unit	Existing Data and Sources
Define zones of water needs by high medium and low i.e. (agriculture, urban, unused land)	4	1 Km.^{2}	Maps, aerial photos
Map Coastal processes i.e. beach erosion, littoral drift, etc.	5	2 Kms.^{2}	Aerial photos

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3. Information compiled to be used in support of ERTS image interpretation for each one of the disciplines is detailed in Section I.C.

4. Locally-obtained products from ERTS imagery used in the analyses performed include the following:

   a. Contact copy negatives from 9.5" positive transparencies. All bands.

   b. Contact copies of 9.5" negatives. All bands.

   c. Enlargements:

Scale	1:500 000	Bands 5 and 7
	1:250 000	Bands 5 and 7

   d. Ozalid color compositions (Diazo Film from 9.5" positives of November 3rd., and November 2nd.; images 1103-15553 and 1102-15494).

   e. One to one million scale mosaic covering almost all of Guatemala, made with prints of August 21, 22, 23 and 24, 1972 (considerable cloud cover existed).

   f. One to one million scale reductions of the following maps (transparent overlays for comparative purposes).

   g. Products in process (Experimentation):

      Color compositions for printing. Methods:

      Screen, Random-dot, Photolysis

      A comparative study will be made of the three methods.

C. Findings to Date

1. Agriculture

Regarding ERTS image interpretation for agricultural purposes, most evaluations were made on color images made with combinations of bands 5 and 6 where the principal agricultural regions of Guatemala can be identified.

Since the images now available cover the end of the rainy season period, there is limited contrast among the various agricultural plots and it is difficult to distinguish crop types. For example, the sugar-cane fields visited near Escuintla within the major test site, cannot be differentiated clearly.

One can, however, identify large pasture areas, especially in the Cartago and El Caobanal fincas near Taxisco, where a field check was made. It is interesting to note that pasture plot rotation in these areas could be clearly identified on ERTS images.

An effort is being made to obtain all pertinent information available at the Ministry of Agriculture, such as work maps and sheets, and location of agricultural developments such as irrigation areas, settlements, experimental stations, soil conservation and reforestation projects.

Agricultural crop land on band 4 (green) can be seen in many areas although there is a chance for significant error depending on associated or convergent evidence or local familiarity with the area.

On band 5 (red) the agricultural areas can be delineated with reasonable certainty and inconsequential errors.

On the near infrared band 7, agricultural crop land is obscure and the chance for error is high depending on local familiarity with the area.

On the additive color combination images made with the Addcol, it is possible to identify more consistently the various tonalities corresponding to perennial crops such as coffee and of annual crops such as corn, cotton and pasture, although the possibility for significant error still depends on local familiarity with the area.

In the wet season ERTS photos are very limited for Agricultural evaluation since no determination of crop quantity or quality can be made on any band.

It is believed that cloud-free sequential coverage will allow for the determination of seasonal variations of agricultural crop lands and pastures.

Main problems are excesive cloud cover and cloud shadows as well as the small size of plots in many areas.

The minimum visible size unit set as a target was 0.5 Km^2, and areas of such sizes were clearly defined. Nevertheless, it is believed that as the weather allows for better images to be obtained, this situation will even improve.

Main advantages are the use of specific bands for each feature such as forest, crops, water, etc. as follows:

a. Using single black-and-white images, a well defined contrast between water, forest and crop-lands can be seen.

b. With color combining techniques, agricultural lands are enhanced using a combination of bands 5 and 6.

c. The use of the Addcol with 3 filters allows for the detection of various tonalities showing different crop types. Diazo color combinations allow for similar evaluations, but with the disadvantage that no rapid changes in color intensities of each band can be made.

d. Image enlargements either by photographic procedures or visually using microfilm readers or magnifying lenses allow for the detection and identification of details not evident otherwise.

f. Even a narrow strip of side overlap between adjacent images provides additional information to better determine the factors that produce a specific difference in tonality in those areas.

Principal limitations:

a. Lack of additional images of comparable quality to 3 Nov. 1972 images.

b. Time-lag between the moment the images are obtained and the moment when they are received in Guatemala (from one to two months), thus eliminating the chance for real-time interpretations.

TABLE 3

Interpretability of Images for Agriculture

ERTS Image Data: 3/XI/72
Frame number 1103 - 25553
Scale: 1:1 000 000
Interpreter: Jorge Mario del Valle

Feature	Percent of frame and interpretability							
	Bands							
	4		5		7		Addcol	
	1	2	1	2	1	2	1	2
Agricultural crop land	4	B	4	B	4	A	4	B
Cover crops, field and seed	-	D	3	C	-	D	3	C
Cereal and Grain Crops	-	D	-	D	-	D	3	C
Rice	-	-	-	D	-	-	-	D
Cotton	-	-	1	C	1	B	1	B

Column 1

Percent Classes

1 = + - 1%

2 = 1+ - 5%

3 = 5+ - 25%

4 =25+ - 50%

5 =50+ - 75%

6 =75+ - 95%

7 =95+ - 100%

Column 2

Interpretability Classes

A = Positive, little chance for error.

B = Reasonable certainty, errors inconsequential.

C = Modest Chance for error highly dependent on associated convergent evidence or local familiarity with area.

D = Large Chance for Error, little better than a guess.

2. Forestry

Perhaps the greatest advantage to be gained in using ERTS images in Guatemalan wildlands is in planning and organizing forest inventories of the commercial timber resource, watershed lands, forest soil studies and environmental quality evaluation.

While general forest vegetation maps have been compiled for most of the high-value timber lands, the exact area and distribution of all Guatemalan forest lands is not known.

By using ERTS images for multistage analysis it is possible to optimize the data collecting and compilation efforts by space and aerial photo, and ground observation methods. These resource data are vital to monitoring the environmental characteristics of the forest lands and the numerous changes in vegetation concentrarion and composition that have taken place in Guatemala.

A second important advantage will be the provision for multidate analysis by both visual and optical methods in detailed mapping of vegetation communities on a seasonal basis.

Careful selection of test areas for evaluating ERTS imagery has provided data on a variety of environmental types.

The image evaluation was performed on each black-and-white MSS band separately, and on composite color images made on an Addcol device and by Diazo multilayer processes.

In spite of considerable cloud cover, typical of Guatemalan wet season conditions, some very promising results have been obtained in evaluating ERTS of our wildland test areas.

The following table defines the results of our first-look analysis of the imagery received to date.

TABLE 4

Interpretability of Images for Forestry

ERTS Image Date: November 3, 1972
Frame Number: 1103-15553
Scale: 1:1 000 000
Interpreter: Aguilar C.

Feature	Percent of frame and Interpretability							
	Bands							
	4		5		6		Addcol	
	1	2	1	2	1	2	1	2
Natural Vegetation	4	B	4	A	5	C	4	A
Density and Vigor-High	-	D	-	D	-	D	-	C
Moderate	-	D	-	D	-	D	-	C
Low	-	D	-	D	-	D	-	C
Vegetation Dormant	-	D	3	D	-	C	-	D
Herbaceus types	3	D	3	C	-	C	-	C
Shrub-Scrub types	2	C	2	C	-	C	-	C
Michophyllous-Salt tolerant	1	C	-	D	-	C	-	D
Shrub Steppe (Sagebrush)	1	D	1	C	1	C	-	D
Evergreen Macrophyllous	4	C	4	B	4	C	3	A
Deciduous Macrophyllous	-	D	3	C	4	C	-	D
Savana types	-	D	1	D	1	C	1	C
Forest and Woodland types	4	B	4	A	4	C	4	A
Needleleaf	3	B	3	B	3	C	3	B
Broadleaf Deciduous	-	D	-	D	2	C	3	B
Broadleaf Evergreen	3	B	3	B	2	C	3	B
Needleleaf-Broadleaf	3	B	2	B	2	C	-	B

Column 1

Percent Classes

1 + - 1%
2 1+ - 5%
3 5+ - 25%
4 25+ - 50%
5 50+ - 75%
6 75+ - 95%
7 95+ -100%

Column 2

Interpretability Classes

A. Positive, little chance for error
B. Reasonable certainty-error
C. Inconsequential
C. Modest chance for error. Highly dependent on associated/convergent evidence or local familiarity with area
D. Large chance for error. Little more than a guess.

3. Geology

The information to be used to support ERTS imagery interpretation includes:

- Geologic map of the country, scale 1:500 000
- Geologic maps scale: 1:250 000 covering southwestern and southestern Guatemala (2 sheets, 1°x 1.5°)
- Geologic maps scale 1:50 000 covering small areas on northwestern and southerestern Guatemala (11 sheets)
- Aerial photos at several scales covering the country

It was possible to identify some of the major volcanic cones and natural lakes of about 10 Hectares or larger in size.

It was not possible to determine if vegetation characteristics could be used as indicators of geologic structures but it should be kept in mind that the images examined were taken on November 3,1972, at the end of the rainy season, when the vegetation was nearly uniformly green and shill vigorous. An attempt will be made by examination of later date imagery and by analysis of NASA ERTS color composites, when received, to determine if vegetation indicators can be used to map geological structure, lithologic boundaries, tectonic features and geothermal zones. Cloud cover obscured many parts of the photo, including parts of the Guatemala City area, but the runway of the international airport could be identified. It is to be expected that on later date images, with less cloud cover, other urban areas con be detected and additional features of geologic interest identified.

For example, we observed a definite correspondence between certain rock types on an existing surface geologic map and the ERTS band 7 photo taken on November 3, 1972, in the region of lake Amatitlán south of the City of Guatemala. We will evaluate these preliminary findings on ERTS images taken on other dates, and by ground-checking selected locations we will attempt to extend such information to other areas.

The features observed on ERTS band 7, were darker in tone than surrounding areas and appeared to conform in shape and location to the particular rock types mapped on our existing charts.

There is also some promising indication that altiplano pumice basins, important for our nation's agriculture, can be delineated and identified on the November 3, imagery. Thus, important soil boundaries may be visible as unique signatures on wet season ERTS imagery. We are most anxious to evaluate ERTS images taken during the Guatemala dry season for further evaluation of soil boundary mapping and to make multidate camparison images by additive color techniques.

TABLE 5

Interpretability of Images for Geology

ERTS Image Date: November 3, 1972
Frame Number: 1103 - 15553
Scale: 1:1 000 000
Interpreter: O. D. Salazar

Feature	Percent of frame and Interpretability							
	Bands							
	4		5		7		Addcol	
	1	2	1	2	1	2	1	2
Barren land	-	-	-	-	-	-	-	-
Playas	-	-	-	-	-	-	-	-
Geological Structure	1	D	1	D	1	D	1	D
Rocklands	1	D	1	D	1	D	1	D

Column 1

Percent Classes

1 = - 1%
2 = - 5%
3 = - 25%
4 = 25+ - 50%
5 = 50+ - 75%
6 = 75+ - 95%
7 = 95+ -100%

Column 2

Interpretability Classes

A = Positive, little chance for error
B = Reasonable Certainty
C = Modest chance for error highly dependent on associated/covergent evidence or local familiarity with area.

D = Large chance for error, little better than a guess.

4. Land Cover

By: Luis Ferraté

a. The landscape approach as a system to define homogenous regions in the Republic of Guatemala.

Regionalization is a method to stratify areas in a given territory by means of analyzing the physical geographic differences and cultural patterns that have originated historically as a result of the influence of these physical-geographic zonal and azonal factors. These areal differentiations must exhibit some similatiry of physical resources, energy flows, productivity and land uses. Unfortunately, the regions in Guatemala are based on geopolitical divisions, (i.e. departamentos and municipios), or gross physical features, (i.e. watersheds), or economic regions (i.e. cotton, coffee, etc.), and/or cultural paterns (i.e. linguistic, ethnic).

All of them reflect either cultural or physical differences but no attempt has been made to see the interaction between the physical-biological resources and their utilization. ERTS-1 multiband imagery is being used to define some of these landscapes (i.e. physicultural units and systems), up to a scale of 1:250 000. Multi-stage photo interpretation techniques have been used to detail some aspects of the land systems up to a scale of 1:50 000, in the María Linda River Basin and Totonicapán (areas of two test sites).

This evaluation-regionalization, defines Guatemala as a geopolitical unit, part of the azonal division of Mesoamerica. It is defined by certain latitudes and longitudes, megarelief and atmospheric circulation.

A series of land systems with homogenous features can be easily recognized in this geopolitical unit by using the multiband, multistage (and we anticipate multidate) approch using ERTS-1 imagery specifically. Most of them are extensions of other land systems of neighboring geopolitical units and they should be identified and classified as a subcontinental unit. The land (physiogeographic) systems are the primary and most important units of regionalization, because each represents an individual natural complex having an homogenous

relief type or geological base; specific climate and geomorphic-physiognomic features that are interrelated to general cultural patterns and technological trends. The land units are subdivisions of the land systems where differences in geomorphological processes and specific land forms are defined. Landscape units are the minimum areas that can be defined, mostly by the specific cultural patterns and land utilization types. Therefore, the main tools to define land systems, land units and landscape areas are the geomorphic expression and land uses as a result of the interaction between the natural environment and cultural patterns. Our preliminary analysis indicates that some of this information can be extracted from ERTS-1.

b. Advantages of using ERTS-1 imagery for the regionalization of Guatemala using the landscape approach.

For the first time, sequential observation of the local environmental conditions of the different land systems and units can be obtained with certain periodicity using ERTS-type imagery. The vigor and patterns of the vegetation can be monitored, mapped and be interrelated with levels of education and technology. Planting, cropping and harvesting periods can be seen and analyzed. The gross behavior of landforms can be suggested by the erosion-sedimentation patterns. Specific land systems can be mapped and subdivided into land units, sometimes even into landscape units. Later, energy flows based on the vigor and productivity of the physical resources of the land systems can be studied. Soil and plant inter-relationships in the environmental units can be detected, allowing for the formulation of land-use and topoecological keys, by use of multistage techniques.

Other use of ERTS-1 imagery is its potential to update existing maps. Some geomorphic units--land--forms--can be detected and their response to the prevailing climatic conditions can be monitored.

c. Major accomplishments obtained from the ERTS-1 imagery in Guatemala.

Twelve different types of nine land-use forms defined are bound to be identifiable on the ERTS-1 imagery. Nine of them were identified and classified after ground checking by field trips to 2 of the 3 test areas. (María Linda and Altiplano Occidental). Linear and areal differentiation and identification of some cultural patterns and topo-geological features developed. Tables 6 and 7 summarize this research.

Table 6

Table 6 was integrated into the existing environmental--land use and land potential--projects of the Center for the Evaluation of Forest Ecology (CETEFOR), and the following photointerpretation legend will show what can be expected from ERTS-1 imagery and other multiband-multistage imagery.

TABLE 6

Linear and Areal Differentiation for Land Use

Major Land Use	Bands						
	Band 4	Band 5	Band 6	Band 7	4,5,7 Addcol	Diazo 5-6	Diazo 5-6-7
Urban-Industrial	2 1000 / 2 1	2 1000 / 2 2	2 100 / 2 2	2 9 / 2 3	2 1000 / 1 1	2 100 / 2 1	2 100 / 2 2
Horticulture (coffee)	5 500 / 2 1	5 500 / 2 2	8 500 / 1 3	5 500 / 3 2	5 1000 / 1 2	5 1000 / 2 2	5 500 / 1 2
Agriculture	5 1000 / 2 2	5 1000 / 2 2	3 500 / 1 1	15 500 / 2 2	5 500 / 1 1	3 500 / 1 1	3 500 / 1 1
Annual-Seasonal (grasses)	- - / - -	5 1000 / 2 2	3 500 / 1 1	5 500 / 2 2	3 500 / 1 1	3 500 / 1 2	3 500 / 2 1
Perennial Grasslands-(cultivated pasture)	12 2000 / 2 2	4 600 / 1 2	2 500 / 1 2	5 500 / 2 2	4 500 / 1 1	3 500 / 1 1	3 500 / 2 2
Rangelands-(shrub-scrub)	6 1000 / 3 3	5 350 / 1 2	3 350 / 1 2	2 500 / 3 3	2 350 / 2 2	3 350 / 1 2	3 350 / 1 1
Water Resources (rivers lakes)	8 1000 / 3 3	5 500 / 1 3	8 1000 / 3 3	5 1000 / 3 3	5 500 / 3 2	8 1000 / 2 3	5 1000 / 1 2
Forest (rubber), (coniferous deciduos mixed)	3 30 / 1-2 1	3 30 / 1 1	3 30 / 1 1	3 30 / 1.2 1.2	3 30 / 1 1	3 30 / 1 1	3 30 / 1 1
Fallow-Idle	12 2000 / 2 2	5 300 / 1 1	1 500 / 3 1	5 300 / 3 2	5 300 / 1 1	2 300 / 2 2	2 300 / 2 1
Wetlands (marshes, lake deltas)	5 800 / 2 3	2 500 / 1 2	10 800 / 3 2	1 100 / 2 3	1 100 / 2 2	5 300 / 2 3	3 100 / 2 2
Transport (fluvial, terrestrial)	2 50 / 2 1	2 50 / 1 1	2 30 / 1 1	2 50 / 1 2	2 50 / 1 1	2 50 / 1 1	2 50 / 1 1
Mining	- - / - -	- - / - -	- - / - -	- - / - -	- - / - -	- - / - -	- - / - -
Other (clouds, shadows)	3 150 / 1 1	3 150 / 1 1	3 150 / 2 1	3 200 / 1 1	3 150 / 1 1	3 150 / 1 1	3 150 / 1 1

A	B
C	D

A = Minimum Area (Km^2)

B = Minimum Linear Distance in meters

C = Interpretability 1 = Good, 2 = Fair, 3 = Poor

D = Chance of error 1 = Inconsequential, 2 = Modest, 3 = Large

Most of the interpretation and quantification was accomplished in 2 test areas, (María Linda River Basin and Chimaltenango-Quetzaltenango). Other regions of the country were used for comparison.

TABLE 7

Differentiation of Topo-Ecological Features

(After V. de Weg 03.69, modified by Ferraté, 1972)

Topo-Ecological Feature	Band 4		Band 5		Band 7		Diazo 5-6		Diazo 5(6-7		Observations
1. Denudational Forms (general)											
a) Plain (highlands)	1	1	1	1	1	1	1	1	1	1	Pumice grabens with grasses (probably wheat and corn), and mixed forest. Some dissection can be seen.
	1	2	1	2	1	3	1	1	1	1	
b) Piedmont	2	1	2	1	2	1	2	1	2	1	Volcanic southern piedmont, high vigor vegetation (coffee). Deciduous vegetation and rangelands.
	1	1	1	2	1	3	1	1	1	1	
c) Pediment	3	2	3	2	3	3	2	3	2	2	Some doubts regarding identifocation. El Progreso piedmont with xerophyte vegetation can be seen by analyzing the drainage and vegetation types.
	2	2	2	2	2	3	2	2	2	2	
d) Break in slope	1	2	1	2	1	2	1	1	1	1	Most types of slope are seen.
	1	1	1	1	1	2-3	1	1	1	1	
e) Tops (sedimentary)	1	2	1	2	1	2	1	2	1	2	Some pumice tongues in highly dissected grabens. Grasses and possible forest regeneration.
	2	2	2	2	2	3	1	1	1	1	
f) Watershed	1	2	1	2	1	3	1	1	1	1	Achiguate River: the headwaters, the brained and meander part can be identified.
	1	2	1	2	2	3	1	1	1	1	
g) Mass movement	2	2	2	1	2	3	1	2	1	2	Atitlán and Momostenango area. Drainage and vegetation are the key factors.
	1	2	1	2	2	3	2	1	1	2	
h) Erosion scar (gullies)	1	1	1	1	2	3	1	1-2	1	1	Can be seen all over the highlands and some in the piedmont.
	1	1	1	1	2	3	1	1	1	1	

Cont.

TABLE 7 (Cont. 2)

	Band 4		Band 5		Band 7		Diazo 5-6		Diazo 5-6-7		Observations
i) Badlands	2	3	2	3	3	3	2	3	2	3	Vegetation is the clue. Hard to identify even knowing the exact location. With a micro-film reader, it might be possible.
	3	3	3	3	3	3	3	2	3	2	
j) Karst	2	3	2	3	2	3	2	2	2	2	Can be identified by the vegetation, location and vegetation texture.
	2	2	2	2	2	2	2	2	2	2	
k) Terraces (structure)	3	3	3	3	3	3	3	3	3	3	Difficult without micro film readers.
	3	3	3	3	3	3	3	3	3	3	
l) Fans	1	2	1	2	1	2	1	2	1	2	A lot in the piedmont. Drianage pattern and vegetation vigor can be detected.
	2	2	1	2	2	3	2	2	2	1	
2, Depositional forms due to marine activity											
a) Coastal Plain	1	1	1	1	1	2	1	1	1	1	Perfectly defined. Land uses show some soil associates, some ecosystems are shown.
	1	1	1	1	1	2	1	1	1	1	
b) Spits	1	1	1	1	1	1	1	1	1	1	Punta de Manabique: Sedimentation activity and currents cam be monitored.
	1	1	1	1	1	1	1	1	1	1	
c) Deltas	1	1	1	1	2	2	1	1	1	1	Atitlán and Amatitlán lake deltas; Polochic delta. Vegetation showing ecosystems are shown.
	1	1	1	1	1	3	2	1	1	1	
d) Estuaries	2	2	2	2	1	2	1	1	1	1	Mangrove is the clue. Brackish water swamp ecosystems are shown.
	1	2	1	2	2	2	1	1	1	1	

Cont.

TABLE 7 (Cont. 3)

	Band 4		Band 5		Band 7		Diazo 5-6		Diazo 5-6-7		Observations
e) Bay-mouth bar	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	
f) Littoral dunes	2	3	2	3	2	3	2	2	2	2	Can be identified probably by the vegetation and wave action.
	3	2	3	2	3	3	3	1	3	1	
g) Coral reefs	2	2	2	2	2	3	1	2	1	2	Can be seen perfectly. Some atolls and the stage of the reefs can be identified.
	-	-	-	-	-	-	-	-	-	-	
3. Fluvial Forms											
a) Rivers Meanders	1	1	1	1	2	2	1	1	1	1	Achiguate, Samalá and Motagua can be identified. Meanders show degree of slope.
	2	1	2	1	3	3	1	1	1	1	
b) Lakes, ponds	1	1	1	1	2	2	1	1	1	1	Ixpaco is the minimum size (10 hectares).
	1	1	1	1	2	3	1	1	1	1	
c) River Valleys	1	2	1	1	2	2	1	1	1	1	Part of Motagua and Guacalate river valleys can be identified. Stages and processes also.
	2	2	2	2	2	3	1	2	1	2	
d) Terraces	2	2	2	1	2	3	1	2	1	1	Vegetation show some differences in the terrace landscape. Land uses too.
	2	1	1	1	2	3	1	1	1	1	
e) Slopes	1	1	1	1	1	2	1	1	1	1	Cancavities, convexities and energy flows of some watersheds (María Linda) can be identified.
	1	1	1	1	2	3	1	1	1	1	
4. Volcanic Forms											
a) Volcanic cone	1	2	1	2	2	2	1	2	1	2	Drainage, clouds and texture are the clues. Vegetation catenas can be extrapolated.
	2	2	2	2	2	3	2	2	2	2	

Cont.

TABLE 7 (Cont. 4)

	Band 4		Band 5		Band 7		Diazo 5-6		Diazo 5-6-7		Observations
b) Crater	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	
c) Caldera	1	1	1	1	1	1	1	1	1	1	Ayarza and Calderas can be located.
	1	-	1	-	1	-	1	-	1	-	
d) Lavafied	2	2	2	2	2	2	2	1	2	1	Some vegetation and land use indicate lavafieds.
	2	-	3	-	3	-	2	-	2	-	

A	B
C	D

A = Interpretability 1 = Good, 2 = Fair, 3 = Poor

B = Degree of error 1 = Large, 2 = Medium,,3 = Small

C = Drainage analysis 1 = Good, 2 = Fair, 3 = Poor

D = Vegetation analysis 1 = Good, 2 = Fair, 3 = Poor

The preliminary topo-ecological legend has provided a useful method for the systematic definition of large ecosystems and human habitat. It is expected that after interpreting some of the conditions and features in the test site with the new instruments and ERTS-images that are anticipated (micro-film reader and better quality ERTS-1 multiband and multidate imagery), it is going to be possible to detail some landforms in the following manner, (after Lueder, 1959, reestructured by Luis Ferraté, 1972):

Flood plains	Fluvio-delta plains	Piedmont plains
Meanders	Tidal flats	Bajadas
Covered plains	Marshes	Filled valleys
Composite	Estuaries	Deltas
Bar meanders	Spits, mangrove swamps	Talus
Bar plains	Medanos	Screes

Emergent costal plains	Volcanic forms	Fluvial forms
Doaks	Cinder cones	Terraces
Interfluves	Crater	Valleys
Beaches	Lava beds	Back swamps
Marine terraces	Dykes	Braided plains
Beach ridges	Lahar flows	Meander plains
Lake beds	Mud flows	Straight plains
River beds		Alluvial fans

All of these landforms are small ecosystems by themselves and present homogeneity regarding physical resources (soil, water, vegetation, insolation, parent material and geomorphic processes) as well as their utilization (productivity).

d. Limitations of ERTS-1 Imagery Due to Quality and Lack of Instruments.

The imagery that has been received from ERTS-1 has had several limitations. Few areas of the country have been monitored twice and most areas have about 40% cloud cover or more. These factors have created 3 main problems:

- In order to compare the sequential presence or absence of the vegetation and the behavior of the landforms to the different land use systems, it has been necessary to do some extrapolation from other

areas of the country to the three test sites. This has also required modification in the development of photointerpretation legends overall. The topo-ecological land units have been adapted to the two primary test sites.

- The quality of the imagery has been obscured by extensive cloud cover. Tables 6 and 7 show that cloud free imagery has given more information than expected.

- The lack of instruments (micro-film readers, 20x reticle magnification lenses), have restricted the interpretation to scales of 1:100,000 and 1:250,000.

e. Evaluation of ERTS-1 Imagery in Two of the Three Test Sites.

Ground truth has been obtained in 2 of the proposed 3 test sites, (María Linda and Altiplano Occidental). The volcanic highland areas have been visited more frequently than the southern coastal plains. The highland test site, (Altiplano Occidental), with an area of about 2000 Km^2, is a region of high feature contrast due to the diversity of ecosystems, (pumice grabens, horst, geomorphic processes and overall cultural diversity). These land units impige on the landscape (mainly in the use of the vegetation) creating a new series of cultural ecosystems, that are by themselves landscape units. The southern coastal plain test site, with an area of 2500 Km^2, is an area of less contrast, and large land units can be defined. Cultural diversity is nil, but the technological processes are quite diverse producing different habitats in the land units. The third area, (in Petén), has about 100 Km^2, and is located between two ecosystems defined by Savanna and Karst topography areas of where natural vegetation exist.

Comparison of the 3 test areas

No.	Location	Area (Km^2)	Accesibility	Physical diversity	Cultural Diversity
1.	Volcanic Highlands (Aktiplano Occidental)	2000	Good	High (±20 ecosystems)	High (4 Ethnic Goups)
2.	southern Coastal Plain (María Linda)	2500	Excellent	Medium (±8 ecosystems)	Low (2 ethnic groups)
3.	Petén Savanna Karst Landscapes	100	Poor	Low (±2 ecosystems)	Low (1 ethnic group)

f. Information Compiled for Use in Interpreting ERTS-1 Images.

In order to achieve some success in the interpretation and analysis of the ERTS-1 Imagery, existing information has been compiled. It includes information on agriculture, geology, vegetation, ecology, pollution, and water resources, as fallows:

TOPOGRAPHIC MAP OF GUATEMALA, SCALE 1:50 000

BASIC MAP OF GUATEMALA, SCALE 1:250,000

It has been used to analyze physiography, soil associations, land use and vegetation cover. Comparison are being made to see the potential of ERTS-1 to actualize land use information.

RELIEF MAP OF GUATEMALA, SCALE 1:250,000

It has been used for geomorphogenesis and geomorphography. The topo-ecological and land use keys are tested on this map. Ecosystems have been defined but not checked on the field.

FORESTRY MAP OF GUATEMALA, SCALE 1:250,000
(Petén)

Forestry types are being studied in Petén. No reliable ERTS-1 imagery has been obtained for this area.

PRELIMINARY MAP OF GUATEMALA, SCALE 1: 1 000,000

HYPSOMETRIC MAP OF GUATEMALA, SCALE 1: 500,000

GEOLOGICAL RECONNAISSANCE MAP OF THE ALTA VERAPAZ REGION
SCALE 1:125,000

GEOLOGICAL MAP OF GUATEMALA, SCALE 1:50,000
(not complete)

GEOLOGICAL MAP OF GUATEMALA, SCALE 1:250,000
(not complete)

GEOLOGICAL MAP OF GUATEMALA, SCALE 1:500,000

LAND USE MAPS OF THE SOUTHERN COASTAL PLAIN, SCALE 1:50,000

Land-use and land-tenure has been compared with ERTS-1 imagery.

WATERSHED MAP OF GUATEMALA, SCALE 1:500,000

LANDFORM MAP OF GUATEMALA, SCALE 1:1 000,000

This map has been used for the definition of land systems.

NATIONAL ATLAS OF GUATEMALA, SCALE 1:1,500,000

Information on soil, water, vegetation, land use, forestry, geology, geomorphology, life zones, ecology, etc., has been compiled, analyzed and published in this Atlas.

5. Water Resources

ERTS-1 image evaluation was based primarily on the following frames:

Frame Name	Band	Date
Guatemala (GUA)	MSS 4	3 Nov., 1972
" "	" 5	" " "
" "	" 7	" " "
Izabal (IZ)	" 4	22 Aug., 1972
"	" 5	" " "
"	" 7	" " "

Features investigated were:

playas (beaches)
ponds, lakes, and reservoirs
water courses
sediment bodies
cloud effect

In general terms, the quality of the images was good for the interpretation of the above cited features, although cloud cover was high for the 22 Aug., 1972, Izabal frames, allowing interpretation only of limited areas.

Other information to be used in support of ERTS image interpretation is as follows:

Maps:

a. Geologic map 1:500,000
b. Surface water inventory map 1:500,000
c. Topographic maps 1:500,000, 1:250,000 and 1:50,000
d. Geomorphology map 1:70,000
f. Positive transparencies of Geologic, surface water inventory and land use maps 1:1 000 000 (made from above maps for ERTS evaluation)

Aerail photos of test area (from existing files):

a. Lockwood 1966, scale 1:15 000, Guatemala City,-Amatitlán, Panchromatic-minus blue (MB)
b. Lockwood 1966, scale 1:4,000, Guatemala City,-Amatitlán, Panchromatic-MB
c. Mar Hurd 1964, scale 1:30,000, Guatemala City,-Antigua - Chimaltenango, Panchromatic-MB

d. WWS 1954, scale 1:60,000, Guatemala City - Pacific Ocean, Panchromatic-MB
e. Hunting 1962, scale 1:40,000, Guatemala City - Pacific Ocean, Panchromatic - MB
f. D.G. de C. 1960, scale 1:20,000, Guatemala City - Amatitlán, Panchromatic-MB
g. Aero-exploration, 1965, scale 1:17,000, infrared-MB, Escuintla - Pacific Ocean.
h. Lockwood 1967, scale 1:30,000, Escuintla - Pacific Ocean, Panchromatic-MB,
i. EROS 1973, scale 1:25,000, I^{2S} multiband, (blue green, red infrared), Guatemala City - Pacaya,- Palin - Escuintla, Achiguate River.

Data needs and priorities for water resources investigations are shown on Table 2, along with the intended unit sizes. The images mentioned above were analized individually and in several diazo and Addcol color combinations, in order to evaluate them in regard to data needs shown on Table 2. Results obtained are shown on Table 8.

TABLE 8

Interpeetability of Images for Water Resources

Features Imaged	Frame Name and band					
	Gua 4	Gua 5	Gua 7	Iz 4	Iz 5	Iz 7
Playas (beaches)	A	A	D	D	B	-
Ponds, lakes reservoirs	C	C	A	C	C	A
Water courses, permanent	C	D	A	-	-	A
Sediment bodies	-	-	-	B	A	-
Beach Lagoons	C	C	A	C	B	A
Cloud cover	5%	5%	5%	80%	80%	80%

Interpretability classes

A = Positive, little chance for error
B = Reasonable certainty, errors inconsequential
C = Modest chance for error; highly dependent on assotiated/covergent evidence or local familiarity with area
C = Large chance for error; little better than a guess

Diazo color composite images were made with the 3 Nov., 1972, Guatemala frames, with results as shown on Table 9.

TABLE 9

Interpretability of Diazo Composite for Water Resources

Features imaged	Interpretability of Diazo Composite			
	Composite 1		Composite 2	
	Band	Color of screen	Band	Color of screen
	6	light brown	6	light brown
	5	blue	5	blue
	7	red	-	-
	7	pink	-	-
Playas (beaches)	B		C	
Ponds, lakes, reservoirs	C		C	
Water courses, permanent	C		B	
Sediment bodies	-		-	
Beach lagoons	C		C	
Cloud cover	5%		5%	

Several Addcol color combinations were made for the 3 Nov. 72, Guatemala frame, the 22 Aug., 1972 frame and the 21 Aug. 1972, Caribbean frame, obtaining enhancement of the following features:

Sediment bodies and probable sediment origin
Underwater keys (reefs)
Urban areas
Water courses and lakes
Separation of clouds and cloud shadows from other features
Shrub-scrub types
Crop types
Forest and woodland types

Given the above results and the quality of the images received and analyzed up to date, we have been able to accomplish the following:

Task	Observations
Evaluate existing Surface water inventory Maps	Good results
Delimite potential underground Water resources	Additional images are needed
Deliniate (stratify) zones of danger from erosion, by observing Silt patterns, fleoding Sediment deposits	Limited observations; Additional images Are needed
Define zones of water needs by high, medium and low, (i.e. agriculture, urban, unused land)	Good results
Map coastal processes, i.e. beach erosion, littoral drift,etc.	Good results

6. Residual errors in multispectral scanner (MSS) System corrected images (SYCI) of ERTS-1

By: Carlos Lemmerhofer

An experiment to compare the relative position of photo-identifiable points in a Syci (Bulk) MSS image of ERTS 1 with their actual position on the terrain was performed. The coordinates obtained from the ERTS images at scale 1:1,000,000 were lineally transformed (see Table 10), and compared with coordinates obtained from 1:50,000 maps.

a. Procedure:

- Obtain 1:250,000 enlargemant of image E 1103-15553-6-01.
- Overlay 1:250,000 map on the enlargement of the image and select photoidentifiable points common both to the photo and the map.
- Locate the points on 1:50,000 maps.
- Locate the points on the 9.5" (1:1,000,000) positive transparency
- Read U. T. M. point coordinates an 1:50,000 mass.
- Read coordinates, in millimeters, of the points marked on an everlay of the 9.5" (1:1,000,000) transparencey.
- Perform a Hermert Transformation by least squares of all the points.

Number of points used: 20

TABLE 10

LINEAR TRANSFORMATION OF COORDINATES OBTAINED FROM ERTS 1:1 000 000 IMAGES

$X = AX' + BY' + C(X)$
$Y = AY' - BX' + C(Y)$

NO	X	Y	X'	Y'	V(X)	V(Y)	
12	1648700.00	667100.00	196.42	117.75	-184.66	-401.72	
11	1653800.00	696900.00	206.15	146.40	34.07	-317.90	
22	1647900.00	769400.00	212.31	219.14	- 52.28	-240.92	
10	1630050.00	694300.00	182.06	147.41	101.12	18.81	
9	1615600.00	688300.00	166.70	143.68	123.82	185.81	
6	1612500.00	768100.00	177.05	223.50	-121.88	-71.85	
33	1600000.00	675000.00	149.15	133.35	70.46	-109.98	
34	1590200.00	675400.00	139.32	135.31	241.49	31.39	
38	1588700.00	730900.00	147.05	190.45	143.63	69.83	
37	1594200.00	735400.00	153.15	194.10	249.65	- 8.59	
5	1603250.00	757700.00	165.80	214.40	189.80	297.37	
4	1598400.00	766500.00	162.85	224.20	-165.71	- 43.53	
1	1595000.00	811450.00	166.90	269.25	-195.81	14.48	
15	1584600.00	670000.00	133.04	130.60	39.34	217.12	
14	1567000.00	697300.00	120.02	160.52	101.87	263.87	
13	1578300.00	727100.00	136.40	188.25	-158.61	166.56	
39	1575450.00	760100.00	138.75	221.50	106.17	137.41	
7	1575600.00	788650.00	143.90	249.93	-16418	- 65.90	
2	1582400.00	795100.00	151.71	255.33	-151.71	-191.38	
17	1559560.00	753450.00	122.21	217.50	-206.60	111.92	M=169.81

A = .981832577/+03

B + -.163070301/+03

CX = .147523463/+07

CY = .519869670/+06

X,Y = 1:50,000 Map Coordinates

X'Y' = ERTS 1 Coordinates

V(X), V(Y) = Deviations

M = Mean Error

A, B, CX, CY = Transformation Parameters

b. Comments:

- All the control points used are intersections of rivers.
- The 1:50,000 maps were compiled with 1954 photos.
- The control points (river intersections) may have changed position with time.
- The control points may have photoidentification error due to the small scale (1:1,000,000).
- Errors of appreciation may be made on the reading of coordinates of the control points at 1:50,000 and 1:1,000,000 scale.
- Mean error obtained is 170 meters (o.17 m.m., at 1:1,000,000 scale).
- Maximum error appear at the NORTH coordinates of the control points at the ends of the image, (Perpendicular to the directions of the scan of the "Scanner").
- The image utilized has control points only on its upper. (North) half due to the fact that the remainder (South half) is the Ocean.
- The results may be improve carrying out the process to a higher refinement on choosing and measuring the control points.

c. Comparative Study of Actual Results with Forecasts:

From ERTS User's Handbook:

-Table F 1-6 MSS Bulk output product
Residual Errors (r.m.s)
Positional Mapping Accuracy
Film Products 743 m ters
Paper Products 757meters

-Table F 1-8 MSS Precision output products
Residual Errors
Positional Mapping Accuracy
Film Products 242 meters
Paper Products 246 meters

-Actual Experience: errors of Coordinates is MSS bulk image, (E 1103-15553-6-01).

Film Products

Maximum Error: 400 meters at the end of the image (Coordinates: North)
Mean Error: 170 meters, using 20 control points

Conclusion: (from one experiment)
ERTS 1 images have positional mapping accuracy adequate for representations at 1:1,000,000 and 1:500,000 scale maps.

II. WORK SCHEDULE

As additional coverage becomes available representing other seasonal periods, we anticipate excellent results in our use of ERTS imagery to update and expand land use and resource data in Guatemala.

We request an extension of time to complete our investigation because of a need to obtain cloud-free coverage during the two annual seasons selected for our study -- wet season and dry season. The first cloud-free coverage of our primary test areas was taken on November 2nd. and 3rd., 1972. We require coverage from one annual cycle starting at this time, and therefore, request ERTS coverage beginning in mid-Arpil, 1973, and ending in late March, 1974, assuming of course that ERTS-1 continues to function satisfactorily.

Based on above considerations, our work schedule as submitted in our Data Analysis Plan, is as indicated on Figure 2.

FIGURE 2 WORK SCHEDULE

PROJET: INVESTIGATION OF THE UTILITY OF ERTS-1 IMAGERY FOR UPDATING LAND USE AND RESOURCE DATA IN GUATEMALA.
GSFC ID No. F0400
SR-369

DATA ANALYSIS PLAN

TASK NUMBER	TASK NAME	TASK COMPLETED
0	PRE-LAUNCH	
0.1	Determine local capacity for processing information.	6/72
0.2	Obtain bibliography	6/72
0.3	Training of local personnel.	4/72
0.4	Prepare equipment.	2/73
0.5	Select preliminary test areas.	8/72
1	PRELIMINARY ANALYSIS	
1.1	Analyze first ERTS-1 images.	3/73
1.2	Select final test areas.	3/73
1.3	Review of Data analysis plan.	3/73
2	CONTINUING ANALYSIS	
2.1	Obtain ERTS-1 images.	
2.2	Evaluate the overall quality of each ERTS photo.	
2.3	Obtain ERTS color materials	
2.4	Prepare mapping legend for Vegetation, Geologic and Environmental features.	
2.5	Perform intensive additive color photo interpretation (Addcol and Diazo).	
2.6	Make enlargements of selected portions of photos for field work.	
2.7	Obtain aerial photos for selected areas at same seasons and on same spectral bands as ERTS images.	
2.8	Perform intensive ERTS photo interpretation.	
2.9	Perform aircraft photo interpretation of selected sample areas for multistage analysis.	
2.10	Perform field data collecting.	
2.11	Correct and amplify existing maps using ERTS-1 and aerial photo data and ground information.	
2.12	Compile quantitative and qualitative resource and environmental data.	
2.13	Prepare photo interpretation keys and reference materials	

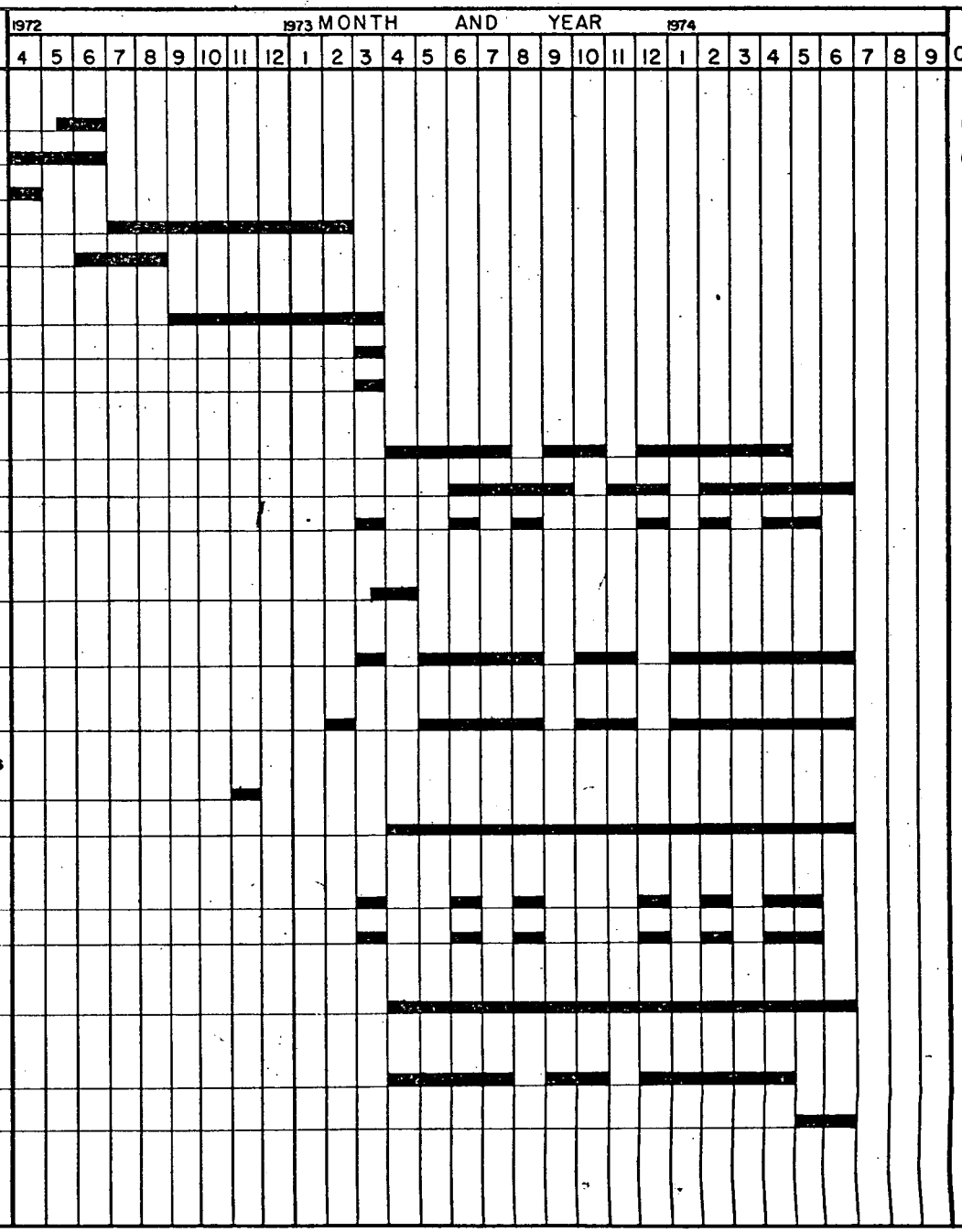


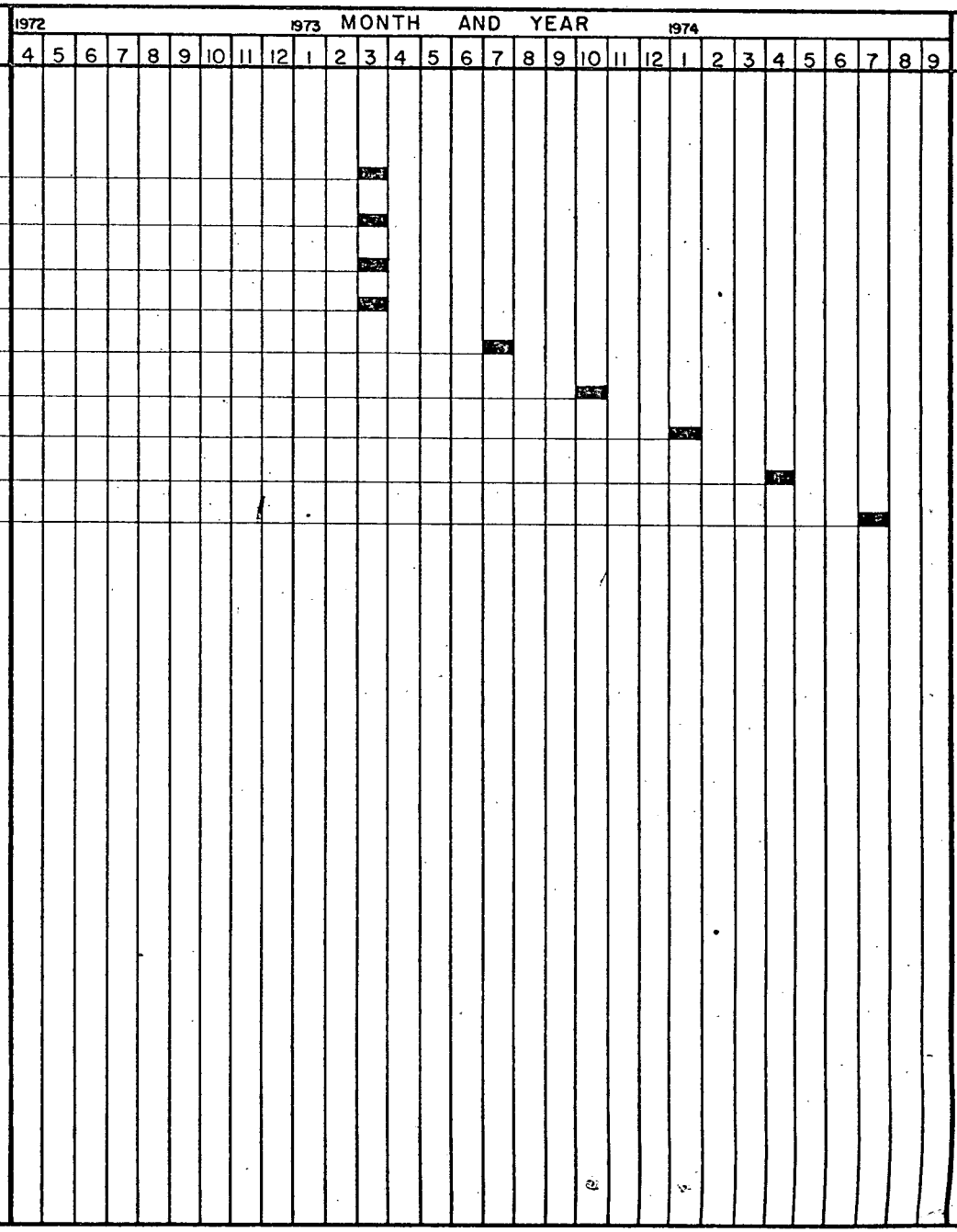
FIGURE 2 (Cont. 2.)

PROJET: INVESTIGATION OF THE UTILITY OF ERTS-1 IMAGERY FOR UPDATING LAND USE AND RESOURCE DATA IN GUATEMALA.

GSFC ID No. F0400
SR-369

DATA ANALYSIS PLAN

TASK NUMBER	TASK NAME	TASK COMPLETED
3	REPORTING	
3.1	Data analysis plan	
3.2	Type I No.1	
3.3	Type II No. 1	
3.4	Type I No. 2	
3.5	Type II No.2	
3.6	Type I No.3	
3.7	Type II No. 3	
3.8	Type I No.4	
3.9	Type III (Final Report)	



III PROBLEMS

As has been detailed in several portions of this document, we have encoutered anticipated problems with cloud cover obscuring significant partions of our country during ERTS overpasses. We hope that cloud-free coverage will be available of all desired seasonal periods.

Until acceptable multidate coverage of our test sites is received, we will not be able to make the desired environmental evaluations. However, none of these problems have discouraged our team of investigators and their enthusiasm for continued gains in updating resource maps of Guatemala is high.

IV PERSONNEL

No major changes on personnel assigned to the project have occured, with the exception of one specialist in Cartography who joined the group in June, 1972. As it now stands, the working group is formed by the fallowing persons:

Luis Ferraté	Ecology
Werner Schmoock	Agriculture
José Aguilar	Forestry
Jorge M. del Valle	Agriculture
Oscar Salazar	Geology
Carlos P. Lemmerhofer	Cartography
Luis E. García M.	Water Resources Principal Investigator
Robin I. Welch (Consultant)	Technical Advisor

V PLANS FOR NEXT REPORTING PERIOD

An intensive analysis of the imagery received to date has been completed and the findings are reported in this document. Several factors of great interest have been uncovered during this analysis that will require additional evaluation of existing imagery, and multidate comparison of images as

coverage from additional overpasses is received. We will continue these investigations on existing imagery using various techniques of additive color display, enlargement by microfilm viewer, photographic darkroom manipulation and visual interpretation. Our revised data analysis plan indicates the sequence of task to be undertaken in ERTS image evaluation and test site analysis.

We have ordered color products from User Services for the November 3, 1972, image of Guatemala, and will undertake intensive interpretation during this period as soon as products are received.

One of our scientists will be visiting EROS data facility in June to attend training sessions and will make a complete evaluation of all images of Guatemala on file at Sioux Falls. He will perform some interpretations on additive color images and will order selected images for our use if necessary.

We eagerly await products from additional ERTS overpasses of our country for our continued investigation.

VI CONCLUSIONS AND RECOMMEDATIONS

Our conclusions as reported herein are restricted by receipt of only limited amounts of cloud-free coverage of our test areas. We have, however, determined that in nearly all resource disciplines ERTS data will be useful for updating resource maps in Guatemala and in sereral cases, we have detected vegetation and soil features not previuosly mapped. We are in the process of determining the significance and reliability of these anomalies.

In most cases the interpretation findings are as anticipated from previous experience with multiband images. We were surprised to note that band 7 provides very promising indications of some economically important environmental communities related to land use and soil type boundaries (pumice basins). We are continuing this investigation in order to determine the reliability of these preliminary findings. Band 4 provides information on location of submerged reefs in the Caribbean Sea. Band 7 permits viewing through thin cirrus cloud layers for features of medium to high contrast. Band 6 provides nearly the same information as Band 7 for our vegetation and water investigations. Band 5 is perhaps the most useful single band for multiple resource interpretation.

A combined band 5 and 6 additive color image provides the most useful photo for deliniating agricultural field patterns.

These two bands were also useful for marine shoreline evaluation for sediment body movement in water areas as well as littoral drift and beach lagoon conditions. Band 4, also provided useful information on movement of suspended sediment bodies in water areas.

We have not received color products from NASA and therefore made no evaluations of ERTS color prints during this reporting period. We hope to receive requested color products during the next reporting period and will make evaluations of those materials at a later date.

ERTS 1 images have positional mapping accuracy adequate for representations at 1:1,000,000 and 1:500,000 scale maps. The scener mean error for MSS bulk image was of the order of 170 meters as determined by photogrammetric map/photo comparisons.

Our recommedations are restricted at this time to suggesting that in any operational system of ERTS type vehicles that several such spacecraft be launched in nearly identical orbits except being out of phase to provide of cloud cover. We realize of course that such recommendations are presumptuous, but nevertheless, represent a true constraint to useable satellite coverage where cloudy conditions persist for extended periods.