

THE ENVIRONMENTAL IMPACT
OF ILLICIT NARCOTICS CULTIVATION
IN SELECTED FOREST REGIONS OF LATIN AMERICA
AND THE CARRIBEAN BASIN

Prepared By

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I. INTRODUCTION

The Environmental Research Institute of Michigan (ERIM) presents this document in response to a request for a "White Paper" with supporting company qualifications to address three narcotics case studies in western Jamaica, northern Colombia, and central Peru. The case studies address the environmental impact of illicit narcotic cultivation in those areas. They include a literature search of related environmental studies and reports, field work, data collection and analysis, and a final report on each country.

This document applies to any or all of the three countries being considered. ERIM personnel have extensive experience in the Andean countries of South America as well as the Caribbean. Specific ERIM projects in Venezuela (along the Colombian border) and Peru are cited in Section IV. ERIM personnel to participate in this project have field experience in the Dominican Republic and Haiti, have participated in an illicit drug project for Jamaica and have worked in island ecosystems in other tropical regions.

ERIM has a long history of experience in the various facets of this study:

- environmental studies
- remote sensing project design, data collection, processing and analysis
- sampling design
- field surveys/on-site data collection

Through classified projects, ERIM has current experience in sampling design and narcotics crop estimation in various countries along with experience in impact assessments of narcotics activities. This document is unclassified, so these studies will not be described in detail here. Further information can be made available in a separate document.

In the unclassified area, ERIM has conducted resource assessments in most parts of the world. These studies are very similar to the one



proposed here in that they involve interpretation of remote sensing data and integration of other data sources from study design to final report and project recommendations. These projects have typically involved on-site work with country officials and coordination of field survey teams. This particular study represents a marriage between on-going classified work on narcotics and a capability to do environmental impact studies, currently focusing on other crops for other sponsors.

Section II of this document covers the material which could be considered a "White Paper". The issues, an approach and a methodology are briefly described. Following response to this from the sponsor, a formal proposal could follow. Section III describes two of ERIM's similar resource assessments. These provide a sense of the types of activities involved in these studies. Section IV gives general ERIM capabilities, related unclassified projects and resumes of ERIM staff members who could participate in this work. Section V contains an inventory of Landsat scenes currently available at ERIM for Colombia, Jamaica, and Peru. These were obtained during previous projects.



II. TECHNICAL DISCUSSION

This section discusses the issue of illicit narcotics plant cultivation, the proposed approach to the problem and the resulting methodology.

A. ISSUES

Government planners and policy makers in the Latin American and Caribbean region need to be presented with irrefutable and easily understood evidence that illicit narcotics cultivation is environmentally destructive and therefore has a significant, long-term negative impact on their respective countries. During the last fifteen years ERIM has developed operational, scientifically-valid methods which can be used for assessing and quantifying the impact of such environmentally destructive land use; ERIM staff members have been applying these techniques in narcotics studies for over ten years.

Most land in the three countries (Jamaica, Colombia and Peru) considered in this study is highly susceptible to deterioration under traditional land use and management practices. Illegal cultivation of narcotic plants utilizes these practices, and as a result of expanding drug crop cultivation, such lands are increasingly subject to degradation such as deforestation, erosion, loss of soil nutrients, and reduction in species diversity (See Figure 1).

The apparent high fertility of the soils of the humid tropics is often an illusion. In fact these are some of the poorest soils in the world. The abundant vegetation of the humid tropics thrives only because of a rapid and short nutrient recycling process brought about by a combination of hot weather and high humidity. Quite often, the soils have already reached their ultimate stage of weathering and have long been depleted of their basic nutrients through excessive leaching; removal of plant cover can lead to rapid irreversible damage.



Landsat Multispectral Scanner (MSS) False Color Composite Subscene dated January 7, 1977 of an area in northern Colombia. The mountainous areas visible are the Sierra Nevada de Santa Marta (upper left) and the Serrania de Perijá (center right). The highlands are largely forested while adjacent lowland areas are cropped or used as pasture. Deforestation and consequent erosion due to land clearing for illicit hillside crops can have serious environmental consequences in such areas.

FIGURE 1



There are serious consequences associated with the removal of forest vegetation. In addition to the direct loss of forest products and future productivity, species diversity may be reduced because the habitat for both plant and animal species is damaged or destroyed. Once the protective mantle of vegetation is removed through deforestation or burning, the soil is directly exposed to rain, and the various soil horizons are rapidly washed away as sediments along the drainage system. These suspended solids drastically alter the physical, chemical and biological characteristics of water bodies downstream and exert profound adverse influences on aquatic fauna. Excessive sedimentation of streams greatly reduces the carrying capacity of the drainage channels thus inducing lowland flooding and damage to wetlands. In addition, excessive sedimentation is the leading cause of the siltation of reservoirs and dams whose lifetime, as a result, can be substantially reduced.

B. APPROACH

The ERIM approach for assessing the environmental impact of illicit narcotics cultivation represents an efficient integration of available data, technological capabilities, experience, and responsiveness to the issue. The principles which govern its design are the same as those which the U.S. Forest Service and other Federal agencies utilize to design their highly effective multi-resource inventories (Dixon, 1978; Cunia, 1978; Schrueder, 1981).

The design of this study is based on four phases. Phase I guarantees that the objectives of the study are clearly defined in the context of the specific study areas, and that all relevant information/data are available; Phase II insures that technical tasks of the project effectively address project objectives; Phase III implements assessments to obtain baseline and current resource condition information; and Phase IV applies this information to appropriately assess and describe the environmental degradation.



ERIM's experience with similar projects provides the insight needed to produce quality results for this study in a timely way (See Section III). This experience includes image processing, Geographic Information Systems (GIS), aircraft and field data collection, sampling and estimation, and the synergistic use of conventional and remotely sensed data. The innovative use of multisource data via such techniques is an ERIM specialty and is essential to quickly producing accurate results from the limited data available.

C. METHODOLOGY

Phase I

The three study areas differ in their ecological and cultural conditions and data availability. It may, therefore, be necessary to treat them separately in order to specify the most appropriate and effective assessment procedures for each. Accordingly, it is important to have an in-depth foreknowledge of these factors before designing the procedures. Phase I will assist in obtaining that understanding through construction of several key databases.

An issues database will be compiled for each study area. The database is comprised of details related to the nature of the illicit drug cultivation problem, where it occurs, what are its known effects, and what information is missing that is required to assess its impacts. A key aspect of constructing this database will consist of current information derived from personal interviews with knowledgeable persons such as sponsor and other government officials, academic specialists and scientists. Assistance from the sponsor will be critical in identifying and developing many of these contacts.

A review of specific research previously performed or ongoing in the regions of interest will be of help in stratification and for calibrating our inventory techniques and assessment procedures. It will also serve to increase our awareness of the unique characteristics of each project area. This information will be placed in a conventional



data database along with relevant reports and maps obtained from U.S. and host country sources. The remote sensing database will include a list of all workable remote sensing data by sensor, date of coverage, area of coverage, cloud cover, format (digital or image), and source.

Phase II

This study will require efficient use of both conventional and remote sensing data; the purpose of this phase is to select and design analysis procedures which will ensure adequate results from the resource condition assessments of Phase III.

Remotely sensed data plays two key roles in this study: (1) it is the most reliable source of data on certain parameters (e.g., rate and location of deforestation), and (2) it provides the best available basis for extrapolation of certain parameters (e.g., soils data) from regions where they are available to regions where they are not. Conventional data will provide many essential parameters not currently available by remote sensing or for which additional remote sensing is not needed (e.g., rainfall and soils data). The challenge is to combine these sources in such a way as to always use the best data available.

Our recommended methodology will accomplish this by objectively considering the information requirements and the available conventional data (and its quality). When information gaps are found, we will select data sources and analysis approaches to fill these. It is expected that analysis of Landsat data will be of prime importance, but other sensors (e.g., aerial photography) and other approaches (e.g., climate driven models such as the Holdridge Life Zone Model) will also be relevant. The methodology is illustrated in Figure 2.

Phase III

Phase III is devoted to the conducting of inventories and the use of modeling to assess the condition of vegetation, soil, water, and habitat resources. The objectives and methods of these efforts are derived from the information produced by Phase II. Several strategies

PHASE II: SELECTION OF ASSESSMENT METHODS

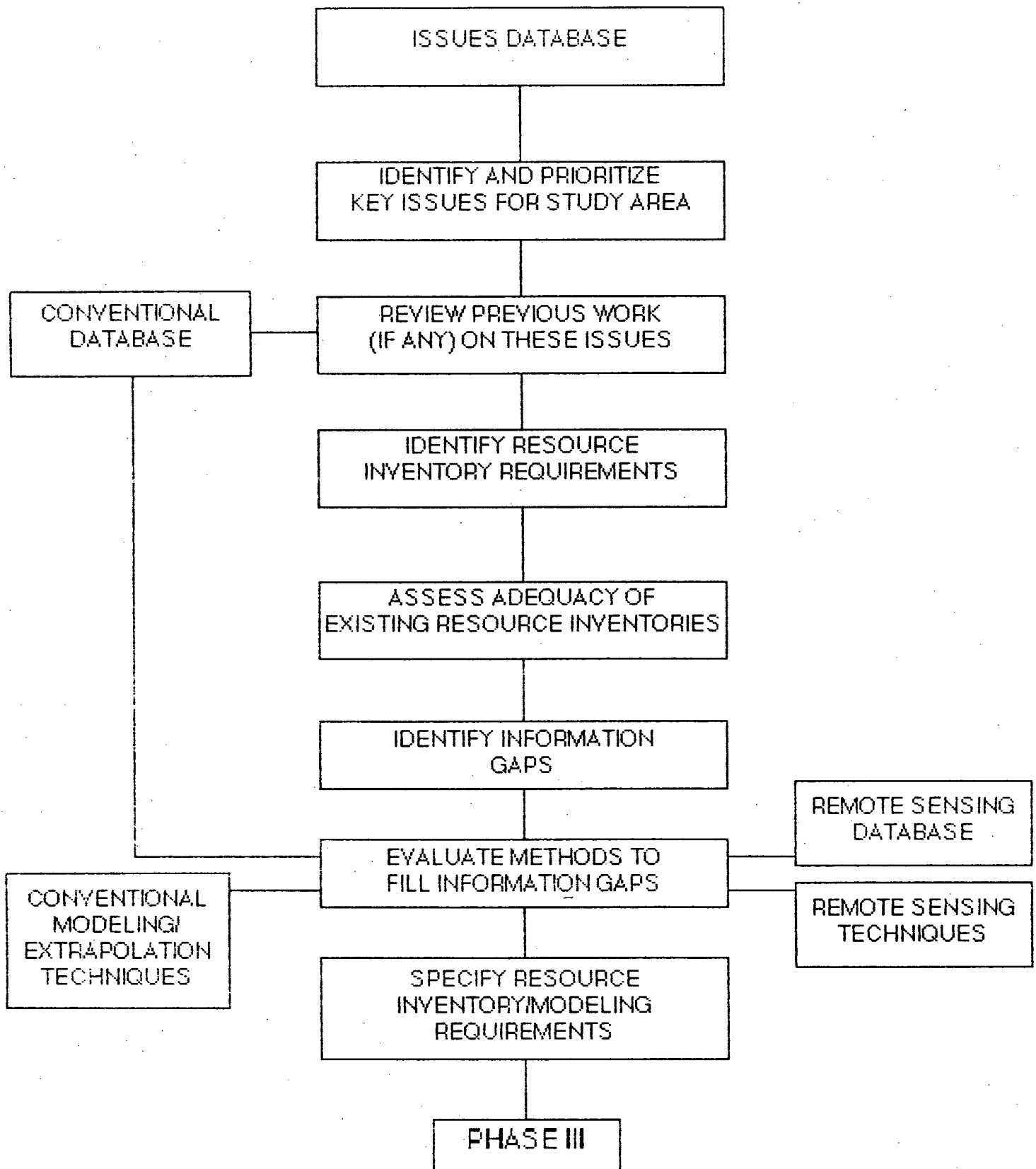


FIGURE 2



for implementing these resource condition analyses are outlined in this paper. The specific details, however, can only be determined when the specific issues and characteristics of the study areas, and data availability are known.

Vegetation Assessment

Several types of information about the vegetation of the study areas may be required, including vegetation type, current condition, change, and rate of change. Each of these information requirements will place special demands on the data collection and analysis procedures used.

Information about current vegetation type may best be obtained by a census of a medium resolution source of remote sensing data, such as Landsat MSS or TM. It may also be possible to assess current vegetation condition using the same data, but the condition assessment most likely would be limited to those areas and/or vegetation types of interest. Vegetation condition assessment may, however, require finer resolution remote sensing data (e.g., aircraft photography) or field work. Under these circumstances, multistage or multiphase assessment procedures may be the most appropriate assessment procedures for extracting this category of information.

Another situation in which a census using a single data source may not be possible is where current data is cloud covered. In this case an alternative data source could be used. If the alternative data source is a medium resolution sensor, such as SPOT, then a census of the cloud covered areas can be performed using the alternative data source, and the results added to the primary data source results. If, however, an equivalent medium resolution data source is not available, then an estimate based on a sample of fine resolution data using stratified random sampling can be used to account for the cloud covered areas. The types of fine resolution data that are expected to be available are airphotos, field observations, and possibly airborne radar data.



To assess change there are two approaches that may be used: (1) direct comparison of two observations of same type of data, and (2) comparison of estimates produced from different types of data. In the first case it is possible to detect and measure change directly. The results are a census of change and an image of where change has occurred. ERIM has developed several highly effective techniques for detecting forest change based on digital analysis of historical and current Landsat data (both MSS and TM). These techniques were developed in support of the U.S. Forest Services National Forest Applications Program. A key element in the effectiveness of the forest change detection algorithms is the highly accurate and precise geometric correction capabilities for Landsat data ERIM has developed (see Figure 3).

Where direct change detection is not possible, other strategies may be used. One strategy that is expected to be very important is multiphase sampling. Multiphase sampling permits combining coarse and fine resolution together in an effective inventory (Woodwell, et al., 1987). It is expected that coarse resolution (e.g., AVHRR) data will be more available for the study areas than medium or fine resolution data. Thus, it may be possible to census the areas at both dates, with no imprecision in the results due to sampling error. However, the limited resolution (1 km) will probably result in a biased estimate (small things will be missed). The bias can be corrected using limited amounts of higher resolution data, which by themselves would have large sampling error. Combining the two data types in a multiphase estimator can retain both low bias and low sampling error.

An example of how a forest change detection inventory would be implemented is shown in Figure 4. The actual inventory procedure selected would depend on available remote sensing data coverage, with regard to sensor type, geographical coverage and date of coverage (historical and/or current).

DETECTING FOREST CHANGE WITH MULTIDATE LANDSAT IMAGERY

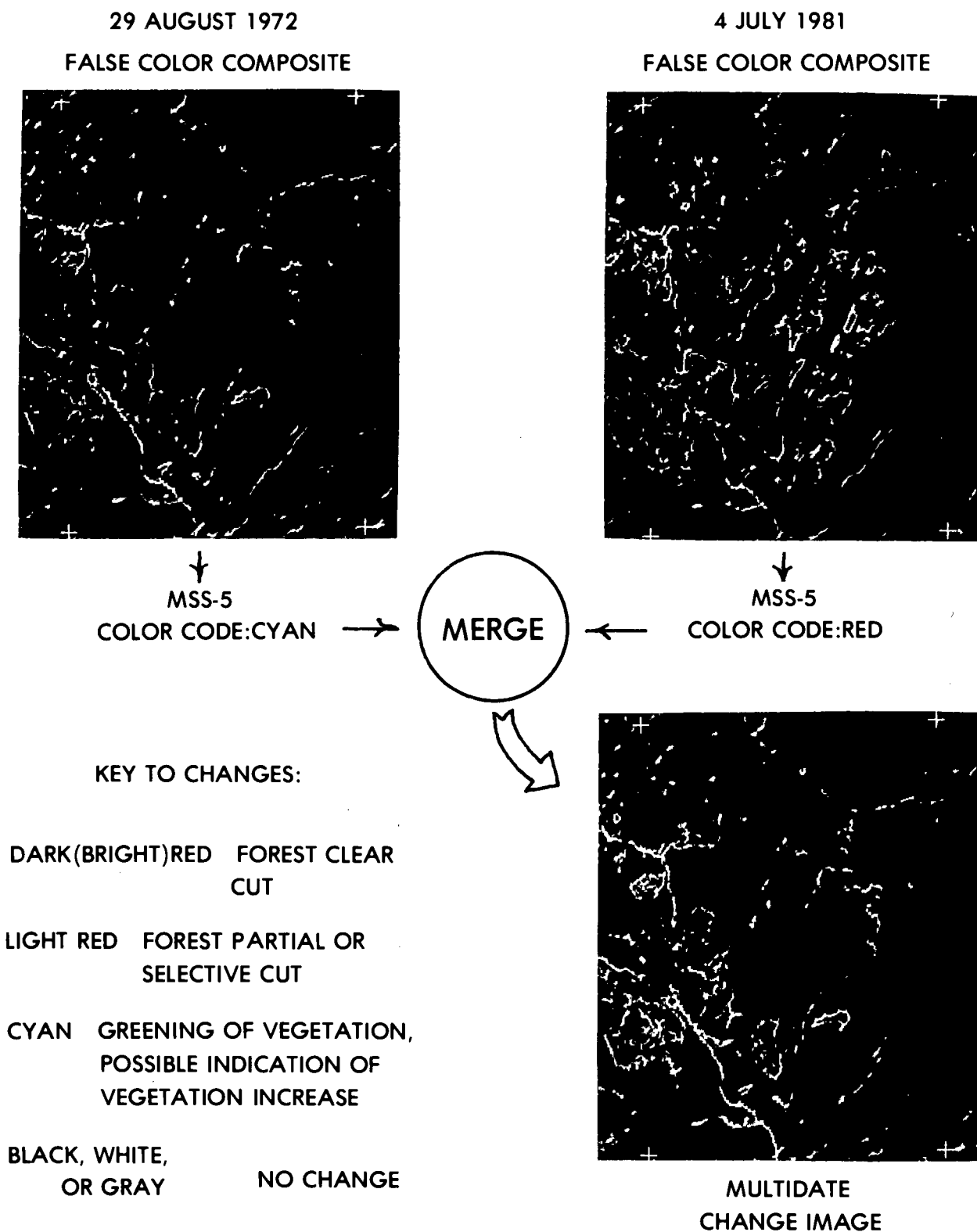


FIGURE 3

III A.

VEGETATION INVENTORIES

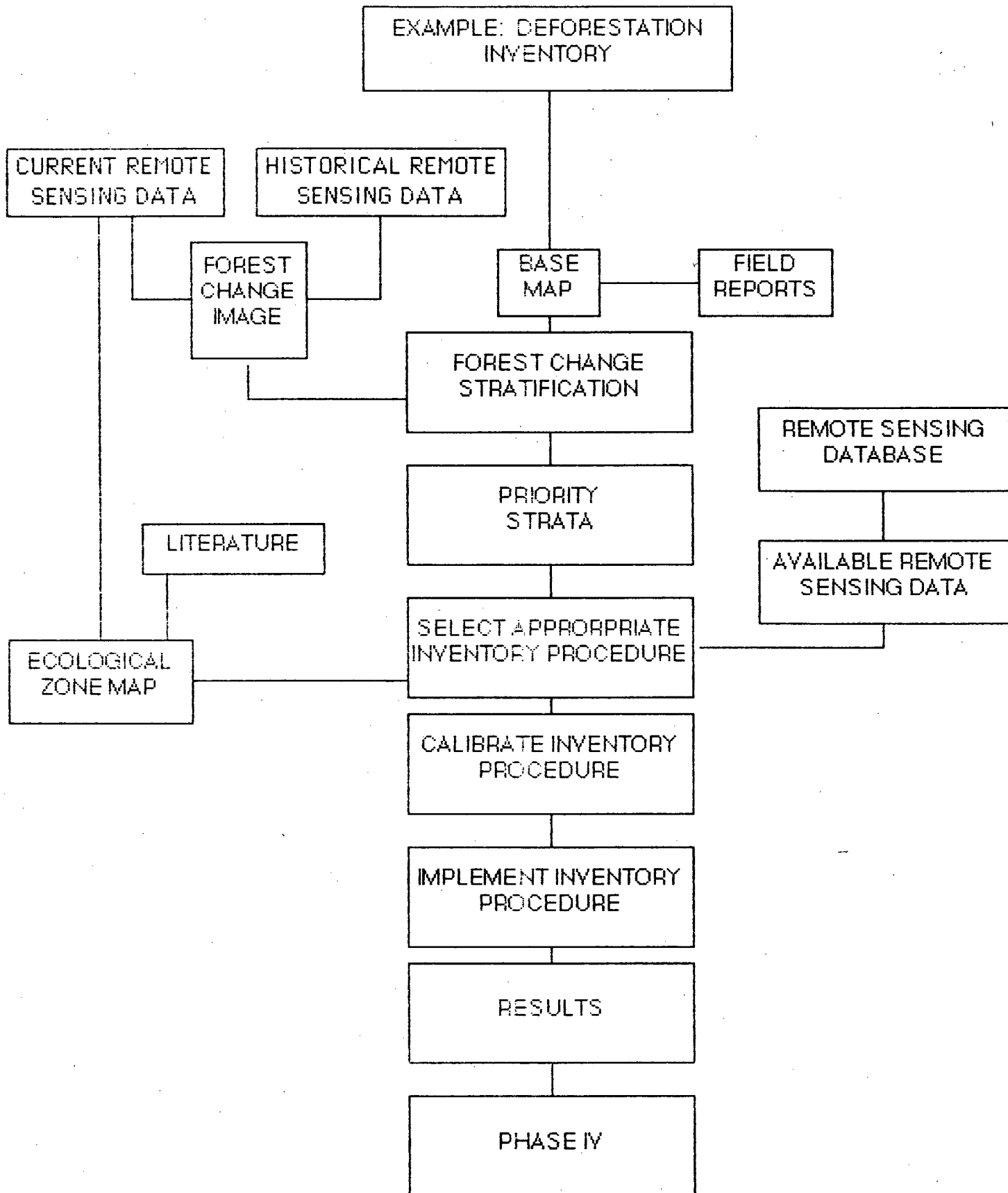


FIGURE 4



Rates of change may be computed from change estimates from two or more dates.

Soil Condition Assessment

Within the tri-country context, the following processes are expected to be the most significant ones: water erosion and physical and biological degradation. A variety of models using traditional data have been developed by soil scientists to assess these impacts (FAO, 1979). Over the years, ERIM has developed ways to implement these models using a combination of remote sensing data, typically available field data and the spatial data handling capabilities of a geographic information system (GIS). To illustrate how these innovations have been made, procedures for assessing the impact of one of the above soil degradation processes are illustrated.

To quantify the extent of erosion ERIM anticipates using the erosion potential mapping procedure it has developed and applied in tropical areas (Laurin, 1984). The general components of this procedure are shown in Figure 5. A key concept embodied in this procedure is that although it permits estimating erosion potential for individual drainage units, the actual measurements used to derive the average basin figures are made on a much finer scale. This results in a more accurate and precise estimate for basins and the localization of erosion damage to specific ecosystems and locations. The procedure is a considerable improvement over traditional methods which typically rely on average basin measurements as the basic level.

Water Quality Assessment

It is anticipated that separate procedures will be necessary to assess the impact of illicit cultivation of drugs on rivers, lakes and wetlands. The water quality estimation models appropriate for these assessments have several data input requirements in common. Perhaps the most important of these common requirements are shown in Figure 6, where

III B SOIL INVENTORIES

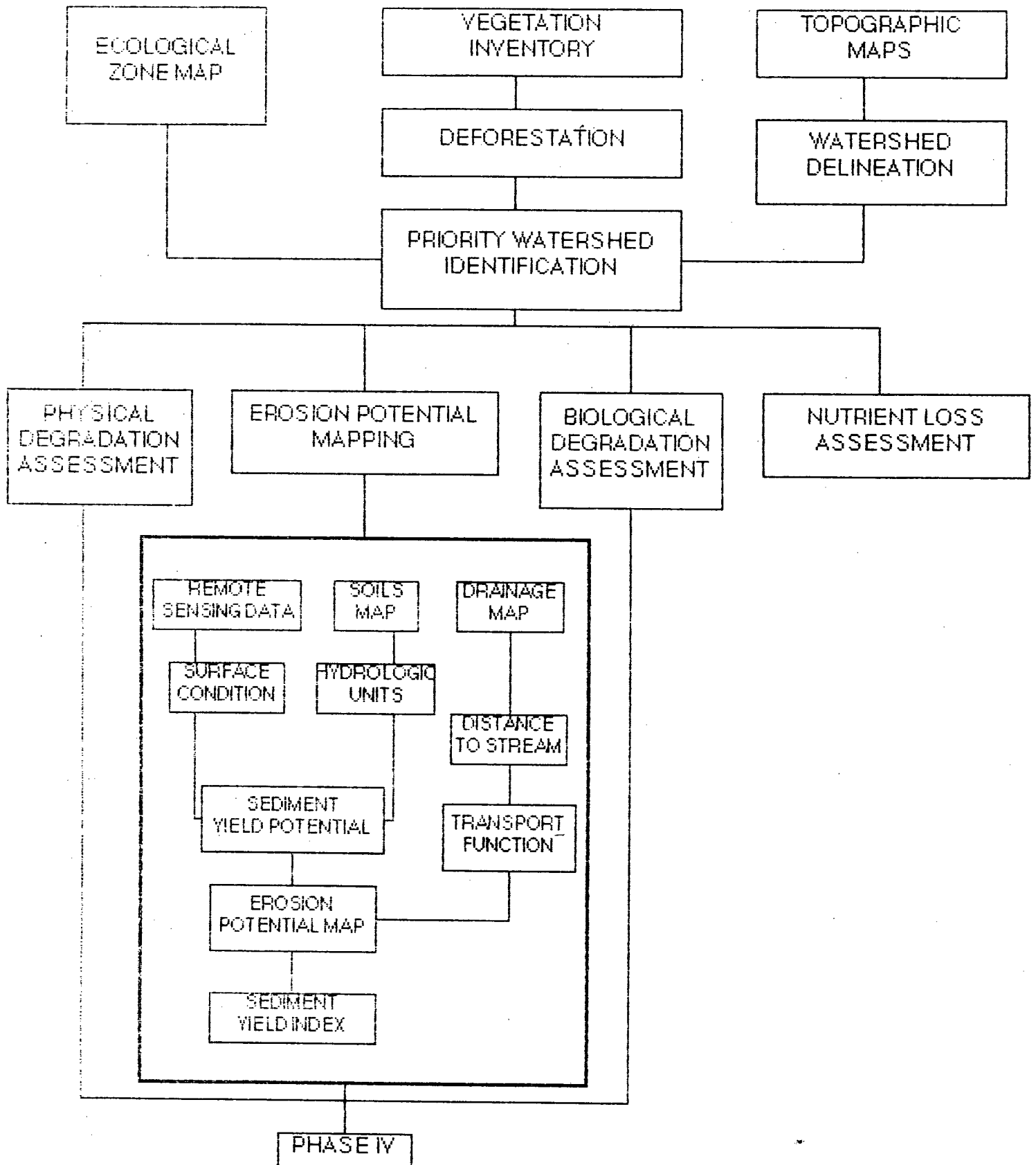
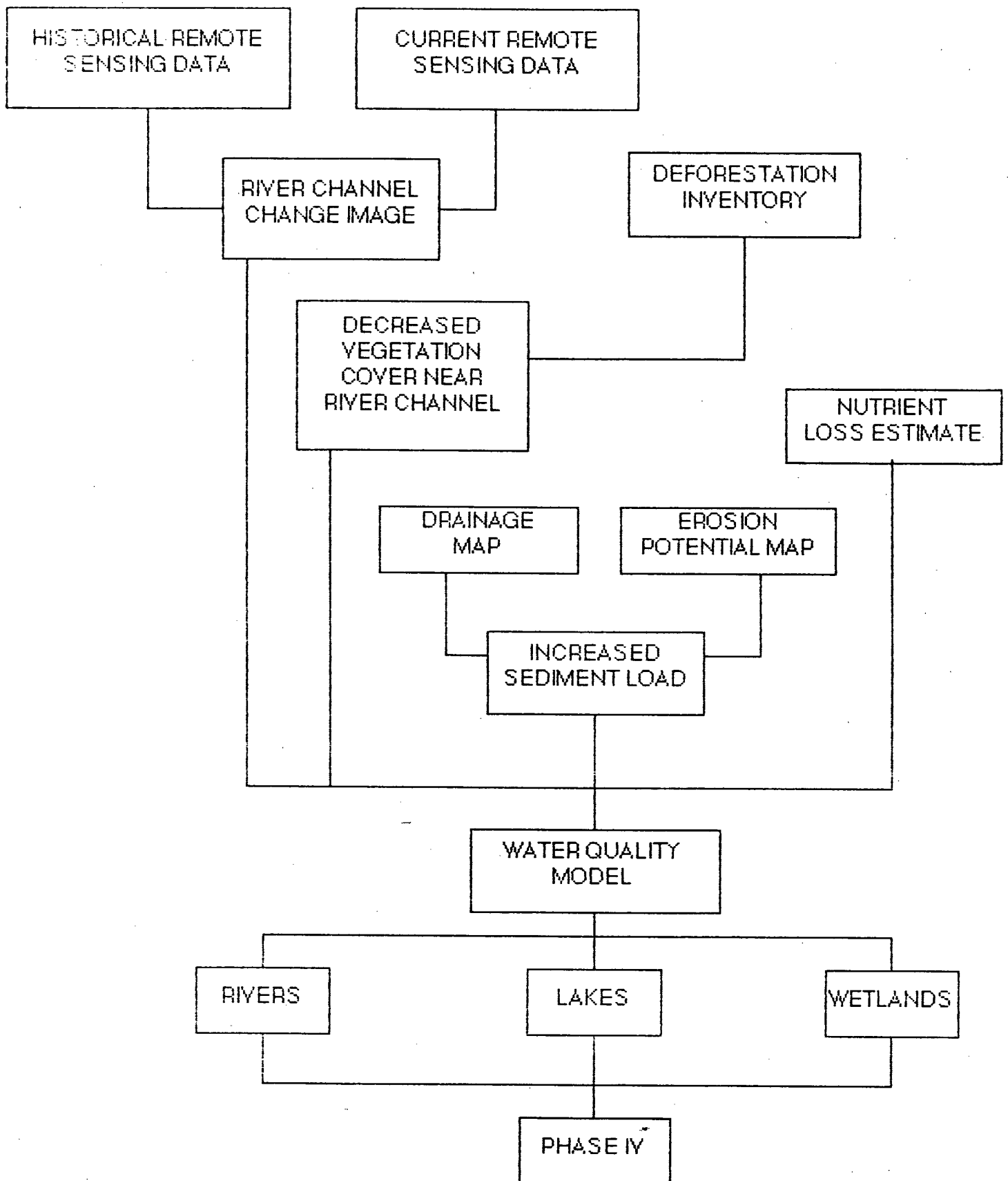


FIGURE 5

IIIC

WATER QUALITY ASSESSMENT





the general strategy ERIM recommends for assessing water quality is outlined.

Alterations in stream and river channel morphology can greatly affect aquatic life and the vegetation communities which surround the channels. Some habitats may be destroyed while others are created. Decreases in vegetation cover next to streams and rivers not only increase siltation, but may also reduce cover for aquatic life and raise water temperatures. Since many fish have water clarity and temperature range requirements these effects may have important consequences for fish population survival. The ERIM Geographic Information System (GIS) will be of special assistance in this part of the study because of the importance of spatial context in these evaluations.

Habitat Assessment

The general approach ERIM recommends using for habitat assessment is illustrated in Figure 7. Changes in vegetation communities and the amount of human activity in an area may have major effects on the wildlife populations of the area. ERIM has worked with the U.S. Fish and Wildlife Service, the U.S. Forest Service, and State game management agencies to develop quantitative methods for wildlife habitat evaluation. One type of methodology that may be especially useful in this study are habitat quality rating models. Habitat quality models evaluate both the availability and spatial arrangement of habitat in order to assess its suitability for supporting a given species or group of species. The sophistication of the habitat model is made possible through the use of the GIS, because it provides a practical way to quantify the important spatial variables in these models: juxtaposition and interspersion.

Phase IV - Integrated Environmental Impact Assessment

The combination of the variety of data ERIM recommends obtaining, its quantitative nature, and the experience of ERIM staff in evaluating such data will insure an accurate assessment of the environmental

III D HABITAT ASSESSMENT

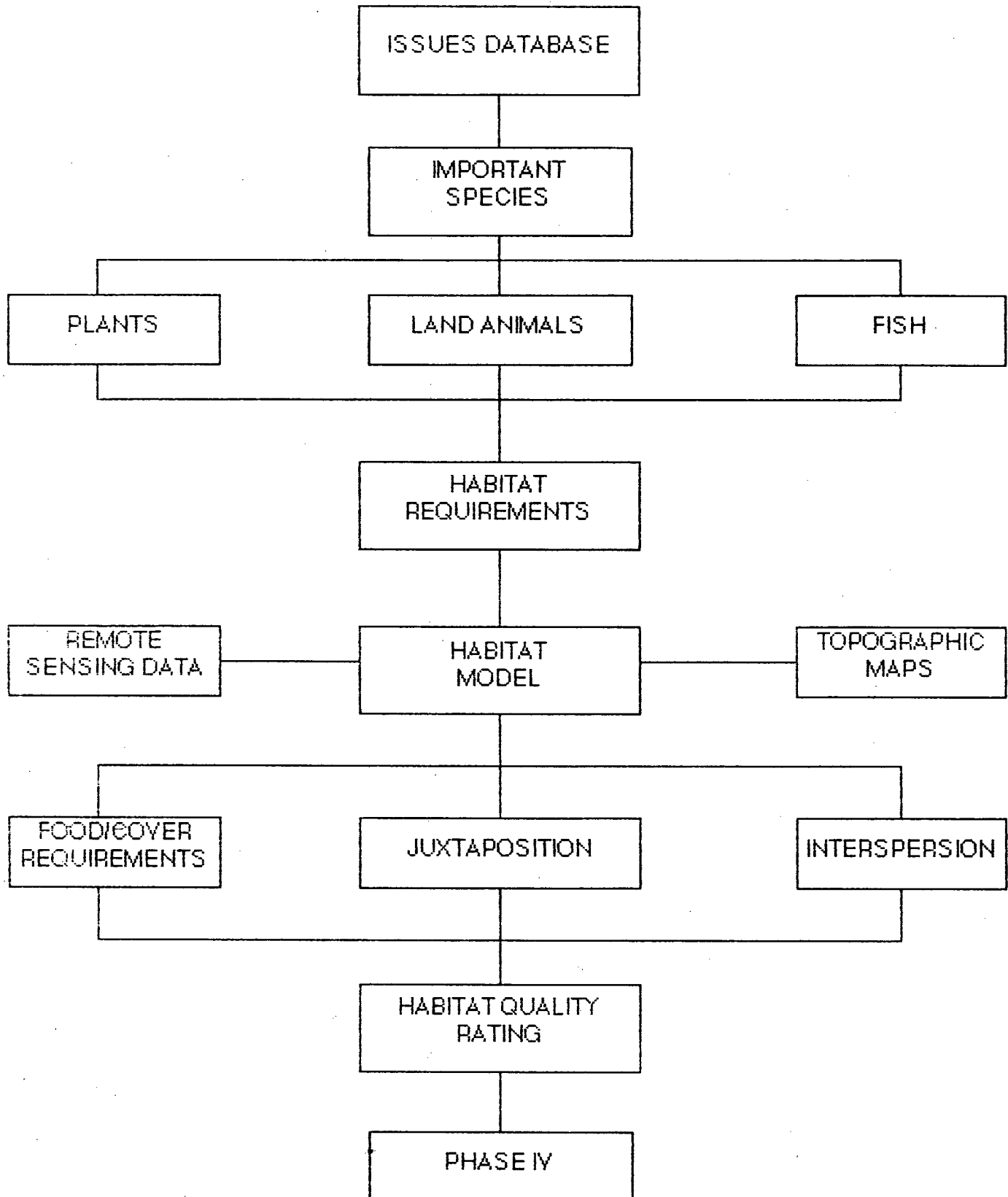


FIGURE 7



impacts of illicit drug cultivation. These findings will be divided into direct impacts, secondary or indirect impacts, and predictions about future impacts based on present trends (see Figure 8).

* The impact assessment will recognize the characteristics of the specific study country. These characteristics include resource endowment, importance of tourism, self-sufficiency in food production, trends in resource use, etc. For example, Peru, a food importer, has experienced a decline in per capita food production over the past 20 years and Jamaica, an exporter of hardwoods, is experiencing a decline in forested area (not including deforestation for drug production). The assessment will be built upon an analysis of the physical effects that stem from the interaction of the drug related activities and the physical characteristics of the affected resources. These linkage relationships and estimates will be developed in a formal quantitative sense and will then be evaluated for likely impact on the country. In other words, the significance of a physical effect will depend upon its implications for the country. For example, soil loss on a forest site would reduce the potential productivity of the site for forest or agricultural production. The specific techniques used to estimate environmental impacts including physical effects will be based on tested procedures appropriate for the quality and level of detail available in supporting data sets. This sequence and examples of the kinds of physical effects and country impacts are summarized in Figure 8.

A summary of the findings as well as captions for all images and maps will be prepared in English and, if requested, other languages. Furthermore, all images will be completely annotated and their relevance to the study explained. For each major finding of the study there will be graphic documentation, in either table, figure or image form. Special attention will be paid to correlating low altitude aerial photography and field photos to specific locations in remote sensing images and maps to facilitate understanding.

ENVIRONMENTAL IMPACT			
CHANGES INDUCED BY NARCOTICS PRODUCTION	RESOURCE CHARACTERISTICS	PHYSICAL EFFECTS	COUNTRY IMPACTS
		<u>DIRECT</u>	
Deforestation	Terrain	Soil Loss	Condition Incurs Cost to Correct
Crop Cultivation Methods	Climate Characteristics	Soil Nutrient Depletion	e.g., Flood Damages
Crop Selection	Soil Characteristics	Biological Changes in Soil	Productivity Loss in Timber, Crop or Fishery Resources
	Water Characteristics	Changes in Soil Structure	
	Natural Cover	Forest Species Loss	Foreign Exchange Loss (Supplanting Imports or Reduced Tourism)
	Wildlife Composition	Timber Loss	Incidence of Impact, i.e. What Group in the Country is Impacted
		Habitat Loss	
			ETC.
		<u>INDIRECT</u>	
		Sediment Deposition on Land or in Water	
		Chemical Changes in Soil or Water	
		Temporal Run-off Pattern Changes	

FIGURE 8



III. TWO EXAMPLES OF SIMILAR PROJECTS

ERIM has conducted numerous projects in developing countries that have objectives or components closely related with the problem of deforestation and environmental degradation that is addressed in this paper. Two of these projects are particularly relevant to this proposed study and are summarized here.

A. REMOTE SENSING OF THE RESOURCES OF LOS ANDES REGION, VENEZUELA

In 1979, the Environmental Research Institute of Michigan (ERIM) was appointed by the Ministry of Mines and Energy of the Government of Venezuela to conduct a field survey in the Los Andes region. The purposes of the survey were to:

- Locate areas for intensive mineral exploitation.
- Locate areas suitable for agricultural development.
- Assess the region's forest resources and provide recommendations for development and use of these resources.
- Identify potential problems areas where resource development should be regulated or restricted.
- Develop recommendations concerning hydrology, transportation, and urban improvements needed to support future developments.

The project area encompassed about 27,500 sq. kms. and included a wide diversity of ecological zones ranging from very dry tropical forests to Alpine rain tundras. It included all of the state of Tachira and parts of the states of Zulía, Mérida, Barinas, Apure and some of the Colombian borderlands.

The Landsat data processed for this program were acquired from both the U. S. Geological Survey's EROS Data Center in Sioux Falls, South Dakota, USA and the Instituto de Pesquisas Espaciais (INPE) near São Paulo, Brazil. Initial printouts indicated that portions of four scenes



were needed to cover the study area but fewer than ten scenes with less than 90% cloud cover, were available since the first Landsat launch for each of the four scene areas. Since completely cloud-free scenes were not available, additional scenes were chosen to minimize the total area obscured. This paucity of suitable data made it necessary to merge data collected during different seasons of different years by different satellites (Landsat 1 and 3). In addition, data obtained from INPE had to be reformatted to the configuration of the EROS data set. While this data heterogeneity necessitated substantial additional processing effort, it clearly demonstrated ERIM's unique capability to handle and process multisource data without any change in their spatial and spectral quality.

The data were geometrically corrected to remove inaccuracies due to orbit and spacecraft perturbations as well as scanner irregularities. Secondly, the data were contrast stretched in order to improve the tonal separation of features and the overall sharpness of the imagery thereby facilitating its interpretation. The images were enlarged to a final scale of 1:250,000 with substantial overlap being obtained between adjacent scenes.

A reconnaissance flight was conducted to acquire photography of typical sites within the project area. The information was intended to support a preliminary categorization of the data in order to prepare a land use/land cover map of the area. The preliminary categorization was performed so as to determine the types of land use/land cover categories that could be mapped with Landsat in the Los Andes region and to indicate areas where specific ground truth information was needed to refine the categorization. The final field survey was conducted by helicopter in lowland areas and by jeep in the mountains. Land features and terrain classes were extensively documented by color photographs and field notes. In addition, radar interpretation provided supplemental information on the areas obscured by cloud cover in the Landsat imagery.

Following final field checking, the categorized data were edited and digitally mosaicked. The final products consisted of a digital map



and area tables of the various land cover/land use classes. These classes were described in detail and numerous comments were made about them in the final report.

Individual crops could not be identified separately; however, the dominant (and meaningful) classes within the project areas were easily identified and separated. These included the following: forested areas (both dense and sparse), burned and cleared areas, bare rocks, cropland/pasture/shrubland, urban, wet lands, water, snow and ice.

The overlap obtained by using adjacent scenes from different dates provided the opportunity for detecting any changes in the time interval of the acquisition of the two scenes. The most significant changes consisted of large scale (illegal) deforestation within the forest reserves, migration of the meanders of the major rivers and regrowth within formerly deforested areas. Some environmental impact of the deforestation could be observed during the field trips. After heavy rains, the color of the river will substantially change for a long time because of the large amount of sediment transported from the unprotected hillsides. In other places whole portions of the hillside will collapse because of solifluction.

Intensive image interpretation supplemented by radar image analysis provided the basis for the geological applications tasks. Lineaments suspected of being fractures were mapped both from Landsat and radar mosaics. The data were then digitized to create contour maps of lineament density and rose diagrams of lineament trends. Ratio images of Landsat band 4 and 5 were used to discriminate iron oxide deposits from other mineral classes in exposed rocks and soils.

The Los Andes project has shown that Landsat data can be used to perform useful exploratory reconnaissance and resource management functions in this particular area of Venezuela and similar environments elsewhere. More importantly, the digital analysis and processing techniques used have shown that interpreted Landsat data can be combined with data from other sources to provide cartographically accurate



digital files of large geographic areas. These files can be used for agricultural and forest resources planning; and with periodic resurveys, for monitoring changes in these resources. The digital files can also be used to provide the basic structure of a geographically-oriented data base which is a true information management system.

B. GEOGRAPHIC INFORMATION SYSTEM IN NATURAL RESOURCES MANAGEMENT IN PERU.

In 1982, the Environmental Research Institute of Michigan, (ERIM) was awarded a contract to assist Peru's National Office of Natural Resources Evaluation (ONERN) in implementing a Land Use Inventory and Environmental Planning project through an agreement between the United States Agency for International Development (USAID) and the Peruvian government. The purpose of the project was to strengthen ONERN's basic capability to provide timely and accurate resource information that would be useful to planners and decision makers in the field of resource inventory and environmental assessment and protection.

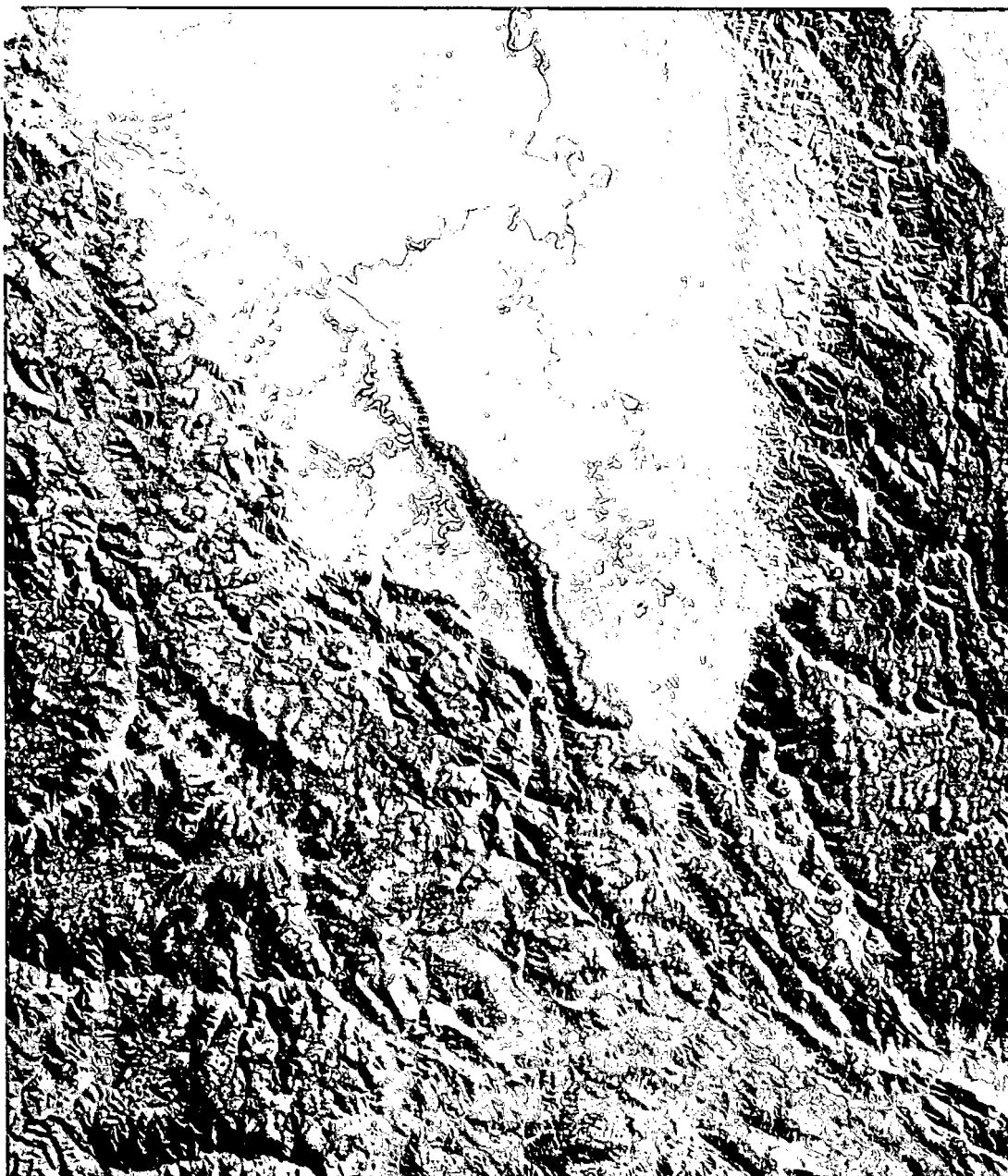
The ONERN/USAID project consisted of three major program components. The first component was a natural resource inventory and information systems phase which emphasized the compilation and assessment of existing resource information, digital processing of Landsat data and color infrared aerial photographic missions to support Landsat interpretation and mapping projects. The second component was the design and installation of a computerized geographic information system (GIS) to be housed in ONERN's recently completed computer facility. The third component consisted of a national environmental profile and a series of three environmental demonstrations which provided ONERN with the opportunity to train personnel and assess the capability of their GIS.

The ONERN GIS procurement could be justified on several counts. The system would greatly enhance ONERN's ability to provide useful and accurate resource information when needed for decision making purposes.

ERIM

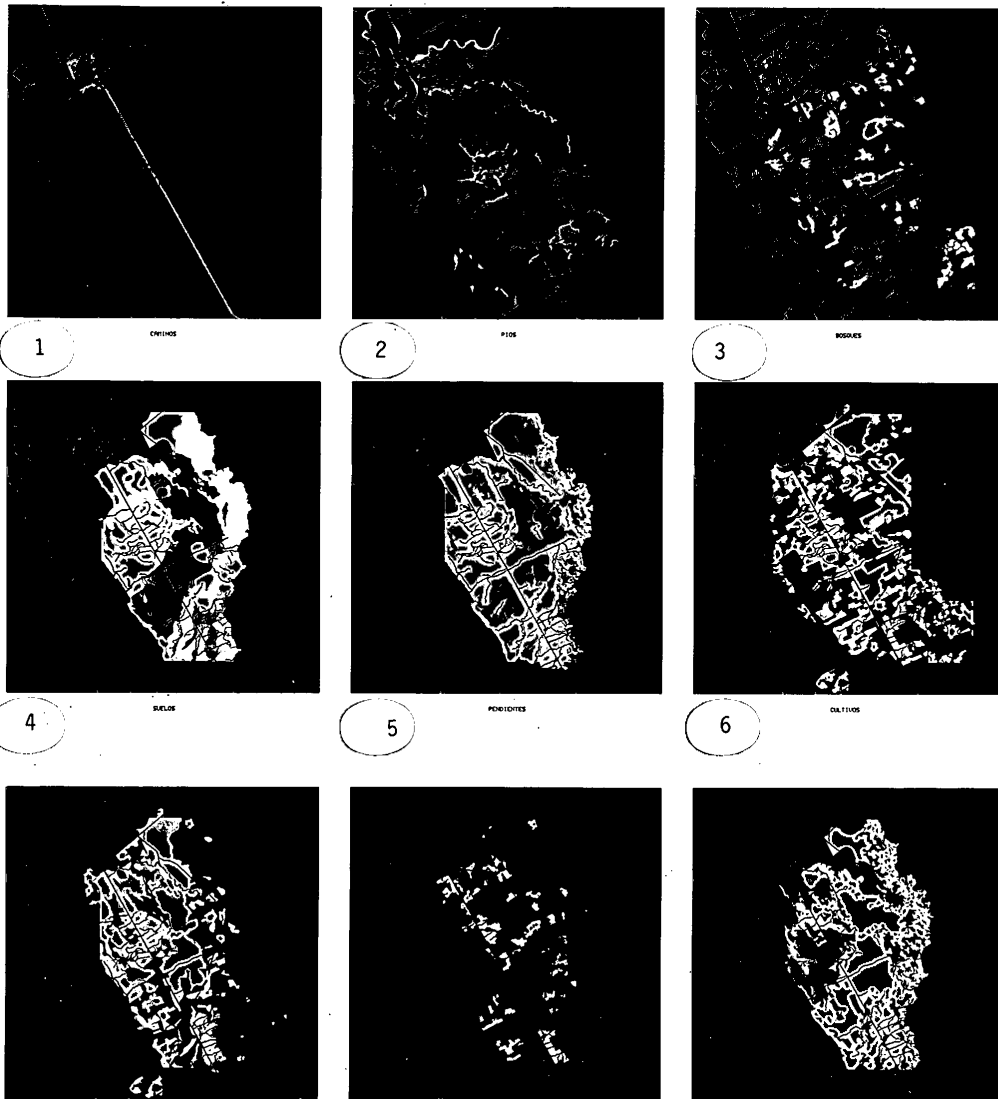
since it would permit storage, manipulation, and display of data and cartographic information which was heretofore impossible. A key objective of the system was to increase the utility of ONERN's existing body of resource knowledge so that valuable information already collected by ONERN could be encoded in the system, integrated with other information, and displayed in new and innovative ways.

The overall goal of the project has been achieved. The various demonstration projects have served to demonstrate the capabilities of the GIS and to familiarize the ONERN and USAID community with its potential to aid in resource management decisions. In the three projects, the current level of agriculture and agricultural potential were examined in the Upper Huallaga with efforts specifically being focused on changing land use and potential environmental degradation as a result of illicit coca cultivation; grazing suitability for several animal species was studied for an area near drought-stricken Puno; and a comparison of land development proposals for the Pichis-Palcazú area was undertaken. This effort is illustrated in Figures 9 and 10.



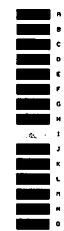
Landsat Multispectral Scanner (MSS) False Color Composite Subscene dated June 6, 1979 of an area along the eastern slopes of the Andes in central Peru immediately to the southeast of the Alto Huallaga Valley. Deforestation and erosion are major environmental problems in the eastern Andes and adjacent piedmont, primarily due to spontaneous colonization and land clearing. Coca cultivation has been a major reason for land clearing in certain areas of the region (Alto Huallaga).

FIGURE 9



PERU
GEOGRAPHIC INFORMATION SYSTEM
ALTO HUALLAGA DEMONSTRATION AREA 1984

The multilayered 20 meter resolution GIS that ERIM developed for USAID proved useful in assessing the magnitude of intensive land use change (principally illicit coca cultivation) and consequent environmental impacts. Specific objectives were to locate and assess land use change using 1980 maps and 1983 CIR photography and determine the resulting change in areas of forest, agriculture, and pasture. Erosion potential was also examined by overlaying land use information with slope classes. Optimal land use of the 100 sq. km. area was determined by comparing 1983 land use with suitability classes generated with the GIS.



Shown at left are nine overlays including (1) Roads, (2) Rivers, (3) Forests, (4) Soils, (5) Slopes, (6) Crops; (7) Co-occurrence of Tocache Soil, Slopes of 0-2%, and Intensive Cultivation; (8) Crop Matrix-Intensive Cultivation vs Slopes of 0-2%, 2-5%, 5-10%, 10-25% and >25%; and (9)

Adaptability of Soils vs Slopes for Intensive Cultivation of Coca.

Scale: 5.3 mm = 1 km

FIGURE 10



IV. ERIM CAPABILITIES

This section briefly describes ERIM's general capabilities and summarizes relevant applications projects. In addition, titles of selected related reports and resumes of key personnel are included.

A. GENERAL CAPABILITIES

The Environmental Research Institute of Michigan (ERIM) is an independent not-for-profit institute engaged in a wide variety of remote sensing research and development activities. A major portion of ERIM's work is in advanced sensor and information processing technology. This work covers sensor instrumentation, the automated extraction of information from sensor data, and the development of new or advanced sensor applications. ERIM is probably best known for its pioneering development of synthetic aperture radar (SAR) systems, infrared (IR), and multispectral scanner (MSS) systems, active-passive scanners, optical and digital image data processing, advanced computer architectures for image processing, and holography.

ERIM is contributing significantly to high technology information transfer by organizing and administering technical conferences such as the International Symposia on Remote Sensing of Environment, the Thematic Conferences on Remote Sensing for Exploration Geology, the National Infrared Information Symposia, and the Tri-Service Radar Symposia. Since 1962 the International Remote Sensing Symposia have been prominent gatherings for scientists and engineers from around the world, who are concerned with civilian applications of remote sensing.

ERIM provides a wide range of remote sensing data collection and interpretation services to the government and civilian sector, performs environmental analyses and resource mapping, and conducts research on information management applications. The staff consists of engineers, physicists, mathematicians, earth scientists, image interpreters, computer specialists, and data collection and processing specialists.



Scientific staff are concerned with applications of remote sensing technology to specific disciplines and problems, such as water resources and bathymetry, wildlife management, land use inventories, cartography, and technology transfer. Other staff are devoted to high technology applications such as robot vision or artificial intelligence for both defense and industry.

ERIM is continually working to increase understanding of the science of imaging and the information contained in imagery. Along with state-of-the-arts processing of remote sensing data into new image products, ERIM is continually developing new data processing techniques. ERIM develops and demonstrates advanced computers for image analysis and interpretation.

ERIM has helped to establish remote sensing centers in several developing countries. Several hundred scientists from the international community have been trained by ERIM staff in applications technology and image processing and analysis methods.

ERIM maintains a flight facility for four aircraft instrumented for sensor research with experimental scanners and radars.

ERIM staff consists of more than 700 full-time research and support personnel, most of whom are located in Ann Arbor, Michigan. ERIM also maintains offices in Arlington, VA, Los Angeles, CA, Fairborn, OH, and Niceville, FL.

ERIM's application staff has extensive experience in field data collection for resource inventories and environmental assessment. A number of relevant application projects are described briefly in the next section.



B. DESCRIPTION OF SELECTED RELATED PROJECTS

Panama Natural Resources Inventory and GIS - 1986-1988

ERIM, under contract to the Government of Panama and the Inter-American Development Bank is currently involved in a remote sensing training and technology transfer project which involves all aspects of remote sensing, including natural resource inventory, pilot projects, technology transfer, and GIS design and installation. Of particular importance is the application of GIS modeling (Sediment Yield Index) in areas of Panama where deforestation, erosion and sedimentation have become serious environmental problems. Environmental monitoring using GIS in such areas is a long-term project goal.

Indefinite Quantity Contract (IQC) for Services - 1984-1986

Through the IQC, ERIM provided remote sensing services to USAID mission and bureaus when required. A variety of remote sensing tasks were undertaken including training a forester from the Ivory Coast in remote sensing techniques for fire scar detection and sponsoring a natural resource management program in Thailand.

India Training I and II - 1984 and 1986

Under contract to the U.S. Department of Agriculture, ERIM provided advanced remote sensing and Geographic Information System (GIS) training to six scientists of the All India Soils and Land Use Survey. The training specifically focused on the application of this technology to agricultural soils and land use study. The applications projects consisted of using GIS technology to develop models that rank watersheds on the basis of sediment yield index (Training I) and their susceptibility to runoff (Training II).



Bangladesh Training Program - 1977-1979

With United Nations/FAO funding, six Bangladeshi scientists were trained at ERIM in digital processing of Landsat Multispectral (MSS) data. Three separate resource investigations were completed including an analysis of land accretion/erosion, and an inventory of forested areas, both in the Ganges delta region. A boro rice crop inventory was also conducted.

Ecuador Technology Transfer and Pilot Project - 1983

ERIM, under subcontract to Purdue University, conducted a visual interpretation workshop at Ecuador's National Remote Sensing Center (CLIRSEN) followed by a digital processing and Geographic Information System (GIS) workshop at ERIM. Fourteen students participated in the first workshop which focused on Landsat image classification and legend preparation. Images of both highland and lowland Ecuador were prepared by ERIM and classification efforts focused on lowland and highland tropical forest classification, as well as eroded highland basin zones. Five persons participated in the subsequent GIS workshop which was followed by additional training at Purdue University.

Peru Land Use Inventory and Environmental Planning - 1982-1984

ERIM, under contract with USAID, worked with the Peruvian government to strengthen its capability to inventory and assess natural resources through projects that are keeping with the nation's developmental and environmental goals. ERIM designed and installed a GIS in Peru that is being used to assess and monitor deforestation and land cover/land use change and their potential impact. In a related follow-on project in 1986, ERIM provided GIS technical support for the GIS installed in 1984.



Costa Rica Land Use Inventory and Mapping Program - 1982-1983

ERIM, under contract with the Inter-American Development Bank and Costa Rica's Instituto Geográfico Nacional (IGN), provided comprehensive Landsat digital processing training to four IGN technicians and subsequently had them participate in the preparation of nine 1:200,000 scale Landsat image quadrangles of Costa Rica. Manual and digital categorization procedures were emphasized in the training with attention being focused on tropical forests and agricultural areas.

Nepal National Remote Sensing Center - 1981-1985

ERIM assisted the Department of Soil Conservation and Watershed Management in Nepal in establishing a national remote sensing center with USAID funds, and providing training in its operation to client staff. This was prompted by needs for natural resource assessment, erosion control, and watershed management.

U.S. Forest Service - 1980-1982

ERIM, under contract to the U.S. Forest Service, developed computer algorithms for change detection and land suitability analysis using Landsat and ancillary data. The principal objective was to consolidate multisource data in a Geographic Information System (GIS) that would support the development of cost-effective forest management procedures.

Mali Land Use Inventory - 1979-1982

ERIM, in cooperation with a major engineering firm, conducted a USAID-funded soils vegetation inventory of southern Mali covering an area of near 600,000 sq. km. using Landsat MSS imagery. The main objective of this project was to derive information on land cover/land use for land capability mapping purposes. Image interpretation and extensive field work was involved.



Sri Lanka Tea Survey - 1979-1981

ERIM assisted the Ministry of State Plantations and the national remote sensing agency in processing 1980 Landsat data in a variety of ways to delineate various conditions of tea plantings. Supervised and unsupervised categorizations were included as were brightness and greenness transformations. This experience provided ERIM with valuable experience on hillside crop condition assessment. In 1982 ERIM provided follow-on support by installing a small digital processing system, and training technicians in its operation.

Italian Agriculture Program - 1979

In addition to advising Telespazio (Italian Space Agency) personnel on agricultural remote sensing, ERIM provided consulting support on using Landsat data for snow mapping purposes which in turn was used for surface water runoff assessment.

Bangladesh Agro-Climatic/Environmental Monitoring Project - 1982-1985

ERIM provided four years of service to the national space agency (SPARRSO) in the use of their newly installed meteorological station. Forest harvesting was one of four applications developed.

USAID Grants - 1975-1976

ERIM has administered 15 USAID remote sensing grants to 13 developing countries since 1975. The grant program supported the creation of remote sensing capabilities in developing countries through small grant awards and technical assistance to developing country scientists. Included were grants for soil conservation studies in Lesotho, palm forest type mapping in Peru, and land use studies in Haiti.



Thailand Training - 1976

ERIM provided one month of remote sensing training for agriculture and forestry applications supported by field work.

C. RELATED ERIM REPORTS

<u>DATE</u>	<u>REPORT TITLE</u>
1985	A Fuelwood Plantation Site Selection for Kenya
1984	A Training Program on Remote Sensing Technology for Land Development - Including a Case Study for Evaluation of the Application of Landsat Data and Geographic Information Systems for Priority Delineation of Watersheds in India
1982	Development and Testing of Landsat-Assisted Procedures for Cost-Effective Forest Management
1981	Analysis and Interpretation of Seasat SAR Data for Portions of Costa Rica, Haiti, and Honduras
1979	Application and Further Development of Remote sensing Techniques for Forest Management
1979	Remote Sensing of the Resources of the Los Andes Region of Venezuela, Volumes 1 and 2
1979	Report of Activities Related to the Collection, Processing, and Analysis of MSS Data over a Forested Test Site in New York
1978	Bangladesh Training Program in the Processing of Landsat Digital Data for Land Accretion, Boro Rice Inventory, and Forestry Applications
1978	Final report - AID's Remote Sensing Grant Program (includes projects on forestry, erosion, and land cover/land use)
1977	Investigation of Techniques for Inventorying Forested Regions
1977	Digital Processing of Landsat Data for the Discrimination of Aguaje and Associated Forest Classes in the Peruvian Amazon
1976	Forest Classification Accuracy as Influenced by MSS Spatial Resolution
1976	Additional Studies of Forest Classification Accuracy as Influenced by MSS Spatial Resolution



- 1974 Analysis of Recreational Land and Open Space Using ERTS-1 Data
- 1974 Yellowstone National Park Mapping from ERTS-1 Computer Compatible Tapes
- 1973 Remote Sensing in Michigan for Land Resource Assessment
- 1972 Contributions to Computer-Generated Land Use Maps of the South-East Forest Region
- 1972 Thermal Contouring of Forestry Data - Wallops Island



D. RESUMES



COLWELL, JOHN E.

RESEARCH SCIENTIST IV

EDUCATION

BS	Geology	University of California, Davis	1967
MS	Forestry	University of Michigan	1969
PhD	Forestry	University of Michigan	1973

EMPLOYMENT

California Department of Agriculture, Crop and Livestock Reporting Service, Summer 1965.

Stanford University, Department of Geology and Mineralogy, Summer 1966.

Mark Systems Inc., Cupertino, California, Remote Sensing Section, Summer 1968.

Willow Run Laboratories, The University of Michigan, Infrared and Optics Laboratory, May-December 1969.

Willow Run Laboratories, The University of Michigan, Infrared and Optics Laboratory, Summer 1970.

Willow Run Laboratories, The University of Michigan, Center for Remote Sensing Information and Analysis, Summer 1971.

Environmental Research Institute of Michigan, 1973-present.

SUMMARY OF EXPERIENCE

Dr. Colwell has been involved in a variety of projects to assess the applicability of remote sensing procedures to rangelands and other vegetation resources. His Ph.D. Dissertation was an analysis of the reflectance of rangeland grasses. Doctor Colwell pioneered in remote sensing of rangeland resources. In his investigation of the Pawnee National Grasslands in Colorado he demonstrated the relationship between remote sensing and rangeland condition. He has developed vegetation indices for monitoring arid land rangelands with MSS data. He has also demonstrated the use of vegetation indices on coarser and finer resolution sensors (e.g., AVHRR and TM).



COLWELL, JOHN E.

RESEARCH SCIENTIST IV

EXPERIENCE (Cont.)

He was involved in developing procedures for assessing wheat yield as part of the Large Area Crop Inventory Experiment (LACIE), a joint project of the USDA, NOAA, and the Department of Agriculture. He prepared a report examining the relative utility of various kinds of remote sensing systems for agricultural monitoring. And he has prepared a review describing the present status and suggesting promising future directions in crop yield forecasting.

Dr. Colwell participated in on-site preparation of a plan to assess wheat yield in Foggia Province, Italy. He has subsequently been involved in further planning with Italian scientists who have visited ERIM for follow-up on the project.

Dr. Colwell has participated in training of Bangladeshi scientists to monitor the boro rice crop of Bangladesh. He has also assisted in developing a procedure for monitoring agricultural resources of a portion of Iran for the Iranian Ministry of Agriculture.

Dr. Colwell has produced a training-oriented summary of the potential and limitations of remote sensing for monitoring agricultural crops in less developed countries. This document was prepared for the U.S. Agency for International Development.

PROFESSIONAL AND HONORARY SOCIETIES

Graduated "with honors", University of California, Davis
Member Phi Kappa Phi (Science Honorary)
Member Phi Sigma Beta (Biological Honorary)
Institute for Environmental Quality Fellow (1971-1973)
Student Policy Advisory Committee, School of Natural Resources,
University of Michigan (1970-72).
NASA Certificate of Recognition and Cash Award for "Creative
Development of Technology" (1979).
NASA Group Achievement Award for "exceptional accomplishments"
(1980).
USDA/Forest Service, Certificate of Appreciation "for
outstanding R&D"

PUBLICATIONS

"Uses of Remote Sensing in the Inventory of Agricultural Crops,"
1972, Willow Run Laboratories, Special Report.



COLWELL, JOHN E.

RESEARCH SCIENTIST IV

- "Bidirectional Spectral Reflectance of Grass Canopies for Determination of Above Ground Standing Green Biomass." 1973. Ph.D. Dissertation, University of Michigan.
- "Vegetation Canopy Reflectance," 1974, Remote Sensing of Environment 3, pp. 175-183.
- "Yield Prediction by Analysis of Multispectral Scanner Data," (with G.H. Suits), 1975, ERIM Report 109600-17-F. Prepared for NASA/JSC on Contract NAS9-14123, Task IX.
- "Wheat Yield Forecasts Using Landsat Data," (with D. Rice and R. Nalepka) 1977. Proceedings of Eleventh International Symposium on Remote Sensing of Environment.
- "Uses of Remote Sensing for Agricultural Statistics in Developing Countries," 1977. ERIM Report 111800-18-T, prepared for Agency for International Development on Contract AID/ta-C-1148.
- "A Technical Review of the US/USSR Joint Study of Vegetation, Soil, and Land Use," with (R. Nalepka, W. Malila, and D. Rice). 1977. ERIM Report 124000-3-T for NASA/JSC on Contract NAS9-15082.
- "Worldwide Wheat Production Forecasts Using Landsat Data," (with R. Nalepka and D. Rice). 1978. In Proceedings of Twelfth International Symposium on Remote Sensing of Environment.
- "Present Status and Future Directions in Crop Yield Forecasting," 1979. ERIM Technical Memo 132400-6-R. ERIM, Ann Arbor, Michigan.
- "Recommendations for an Experimental Landsat-assisted Program of Agriculture and Snow Monitoring in Italy," 1979 (with F. Thomson and R. Cicone). Prepared for Telespazio, Italy, ERIM, Ann Arbor, Michigan.
- "Report of Activities Related to the Collection, Processing, and Analysis of Multispectral Scanner Data Over a Forested Test Site in New York," with (F. Sadowski). 1979. ERIM Report 136900-1-F for U.S. Air Force Contract F30602-78-C-0025.
- "Possible Future Directions in Crop Yield Forecasting," 1979. In Proceedings of Thirteenth International Symposium on Remote Sensing of Environment.



COLWELL, JOHN E.

RESEARCH SCIENTIST IV

- "Use of Landsat Data for Extended Temporal and Areal Assessment of Surface Water Bodies," with (N. Roller). 1980. ERIM Report 141900-6-F for Contract USDI-14-16-0009-79-031.
- "Enumeration of Prairie Wetlands with Landsat and Aircraft Data," with (D.S. Gilmer, E.A. Work, Jr., and D.L. Rebel). 1980. Photogrammetric Engineering and Remote Sensing, Vol. 46, No. 5, pp. 631-634.
- "Detection and Measurement of Changes in the Production and Quality of Renewable Resources," with (G. Davis and F. Thomson). 1980. ERIM Report 145300-4-F for U.S. Forest Service Contract 53-3187-9-47.
- "Landsat Feature Enhancement Or, Can We Separate Vegetation from Soil?". May 1981. Presented at the Fifteenth International Symposium on Remote Sensing of Environment.
- "Forest Change Detection," with (F.P. Weber). May 1981. Presented at the Fifteenth International Symposium on Remote Sensing of Environment.
- "Measurement of Land Accretion in the Coastal Zone of Bangladesh by the Analysis of Landsat Digital Data," July 1981. ERIM Report 501500-2-F for UNDP/FAO.
- "Change Detection and Identification Using Remotely Sensed Data," with (F.J. Thomson). August 1981. Presented at the In-Place Resource Inventories: Principles & Practices, A National Workshop.
- "Data Base Manipulation for Assessment of Multiresource Suitability and Land Change." 1981. ERIM Report No. 154200-1-F.
- "Monitoring the Changing Areal Extent of Irrigated Lands of the Gefara Plain." 1982. Thematic Conference on Remote Sensing of Arid and Semi-Arid Lands, Cairo, Egypt.
- "Developing and Testing of Landsat-Assisted Procedures for Cost-Effective Forest Management." 1982. ERIM Report No. 161800-1-F.
- "Simulation of the Annual and Diurnal Variation in Spectral Directional Reflectance of Selected European Terrain Classes." 1984. ERIM Internal Report.
- "NOAA Satellite Data: A Useful Tool for Macro Inventory and Monitoring." 1985, Environmental Management, Vol. 9, No. 6, pp. 463-470.



COLWELL, JOHN E.

RESEARCH SCIENTIST IV

"Analysis of the Relative Amount of Omission and Commission Errors in Selected Change Detection Procedures." 1984. ERIM Internal Report.

"Investigations of Vegetation and Soils Information Contained in Landsat Thematic Mapper and Multispectral Scanner Data. 1984. ERIM Report No. 160300-101-F.

"Simulation of Reflectance Properties of Selected Terrain Types Under a Variety of Viewing Conditions." ERIM Internal Report, March 1985.

"Regional Inventory of Irrigated Agriculture Through Joint Use of AVHRR Landsat Data, Nineteenth International Symposium on Remote Sensing of Environment, ERIM, Ann Arbor, October 1985.

"Monitoring Desertification Through Detection of Land Cover Changes by Albedo Mapping with AVHRR Data, Nineteenth International Symposium on Remote Sensing of Environment, ERIM, Ann Arbor, October 1985.

Plus a dozen other articles on the use of remote sensing.



DAVID, NANCY A.

EDUCATION

PhD (Applied Mathematics)	University of Maryland	1982
MS (Mathematics)	Stanford University	1971
MS (Statistics)	Stanford University	1970
AB (Statistics)	University of California, Berkeley	1966

EMPLOYMENT

Research Scientist, ERIM, 1983-Present
 Senior Analyst, Everest Consulting Associates, Inc., 1980-1983
 Associate, Technology Research and Analysis Corporation, 1979-1980
 Senior Analyst, Automated Sciences Group, Inc., 1977-1979
 Operations Analyst, SRI International, 1972-1977
 Research/Teaching Assistant, Stanford University, 1969-1972
 Associate Engineer, Lockheed Missiles and Space Company, 1967-1969

SUMMARY OF EXPERIENCE

Dr. David heads the Systems Analysis Section of the Systems Evaluation Department in ERIM's Washington Office. Dr. David is program manager for agricultural applications of radar and for various programs on statistical analysis of data concerning imaging sensors. She is also program manager for studies on narcotics crop estimation and related issues. Since joining ERIM in 1983, Dr. David has conducted image analyst evaluations, analyzed data on image quality and on performance of various sensor systems.

Prior to joining ERIM, Dr. David was a consultant for the Statistics Research Center, sponsored by the U.S. Government, on contract to Everest Consulting Associates. In this capacity, Dr. David consulted on government problems requiring expertise in statistical estimation, sampling strategies and operations research models. Activities included projects on crop estimation and nuclear production/yield.

From 1972 to 1977, Dr. David was program manager and principal investigator for projects in the area of traffic safety at SRI International (formerly Stanford Research Institute). These projects included large scale experiments, often involving police participation. Prior to that, Dr. David was employed by Lockheed Missiles and Space Company, where she developed antisubmarine warfare models.



AFFILIATIONS

Member, American Mathematical Society, American Statistical Association, American Society of Photogrammetry, Operations Research Society of America, and the Society for Industrial and Applied Mathematics

HONORARY AWARDS

Stanford University Fellowship, 1969-1972
California Scholarship Federation, Life member, 1962



FERGUSON, KENNETH P.

RESEARCH & APPLICATIONS SCIENTIST

EDUCATION

MA	Geography	University of Texas-Austin, 1981
BA	Geography	University of Florida-Gainesville, 1974

EMPLOYMENT

Research and Applications Scientist, Information and Processing Division, ERIM, 1985-present.
Remote Sensing Specialist/Geographer, U.S. Geological Survey, Saudi Arabian Mission, 1977-1985.
Geographer, U.S. Geological Survey, 1974-1976.

SUMMARY OF EXPERIENCE

Mr. Ferguson has been directly involved in the application of remote sensing technology to international development problems since 1977. He has developed specifications and monitored the production of Landsat digital cartographic products for the Saudi Arabian Deputy Ministry for Mineral Resources (DMMR). He has compiled a number of geographic maps for the DMMR (see list of publications) using both an Intergraph computer graphics system and conventional compilation methods. He established the first remote sensing center in Saudi Arabia and managed the facility for 8 years. Mr. Ferguson helped to train local scientists in the use of a DIPIX Aries II image processing system at the Center prior to his departure from Saudi Arabia in October, 1985. Mr. Ferguson provided consultative services to several U.S. and Saudi government agencies involved in application of Landsat data to on-going operations concerned with geologic and geographic mapping, environmental conservation issues, remote sensing facility development and management, and training of Saudi scientists in remote sensing methods. He has extensive experience in implementing and completing ground truth surveys in difficult field conditions. Currently Mr. Ferguson coordinates ERIM remote sensing technical support for development projects and investigations in the Middle East and North Africa with particular emphasis on digital cartographic applications.

Mr. Ferguson's advisory assistance to other organizations in Saudi Arabia, are outlined as follows:

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RESEARCH & APPLICATIONS SCIENTIST

Meteorological and Environmental Protection Administration

1. Consulted with the Deputy Director and selected staff on rangeland monitoring methods using Landsat data.
2. Identified habitat of endangered species of gazelle and ibex, and made recommendations for protecting these areas.
3. Assisted staff in interpreting Landsat imagery and compiling maps for a report on management of critical habitats on the Red Sea coast.
4. Advised staff on methods for establishing a remote sensing applications unit.

Ministry for Agriculture and Water

1. Consulted with staff on methods for compiling a schematic soil map of Saudi Arabia at 1:1,000,000-scale using Landsat data products.
2. Written captions for Landsat images used to illustrate Saudi Arabia's first National Water Atlas.
3. Advised staff on methods for mapping agricultural development in the country using Landsat imagery.

Ministry of Planning

1. Advised staff of methods for showing geographic information on Landsat image products for a new National Planning Atlas.

Military Survey Department, Ministry of Defense and Aviation

1. Advised the Director and senior staff on establishment of a Landsat image processing and analysis unit.

King Abdul Aziz City for Science and Technology

1. Co-authored part of a national position paper on Landsat applications in Saudi Arabia.
2. Advised senior staff on establishment of a Landsat ground receiving station.

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RESEARCH & APPLICATIONS SCIENTIST

3. Served by request of the Saudi Arabian delegation as an un-official observer at the Second United Nations Conference on Peaceful Uses of Outer Space (UNISPACE), in Vienna, Austria, 1982.

Arabian American Oil Company (ARAMCO)

1. Cooperated with ARAMCO on a seven year project to produce a new geographic map of the Arabian Peninsula at 1:2,000,000 scale.
2. Conducted workshops in remote sensing and Landsat image interpretation.

Consultant, Brooks, Barr, Graeber and White, Austin, Texas - June 1976 to December 1976. Services to this engineering, planning, and architectural firm were concerned with remote sensing analysis of the immediate vicinity of Buraidah, Saudi Arabia and Qasim Province in the north-central part of the country. The analysis included writing a formal report and providing staff briefings intended to facilitate planning and design of a new town.

Geographer, U.S. Geological Survey, Reston, Virginia - June 1974 to December 1976. Duties included: compiling and synthesizing geographical data from various sources such as high altitude aerial photography and satellite imagery for production of land use and land cover maps; report editing; training summer employees in cartographic techniques; setting up and operating a photographic system for producing 35mm slides at precise scales showing study areas on aerial photography and satellite imagery; briefing and leading tours for foreign visitors.

Instructor, Center for Middle Eastern Studies, University of Texas-Austin from June 1976 through August 1976. Instructed junior and senior level students in a course entitled "Adjustment and Change in the Middle East". Subject matter was geographical and geo-political.

Teaching Assistant, University of Texas-Austin, September 1974 through May 1976. Taught three laboratory sections per week totalling about 40 students per semester on the subjects of climatology, map and aerial photographic interpretation and cultural geography.

Peace Corps Volunteer, August 1966 through August 1968. Was assigned for two years as an agricultural advisor to a small South Indian village to participate in implementation of a joint U.S./Government of India village level food production program. The main objective was to aid local farmers in the introduction of hybrid, high-yielding, proteinous crops to a semi-

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RESEARCH & APPLICATIONS SCIENTIST

arid area of the Deccan plateau with recently developed irrigation resources. Tasks included training local farmers in modern tillage and planting techniques, irrigation, insect control, chemical fertilizing, marketing and co-operative management. Played an important role in reopening a local paper factory which had gone out of business. Conducted an extensive feasibility survey concerning the establishment of a large district level farm for the production of commodities used by the CARE organization in their school lunch feeding program. Designed and coordinated a month long exhibit for the Peace Corps in Bangalore in 1968.

LINGUISTIC KNOWLEDGE

Mr. Ferguson possesses a fair knowledge of written and spoken Arabic, French, and German.

PROFESSIONAL AFFILIATIONS

Fellow - Royal Geographic Society
 Regular Member - Association of American Geographers
 Chairman - Saudi Arabian Natural History Society (1979-1981)

PUBLICATIONS

Greenwood, W.R. and Ferguson, K.P., Jr., Instructions for Compilation of 1:250,000 Scale Geologic and Geographic Maps, U.S. Geological Survey Saudi Arabian Mission Administrative Document, Jiddah, 1980.

Ferguson, K.P., Jr., "Application of Landsat Data to Earth Science Investigations in the Kingdom of Saudi Arabia", in Exploration and Peaceful Uses of Outer Space, National Paper of the Kingdom of Saudi Arabia, Riyadh, Saudi Arabian National Center for Science and Technology, 1982.

Ferguson, K.P., Jr., The Saudi Arabian Deputy Ministry for Mineral Resources Remote Sensing Center: Services and Applications of Landsat Data, U.S. Geological Survey Saudi Arabian Mission Open-File Report, Jiddah, OF-01-2, 1982.

Buttiker, W., and Ferguson, K.P., Jr., "Detection of Faunal Biotopes of Medical Importance in Southwestern Saudi Arabia Using Landsat Images", in Fauna of Arabia, Vol. 5, Jiddah: Saudi Arabian Meteorological and Environmental Protection Administration, 1984.

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RESEARCH & APPLICATIONS SCIENTIST

Ferguson, K.P., Jr., Rogers, Robert H. "Design for a Remote Sensing Center in the Jordan National Geographic Center, Amman: ERIM Report 176510-1-T, Ann Arbor, 1986.

Sellman, A.N., et al., "Thematic Mapper Derived Acreage Estimate of the 1985 Millet/Sorghum Crop in Western Sudan", ERIM Report 192700-1-F, Ann Arbor, 1986.

GEOGRAPHIC MAPS

Ferguson, K.P., Jr., Jackson, R.O., Hadley, D.G., Ramirez, L.F., Mandaville, J.P., and Bowers, S.D., 1984, Geographic Map of the Arabian Peninsula: Saudi Arabian Deputy Ministry for Mineral Resources Arabian Peninsula Map AP-5-B2, scale 1:2,000,000.

Ferguson, K.P., Jr., 1984, Preliminary Landsat Image Map of the Asir Quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Technical Report TR-04-3/IR 624, Scale 1:500,000.

Ferguson, K.P., Jr., 1984, Preliminary Landsat Image Map of the Tihamat ash Sham Quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Technical Record TR-04-2/IR 623, Scale 1:500,000.

Ferguson, K.P., Jr., 1984, Preliminary Landsat Image Map of the Southern Hijaz Quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Technical Record TR-04-6/IR, Scale 1:500,000.

Ferguson, K.P., Jr., 1984, Preliminary Landsat Image Map of the Wadi ar Rimah Quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabia Mission Technical Record TR-04-7/IR 665, Scale 1:500,000.

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GINSBERG, IRVING WILLIAM

MANAGER/SENIOR SCIENTIST

PERSONAL DATA:

Date of Birth: 24 December 1933
Place of Birth: Toronto, Ontario, Canada

EDUCATION

1955 Bachelor of Arts with Distinction from Wayne State University; Major in Physics, minor in Mathematics.

1955 Master Program, Purdue University.

1960 Doctor of Philosophy with Honors from Wayne State University; Major in Theoretical Physics, minor in Mathematics. Dissertation: "The Hydromagnetic Stability of Rotating Spherical Shells of Fluid with Distributed Heat Sources."

ACADEMIC APPOINTMENTS

1955 Teaching Assistant, Purdue University

1955-1956 Teaching Assistant, Wayne State University

1957-1958 G.M. Research Grantee, Wayne State University

1958-1960 Teaching Fellow, Wayne State University

1961-1962 Research Associate, Institute of Science and Technology, University of Michigan

1963-1969 Associate Research Physicist, Institute of Science and Technology, University of Michigan

1964 Lecturer, Cranbrook Institute/Wayne State University

1986 Adjunct Professor, University of Nevada, Las Vegas

PROFESSIONAL EXPERIENCE

1959-1961 Bendix Research Laboratory, Southfield, MI. Physicist. Research in magnetohydrodynamics and theoretical studies of inertial guidance system.

1961-1962 University of Michigan, Institute of Science and Technology, Ann Arbor, MI. Research Associate. Responsible for the theoretical basis of the design

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MANAGER/SENIOR SCIENTIST

- for a laser detector in a radio telescope. Worked on the theory of coherence as applied to lasers.
- 1962-1963 Chrysler Corporation, Detroit, MI. Physicist. Designed and implemented a Q-switched laser source for the Research Laboratories spectrograph.
- 1963-1969 University of Michigan, Institute of Science and Technology, Ann Arbor, MI. Associate Research Physicist. Responsible for research into the reflectance properties of materials. Supervised a group performing target signature analysis. Responsible for studies of the multispectral properties of agricultural vegetation. Responsible for determining the principle basis of multispectral signatures.
- 1969-1972 Sensors, Inc. Ann Arbor, MI. Founder (one of five) and Chief Scientist. Responsible for the development of a line of infrared radiometers. Managed a remote sensing project (funded by U.S. Steel) to map iron ore deposits in the Mesabi. Responsible for the determination of the infrared signature of a U.S. Army armored vehicle. Consultant to Bell Helicopter on infrared countermeasures.
- 1972-1974 Philco - Ford Aeronutronic Division, Newport Beach, CA. Senior Scientist. Directed studies on the infrared signatures of aircraft. Responsible for the evaluation of a two-color infrared air defense missile.
- 1974-1976 Sensors, Inc. Santa Monica, CA and Ann Arbor, MI. Director of New Product Development. Responsible for the development of electro-optical products. Notable were the development of an infrared system for the detection and suppression of fires in armored vehicles, and an automotive emission analyzer.
- 1976-1987 EG&G/EM, Las Vegas, NV. Scientific Specialist III (1976-1977), Section Head IV (1977-1979), Department Head (1979-1987). Responsible for the establishment of a multispectral remote sensing capability for the Department of Energy's Remote Sensing Laboratory.

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GINSBERG, IRVING WILLIAM

MANAGER/SENIOR SCIENTIST

From 1976, the capability has grown from one scientist (Dr. Ginsberg) to more than 25 scientists and technicians who are the primary multispectral remote sensing resource of DOE. He was responsible for providing technical direction and management, and acquiring the acquisition and image processing equipment. Dr. Ginsberg was the primary scientific adviser to the Nevada Operations Office of DOE in the fields of remote sensing, infrared physics, and image processing.

1987 - present Environmental Research Institute of Michigan, Ann Arbor, MI. Manager/Senior Scientist. Responsible for the management of the Remote Sensing Services and Applications (RSS&A) Laboratory. This laboratory consists of three departments, is concerned with the application and exploitation of remotely sensed imagery and support data. The RSS&A Laboratory is the premier organization in: mapping and cartography using satellite imagery, image restoration, data fusion, and using satellite imagery for resource inventory and management. Work is also underway in developing scene simulation and synthesis capability.

PUBLICATIONS

Hydromagnetic Stability of Rotating Spherical Shells of Fluid with Distributed Heat Sources, Bulletin of the American Physical Society; 1960.

Discussion of Reflectance Measurements, I.W. Ginsberg, Sec. 2 of Target Signature Analysis Center: Data Compilation, 8492-5-B; IST, University of Michigan, July 1966.

Spectral Discrimination, Volume I: Methods and Results of Computing Spectral Radiance Statistics for Remote Sensing in the 0.4-1.2 Micron Region, I.W. Ginsberg and J. Beard, IST, University of Michigan, Contract AF 33(615)-3654, Report: 7850-18-P; July 1967.

Modern Infrared Technology, I.W. Ginsberg and T. Limperis, Encyclopedic Dictionary of Physics, Pergamon Press; 1968.

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GINSBERG, IRVING WILLIAM

MANAGER/SENIOR SCIENTIST

Methods of Computing Spectral Radiance Statistics for Remote Sensing in the 0.4-1.2 Micrometer Regions, I.W. Ginsberg and J. Beard, Proc. IRIS, Vol. 12, No. 2.

A Technique for the Detection of Guerrilla Personnel, I.W. Ginsberg, Proc. IRIS, Vol. 13, No. 2.

Target Signature Measurements, (co-author), IST, University of Michigan, Final Report: AFAL-TR-68-198, September 1968.

Target Signature Analysis Center Highlights of Activities, 1967, (co-author), IST, University of Michigan, Report: AFAL-TR-68-185; July 1968.

Target Signature Measurements, (co-author), IST, University of Michigan, Second Interim Report; December 1967.

Target Signature Measurements, (co-author), IST, University of Michigan, First Interim Report; March 1967.

A Comprehensive Target Signature Measurement Program, (co-author), IST, University of Michigan, Final Report AFAL-TR-66-155; December 1966.

The University of Michigan Notes for a Program of Study in Remote Sensing of Earth Resources, contract NAS9-7676, conducted at NASA, MSC, Houston, Texas, 14 February 1968 - May 1968 (co-author).

Engineering Summer Conference Courses, University of Michigan, Lecture notes 1967-1972, Fundamentals of Infrared Technology: Geometric Optics, Physical Optics; Advanced Infrared Technology: Filter Design Theory, Properties of Filters.

A Spectral Discrimination Technique for Agricultural Applications, I.W. Ginsberg, Proceedings of the Sixth Symposium on Remote Sensing of Environment; 1969.

Estimates of the Infrared Signature for the Proposed UTTAS Helicopter, I.W. Ginsberg, Sensors, Inc., Report: 20.158-72; 1972.

Estimates of the Infrared Signature for the UTTAS Helicopter with Daisy Mixer, I.W. Ginsberg, Sensors, Inc. Report: 20.158(A)-72; 1972.

Sky Radiance Data in the 2-5 Micron Band for Engineering Applications, I.W. Ginsberg, Philco-Ford Aeronutronic, TDR Report: ARL-AN/DAW-1-73-15; August 1973.

GINSBERG, IRVING WILLIAM

5/87



GINSBERG, IRVING WILLIAM

MANAGER/SENIOR SCIENTIST

Performance of AN/DAW-1 with MK-28 and New Filters, I.W. Ginsberg, Philco-Ford Aeroneutronic, TDR Report: ARL-AN-DAW-1-83-22, (Contract No. DAAH01-72-C-1050); November 12, 1973.

Geometrical Considerations and Nomenclature for Reflectance, (co-author), NBS Monograph 160, U.S. Department of Commerce, National Bureau of Standards; 1977.

Identification of Heat Losses at INEL, I.W. Ginsberg, EG&G, Inc. Report: RSSD-77-045; September 1977.

Environmental Effects of the Hackberry Fire, Strategic Petroleum Reserve, W. Hackberry, Louisiana, (co-author), EG&G, Inc. Report: EG&G-1183-1767; 1981.

Signature Investigation of Two Underground Nuclear Tests, I.W. Ginsberg, EG&G, Inc. Report: 8101; 1981.

Thermal Infrared Imagery of the Cascade Range Volcanoes, I.W. Ginsberg, Proceedings of a Workshop on Volcanic Hazards in California, California Department of Conservation, Special Publication 63, 1983.

Remote Sensing Technology, Proceedings of a Symposium on Remote Sensing Technology in Support of the United States Department of Energy, I.W. Ginsberg and J.G. Lackey Editors, EG&G/EM Report: EG&G-10282-1057; 1985.

Remote Sensing of LIGA and San Juan Capistrano During FY82, (co-author) EG&G/EM Letter Report, MRSD-86-2; 1986; (SECRET).

A Study of the Properties of the AN/MSQ-118 in the Thermal Infrared Wavelengths, (co-author) EG&G/EM Letter Report, MRSD-86-09, July 1986; (SECRET).

A Statistically Based Glint-Removal Algorithm for Multispectral Imagery, EG&G/EM Letter Report, MRSD-86-14; November 1986.

Fundamentals of Electro-Optical Remote Sensing, I.W. Ginsberg, Krieger Publishing; to be published 1986/1987.

GINSBERG, IRVING WILLIAM

5/87



HARRINGTON, LEIGH

EDUCATION

PhD (Statistics)	University of Connecticut	1968
MS (Statistics)	University of Connecticut	1967
BS	Stanford University	1963

EMPLOYMENT

Research Scientist, System Evaluation Department, ERIM, 1985-Present
Director, Washington Office, Everest Consulting Assoc., 1981-1985
Senior Statistician, Mathematica Inc., 1976-1981
Independent Consultant, 1973-1976
Assistant Professor, Rutgers University, 1969-1971
Lecturer, University College London, 1968-1969

SUMMARY OF EXPERIENCE

Dr. Harrington is a Research Scientist in ERIM's Washington Office. He is currently engaged in various studies related to image interpretation and analysis, statistical models of radar data and sample survey methodologies as it applies to remote sensing. He is a professional statistician with nearly twenty years experience in consulting and education specializing in remote sensing applications, agricultural sample surveys, environmental cost-benefit studies and intelligence analysis.

Prior to joining ERIM, Dr. Harrington was the Director of Washington Operations for Everest Consulting Associates, Inc. While at Everest he was project manager for a large and successful statistics research program for the Central Intelligence Agency. The objective of this program was to identify and exploit statistical methodology useful to intelligence analysts. Example applications include analyzing aspects of international trade; economical and statistical modeling of foreign agriculture; problems related to arms transfers; weapon characteristics/production rates; statistical and economic analysis relating to narcotics and remote sensing sample survey methodology.

While at Everest, Dr. Harrington also directed and was the principal investigator for a Bureau of Mines study to improve BOM production and consumption commodity surveys. He also undertook a study for the Fish and Wildlife Service to optimize their aerial survey of duck habits in the North Central United States and Canada. Dr. Harrington was the principal investigator in several environmental studies, including an analysis of the



Food and Drug Administration's risk assessment of PCB's in fish, a statistical analysis of PCB's concentrations in Hudson River fish and an economic analysis for EPA related to the value of human life and, derivatively, the value of a small change in life expectancy associated with a small change in the environment.

From 1976 to 1981, Dr. Harrington was a senior statistician at Mathematica Inc. While at Mathematica, Dr. Harrington participated in a variety of projects for the CIA relating to SALT verification issues, case histories of concealment, camouflage and deception (CC&D) and the design and construction of computer data bases for CIA analysts.

Prior to Mathematica, Dr. Harrington was an Assistant Professor at Rutgers University and a Lecturer at University College London, London, England.

AFFILIATIONS

Member, American Statistician Association

HONORARY AWARDS

Phi Kappa Phi, Honor Society, 1967
National Defense Education National Fellowship, 1964 - 1967



HICKS, DAVID R.

RESEARCH ENGINEER II

EDUCATION

BA	Geography	Central Michigan University, 1965
MA	Geography	Michigan State University, 1971
PhD	Geography	Michigan State University, 1980

CURRENT RESPONSIBILITIES

Responsibilities at ERIM include acting as liaison and participating in the carrying out of ERIM project tasks and subtasks in Latin America and other world regions, conducting ground truth work on such projects, providing pilot project orientation, preparing and assembling remote sensing training materials for use in ERIM projects, teaching and participating in course development, and providing essential geographic information and analysis in support of ERIM's domestic as well as overseas activities (mainly on, but not confined to Latin America). A second set of responsibilities involves studying the potential role of ERIM in development projects that are being submitted to international lending agencies for funding, following the progress of such projects, and sharing information gained with appropriate ERIM personnel. Participates in the preparation of ERIM project proposals submitted during open bidding for international remote sensing contracts. Evaluates various types of remote sensing data and their potential applicability for specific projects. Provides image interpretation expertise, geographic analyses, and consulting services for specific in-house projects at ERIM.

EMPLOYMENT

Research Engineer, Information and Processing Division, ERIM, 1980-Present.

Part-Time Instructor, January 1980-March 1980, Lansing (Michigan) Community College, Taught course in Economic History.

Research Fellow, Organization of American States. Fellowship awarded to provide financial support for PhD dissertation field research conducted in Brazil.

Teaching Assistant, Michigan State University, 1972-1975; 1978.

HICKS, DAVID R.

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HICKS, DAVID R.

RESEARCH ENGINEER II

Medical Administrative Specialist, U.S. Air Force, 1968-1972.

Instructor, Central Michigan University, 1967-1968.

FOREIGN TRAVEL AND FIELD RESEARCH

Academic

Field geography trip - Ontario, Canada (1965); Yucatan, Mexico (1966); Master's field research (4 months spent in Guatemala 1966-67); field research - Honduras and Venezuela (1973); teaching assistant/researcher in Colombia (1973); Haiti and Dominican Republic (1976); PhD dissertation research (1 year spent in Brazil, 1977); Uruguay and Argentina (1977).

Professional

Argentina, Brazil, Peru, Costa Rica (1981). Participated in sampling frame evaluation in Brazil and ground truth inventory in Argentina, both for AgRISTARS project. Discussed proposed natural resources inventory through remote sensing while in Peru. Similar programs discussed in Costa Rica. Assisted ERIM's Chief-of-Party for six weeks in Peru during start-up phase of Natural Resource Inventory and Environmental Planning Project (1982). Also participated in planning of aerial photography mission during that time. Assisted in the teaching of four-week remote sensing visual interpretation course in Ecuador followed by project identification visit to Panama (1983). Participated in environmental demonstrations of newly installed computerized Geographic Information System (GIS) in Peru during concluding phase of Peru project (1984). Participated in mission planning and conducted field work for ERIM's portion of USAID-sponsored emergency crop area estimation task in western Sudan (1985). Participating in planning, course instruction and field work for Panama natural resources inventory project (1986-1988).

Other

United States, 46 of 50 states including Hawaii. Canada - 2 provinces - much of Ontario and Quebec. Thailand - Extensive in-country travel while serving in U.S. Air Force. Numerous trips and period of residence in Puerto Rico (1973-79). Tourist visits to Egypt and the Netherlands (1985).

HICKS, DAVID R.

2/87



HICKS, DAVID R.

RESEARCH ENGINEER II

FOREIGN LANGUAGES

Fluency in reading, writing, and speaking Spanish
Fluency in reading, writing, and speaking Portuguese
Some knowledge of Russian
Have conducted geographic field research in both Spanish and Portuguese

PUBLICATIONS

Academic

Abstract of Master's thesis then being prepared, published in The Peninsular, Michigan Council on Geographic Education, 1967.

M.A. Thesis: Tourist Areas and Potential along the Pacific Coast of Guatemala, 1971. Field work conducted in Guatemala, in Spanish.

Numerous unpublished papers on economic and transportation development (Brazil and Venezuela) and agricultural colonization (Paraguay), 1973-75.

PhD Dissertation: A Geographic Appraisal of Land Use, Innovation and Government Assistance as Related to Agriculture in Rio Grande do Sul, Brazil, 1980. Field research in Brazil lasted one year, all of which was conducted in Portuguese.

Professional

AgRISTARS Supporting Research, Notes for Brazil Sampling Frame Evaluation Trip, Report No. SR-E1-04138, prepared at Environmental Research Institute of Michigan (ERIM) Ann Arbor under Contract NAS9-15476, August 1981. Field work conducted in Brazil.

AgRISTARS Supporting Research, 1981 Argentina Ground Data Collection, contributing author, Report No. SR-E1-04174, prepared by Environmental Research Institute of Michigan (ERIM) Ann Arbor, and Space Sciences Laboratory of the University of California-Berkeley under Contract NAS9-15476, NAS9-14565, October 1981.

AgRISTARS Supporting Research, Argentina Ground Data Collection Plan for 1981-1982 Crop Year, co-authored with Buzz Sellman (ERIM) Report No. SR-E1-00644, prepared by Environmental Research Institute of Michigan (ERIM) Ann Arbor, with assistance from Space

HICKS, DAVID R.

2/87



HICKS, DAVID R.

RESEARCH ENGINEER II

Sciences Laboratory of the University of California-Berkeley under Contract NAS9-15476, NAS9-14565, November 1981. Also assisted in translation of this publication into Spanish as Plan de Verificacion de Campo y Coleccion de Datos en Argentina para el Ano Agricola 1981-1982, same report and contract number, same publication date.

AgRISTARS Supporting Research, Agronomic Characterization of the Argentina Indicator Region, Report No. SR-E2-04222, prepared at the Environmental Research Institute of Michigan (ERIM) Ann Arbor, with assistance from Space Sciences Laboratory of the University of California-Berkeley, under Contract NAS9-15476, January 1982.

Studying Large Regions Through the Interpretation of Coastal Zone Color Scanner Images: An Example from Southern Argentina and Chile, co-authored with Dr. John Colwell (ERIM) and co-presented with Mr. William Tyler (ERIM) at the East Lakes Meeting, Association of American Geographers, Western Michigan University, Kalamazoo, November 5-6, 1982.

Final Report, Training and Mapping Activities for the Costa Rica Land Use Inventory Program (co-authored with W. Tyler), prepared at the Environmental Research Institute of Michigan (ERIM) under Contract ATN-SF-1869-CR, August 1983.

NOAA Satellite Data: Some multi-purpose applications for the Study of Large Areas prepared with Dr. John Colwell (ERIM) and presented at the annual meeting of the Association of American Geographers, Detroit, April 1985.

NOAA Satellite Data: A Useful Tool for Macro Inventory, co-authored with Dr. John Colwell (ERIM), revision of 1982 Coastal Zone Color Scanner paper. Published in Environmental Management (Nov-Dec 1985).

NOAA Satellite Data: Its Use in Macroinventory for Geographic Assessment, co-authored with Dr. John Colwell (ERIM) and presented at annual meeting of Association of American Geographers (AAG), Minneapolis, May 4-7, 1986.

Currently planning paper on GIS applications in Panama to be presented at 21st International Symposium on Remote Sensing of Environment to be held in Ann Arbor, Michigan from October 26-30, 1987.

HICKS, DAVID R.

2/87



HOGG, HOWARD C.

PROFESSION: Resource Economist Specializing in Resource Planning and Development

EDUCATION

PhD	University of Hawaii - Resource Economics
MS	Oregon State University - Agricultural Economics
BS	Oregon State University - Agricultural Economics

EMPLOYMENT

1985-Present	Consultant, Resource Planning and Development
1984-1985	Visiting Fellow, World Resources Institute, Washington, D.C.
1980-1984	Chief, Earth Resources Branch; Earth and Planetary Exploration Division; National Aeronautics and Space Administration, Washington, D.C.
1975-1980	Chief, Resource Systems Branch; Natural Resource Economics Divisions; Economic Research Service; U.S. Department of Agriculture, Washington, D.C.
1972-1975 (Concurrent Appointments)	Agricultural Economist, Economic Research Service, U.S. Department of Agriculture, Honolulu, Hawaii
1969-1972	Agricultural Production Economist and Agricultural Team Leader, U.S. Technical Assistance Team to the Superintendency of the San Francisco Valley, Government of Brazil
1965-1969	Agricultural Economist, Economic Research Service, U.S. Department of Agriculture, Honolulu, Hawaii
1976-Present	Significant Special Appointments: Member, Projections Review Board, USDA; Editorial Board, <u>Agricultural Economics Research</u> , USDA; Appointment to the Senior Executive Service, NASA; Guest Editor, -Special AgRISTARS edition of <u>Geoscience and Remote Sensing</u> .

SUMMARY OF EXPERIENCE

Dr. Hogg is a specialist in resource planning development, and management (especially monitoring and assessment systems). He has worked at the project, regional, national and to a limited extent global levels in the formulation, evaluation, and implementation of resource projects, policies, and programs. He is familiar with conventional methods for developing data and analytical systems to address these issues as well as the newer resource management techniques that include geographic information systems and remote sensing.



Dr. Hogg has worked in Brazil, Dominican Republic, and Honduras on resource planning and development issues and during the 1984-85 period he was a visiting fellow at the World Resource Institute. Since 1985, Dr. Hogg consulted with the World Bank (Resource Degradation), FAO (Land Use Statistics) and ERIM (Remote Sensing of Renewable Resources). Dr. Hogg also spent 8 years in a research position co-located at the University of Hawaii where he supervised this research, on Asian agriculture and conducted his own successful research program on Hawaiian agriculture. Specific experience includes:

Conducted research in natural resource economics (primarily water resources).

Participated as a member of the U.S. Department of Agriculture (USDA) River Basin Planning Staff in the preparation of watershed plans.

Served as Production Economist and Agricultural Team Leader for a technical assistance team to the Brazilian Ministry of Interior (Superintendency of the San Francisco Valley).

Served as leader of a group responsible for developing analytical and data systems to support national level inter-agency planning activities and policy-program impact analyses.

Managed the NASA component of a large multi-agency agricultural remote sensing program.

Served as a member of the Steering and Technical Program Committees for the 1985 International Geoscience and Remote Sensing Society Symposium.

In addition to the Resource inventory experience cited earlier, participated in the planning and development of an annual world resources report while a visiting fellow at the World Resource Institute (WRI).

Presently provides technical counsel in Resource Economics and the remote sensing of renewable resources to the Environmental Research Institute of Michigan (ERIM) and assisting the statistics division of FAO in preparing a training manual on land use statistics.

PROFESSIONAL ORGANIZATIONS

International Associations of Agricultural Economics
International Geoscience and Remote Sensing Society



LAURIN, RAYMOND

RESEARCH ENGINEER III

EDUCATION

- 1977-78 University of Michigan, School of Natural Resources
Selected courses in remote sensing.
- 1972-77 Michigan State University, School of Agriculture,
Department of Soils, M.S. and Ph.D. in Soil Science.
Area of concentration and interest: soil genesis,
morphology and classification, soil characterization,
land use, remote sensing.
- 1963-66 University of Haiti, School of Law, Port-au-Prince,
Haiti, License in administration.
- 1959-61 Oregon State University, School of Agriculture, BS in
Soils. Area of concentration: soil survey.
- 1955-59 University of Haiti, School of Agriculture, BS in
Agronomy. Area of concentration and interest:
biological sciences, inventory of natural resources,
ecology, soil science.

EXPERIENCE

- 1977 to present Research Engineer - Environmental Research Institute of
Michigan (ERIM), Ann Arbor, Michigan

Develop methods and techniques for the Practical
application of modern remote sensing technology to
resources study (soil mapping, land use study, crop
survey, watershed management). Provide technical
assistance for the utilization of remote sensing.
Design and implement training programs. Monitor grant
projects (Haiti, Zaire, Cameroon). Conduct field survey
(Haiti, Venezuela, Sudan, Mali, Zambia, Algeria,
Tunisia). Prepare and present seminars.

Team Leader. Field data collection for sorghum/millet
production estimate. USAID/Sudan. 1985.
Coordinate field activities; plan data collection
missions; synthesize field data.

LAURIN, RAYMOND

2/87



LAURIN, RAYMOND

RESEARCH ENGINEER III

Project Manager, India Remote Sensing Training (USDA/FAO), 1984/1986.

Design, organize, and implement a training program for six Indian soil scientists. Investigate suitability of Landsat system for improving soil mapping, for monitoring land degradation and for determining watershed priority delineation through Geographic Information System (GIS).

Soil Expert, 1983. A six week mission to Kenya and Zambia to provide technical assistance to ongoing reconnaissance soil survey, by demonstrating a methodology for integrating the use of Landsat image interpretation into the survey; provide guidance for developing soil legends.

Project Manager, Remote Sensing Pilote Project, Ministry of Agriculture, Algeria. (World Bank funded project) 1982-1983.

Design overall program, conduct ground truth, organize training program, write technical reports.

Chief Soil Scientist - Land Resource Inventory Project, Bamako, Mali (USAID funded project). 1980-1982.

Duties and Responsibilities: organize a soil section; conduct preliminary surveys; develop soil vegetation legend; conduct mapping; train a staff in soil classification and in the use of satellite imagery for making soil maps; present seminars; write reports on soils of Mali.

1972-77

Research Assistant - Michigan State University

Duties and Responsibilities: prepare soil maps; assist in teaching soil science; develop methods of soil analysis; train students in mapping and classification of soils, characterize soils.

Post Doctoral Research Associate - Soil Science Department, Michigan State University

Duties: update a soil map of Hillsdale County; write a report on the soils of Hillsdale County.

LAURIN, RAYMOND

2/87



LAURIN, RAYMOND

RESEARCH ENGINEER III

- 1968-71 Resident Soil Engineer - Mueser, Rutledge, Wentworth and Johnston Consulting Engineers, New York, N.Y.
Duties and Responsibilities: supervise sampling and testing of soils; prepare reports on soil properties.
- 1967 Research Fellow - Office de la Recherche Scientifique d'Outre-Mer (ORSTOM), Bondy, France and Pointe a Pitre, Guadeloupe.
Duties: develop methods for analysis of saline soils; prepare a report on Haitian soils.
- 1965-66 Head of Laboratory for Soil and Water Analysis - Land Reclamation Project, United Nations Development Funds, Gonaives, Haiti.
Duties: set up a laboratory for soil and water analysis; develop methods of analysis; train and supervise five agronomists; prepare reports on soil properties and land reclamation.
- 1963-66 Instructor of Soil and Agronomy - School of Agronomy, Haiti
- 1961-67 Assistant Chief of Laboratoire de Chimie et des Terres - Department of Agriculture, Haiti
Duties: conduct routine soils, plants and water analyses; prepare soil maps and land capability maps; teach introductory soils.

PROFESSIONAL AND HONORARY SOCIETIES

Soil Science Society of America
American Society of Photogrammetry

FOREIGN LANGUAGES

French (native tongue)
Spanish (understand well, speak a little)

PUBLICATIONS

Laurin, R., 1968. Les Caracteristiques des Sols et des Eaux de la Plaine des Gonaives et du Nord-Ouest. Technical Report: Projet de recuperation des sols de la Plaine des Gonaives, Haiti, UNDP/FAO.

LAURIN, RAYMOND

2/87



LAURIN, RAYMOND

RESEARCH ENGINEER III

- Laurin, R., 1972. Preliminary report on the soils of Huron County, Michigan.
- Laurin, R., 1973. Argillic and Cambic Horizons developed from High Lime Loam Till Materials, M.S. Thesis, Michigan State University.
- Laurin, R. and E.P. Whiteside, 1977. The Soils of Hillsdale County, Michigan State Agricultural Experiment Station and Hillsdale County Board of Commissioners.
- Lafortune, R., C. Seme and R. Laurin, 1979. Using Landsat Map in the Cul de Sac Plaine, Haiti. Symposium on Remote Sensing, Environmental Research Institute of Michigan.
- Laurin, R. and I. Sibi, 1980. Using Landsat imageries to make soil vegetation maps for large areas in Mali, West Africa. First Thematic Conference on Arid and Semi-arid Lands, Cairo, Egypt.
- Laurin, R. and N. Roller, 1982. Expose de la Methologie pour un projet de Teledetection.
- Laurin, R. 1982. Remote Sensing with Landsat in Tunisia. Present needs, current use and prospect for future utilization.
- Laurin R. 1983. Reconnaissance Soil Survey with Landsat in Zambia, East Africa. Nairobi Regional Remote Sensing Center.
- Laurin, R. and F. Thomson, 1983. Notes techniques sur les criteres de selection des scenes Landsat du projet pilote de Teledetection en Algerie.
- Laurin, R. 1983. Rapport sur la formation delivree a six ingenieurs Algeriens dans le cadre d'un projet pilote de Teledetection.
- Laurin, R., J. Colwell, G. King, R. Reinhold, N. Roller, F. Tanis. 1983. Projet Pilote de Teledetection en Algerie, Vol. I and II, Rapport Final.
- Crist, E.P., R. Laurin, J.E. Colwell and R.J. Kauth, December 1984. Investigations of Vegetation and Soils Information Contained in Landsat Thematic Mapper and Multispectral Scanner Data. ERIM Report 160300-101-F.

LAURIN, RAYMOND

2/87



LAURIN, RAYMOND

RESEARCH ENGINEER III

Laurin, R., editor. June 1985. Amenagement des Bassins Versants. Proceedings of a Seminar. Ministry of Agriculture. Cayes, Haiti.

Laurin, R. September 1985. Amenagement des Bassins Versants. Proceedings of a Workshop. Ministry of Agriculture. Limbe, Haiti.

Sellman, B., et al., January 1986. Thematic Mapper Derived Acreage Estimate of the 1985 Millet/Sorghum Crop in Western Sudan, ERIM Report 192700-1-F.

Laurin, R. November 1986. Remote Sensing in Natural Resources Development - Capsules on the State of the Art. Review Paper presented at the U.N. Conference for the Arab World. Tunis.

LAURIN, RAYMOND

2/87



LEWYCKYJ, Roman M.

EDUCATION

MS	George Mason University	Cand
MS	Georgetown University	1983
BS	Villanova University	1978

EMPLOYMENT

Research Scientist, System Evaluation Department, ERIM, 1986-Present
Analyst, Everest Consulting Associates, 1981-1985
Research Analyst, MATHTECH, 1980-1981

SUMMARY OF EXPERIENCE

Mr. Lewyckyj is a Research Scientist in the System Evaluation Department of the Washington ERIM Office. He has either led or participated in a number of research tasks designed to improve image quality and performance models through analysis and evaluations using image analysts. He is the principal investigator for a project to improve extant state-of-the-art methods used in estimating the nuclear yields of foreign underground tests. He has also participated in studies to assess the accuracy of ballistic missiles.

Prior to joining ERIM in January 1986, Mr. Lewyckyj was a staff analyst with Everest Consulting Associates, Inc., in Arlington, Virginia. At Everest, Mr. Lewyckyj conducted research on selected Third World economies, agricultural problems and anthropological aspects of traditional cultivation practices in Bolivia, Brazil, Columbia and Peru. As a principal investigator, he completed an extensive survey and analysis of methodologies for estimating "underground" economies. While under contract with the US Government, Mr. Lewyckyj contributed to a number of studies on the social and economic aspects of illicit crop production and trafficking.

Mr. Lewyckyj was also a principal investigator for a Bureau of Mines project to develop a world-wide data base on nonferrous ore and metals production (copper, lead, zinc, and aluminum) and production costs/economics.



Prior to joining Everest, Mr. Lewyckyj was a research analyst for Mathematica, Inc., and supported a deception research program sponsored by the US Government. There he contributed to a number of projects on Soviet military and political affairs.

Mr. Lewyckyj received his B.A. in History at Villanova University and an M.A. in Russian Area Studies from Georgetown University. He is currently pursuing a graduate study program in economics at George Mason University. He has excellent language capabilities in Russian and a fair working knowledge of Spanish.

AFFILIATIONS

American Economic Association, Association for Comparative Economic Studies, Southern Economic Association

HONORARY AWARDS

Pi Eta Sigma, Honor Society, 1974
Phi Kappa Phi, Honor Society, 1976



MACRAE, BARRY D.

MANAGER, TECHNIQUE DEVELOPMENT GROUP

EDUCATION

BSEE	The University of Michigan	1964
BA	The University of Michigan	1961

EMPLOYMENT

Manager, Technique Development Group, Information and Processing Division, ERIM 1985-present.

Head, Image Processing Facility Software Support Group, ERIM 1978-1985.

Head, Earth Resources Data Center Software Support Group, Bendix Aerospace Systems Division, 1975-1978.

System Engineer, Earth Resources Data Center, Bendix Aerospace Systems Division, 1971-1974.

Research Engineer, Radio Astronomy Group, University of Michigan, 1961-1971.

SUMMARY OF EXPERIENCE

Mr. MacRae has participated and provided technical direction in the utilization of computer technology for the acquisition and analysis of multisource data since 1961. This experience includes both hardware system design and application software system development. He has also had extensive experience in the area of technology transfer to developing countries including both the installation of image processing computer systems and training in their use. He has provided services a number of times to USAID in the areas of computer facility design, including personnel structures, training of personnel in facility operations, and project assessments. He was instrumental in the development of Geographic Information System technology within ERIM, utilizing experience in the areas of generation and manipulation of georeferenced digital data bases. He currently heads a group responsible for development of advanced techniques for processing and utilizing multisource data for environmental monitoring, resource management, and land use planning.

Mr. MacRae began his career (1961-1971) with the design and construction of low frequency radio frequency radio astronomy experiments for space applications. This work included not only the design of the actual hardware device but also development of a high reliability test procedure for certifying previously unqualified



MACRAE, BARRY D.

MANAGER, TECHNIQUE DEVELOPMENT GROUP

EXPERIENCE (Cont.)

electronic components for space environments. As a result of this quality assurance effort, the three experiments launched during the period of involvement with this project all exceeded their expected lifetimes and all were still operating at the time the supporting spacecrafts were deactivated. As a part of this project, he implemented and supervised a computer facility for processing the received data. He also designed and implemented digital logic interfaces between the computer system and photographic displays, direct-view displays, and an incremental pen plotter. He provided both system and application level software support for scientific studies utilizing the radio astronomy data.

In 1972 Mr. MacRae accepted a position with Bendix Aerospace Systems Division to design and implement a digital image processing facility to support utilization of satellite (Landsat) and airborne multispectral scanner data for use in earth resources and applications studies. The result of this effort became known as the Bendix Earth Resources Data Center (ERDC). Following the implementation of the ERDC he served as system software manager and, using the ERDC as a prototype, he managed and participated in software development programs for multispectral image analysis systems for the governments of Argentina, Japan, India, Egypt, and Brazil.

In conjunction with his software development efforts at Bendix, he also designed special purpose digital logic subsystems for the ERDC and a precision intervalometer for producing stereoscopic imagery from airborne photography.

He participated in the training of scientists at Bendix from India, Bangladesh, and Argentina in the utilization of image analysis systems in processing remote sensing data for land use classification and resource planning studies. In addition, he conducted onsite instruction in the use of delivered image analysis systems in Japan, India, Egypt, Argentina, and Brazil.

In August, 1978 Mr. MacRae joined ERIM upon the transfer of the ERDC from Bendix to ERIM. His initial effort was participation in development of a Remote Image Analysis System (RAS) under a NASA Technology Transfer program. This system allowed access to a powerful image processing software system residing on the ERIM ERDC computer facility via telephone lines utilizing a portable interactive color display system. Following this development, he was responsible for software development providing Geographic Information System capability



MACRAE, BARRY D.

MANAGER, TECHNIQUE DEVELOPMENT GROUP

EXPERIENCE (Cont.)

on the same hardware system. This responsibility extended to the training of representatives of various educational institutions, government agencies, and private companies in the utilization of the system for specific projects. During this period he also served as both system and application level software support for the ERDC in the development of techniques for radiometric and spatial enhancements of multispectral data.

He was responsible for the design and implementation of a Geographic Information System for the Government of Peru to provide land use/resource assessment and management for the entire country. This responsibility included project management, technical participation in the software system development, and onsite training of the facility personnel in Peru.

He recently provided technical direction to USAID on the operation and maintenance of a computer facility in Dhaka, Bangladesh for the processing of meteorological land multispectral satellite data. This project involved assessment of the current status of the project with recommendations on organizational structure, system maintenance programs, and personnel training programs.

Current responsibilities include technical direction in the upgrade of a multispectral image analysis computer facility at the Remote Sensing Center in Cairo, Egypt. This responsibility includes both program supervision and technical participation in the installation of specialized hardware and the requisite software to provide map generation capability utilizing satellite data. He is also responsible for the design and implementation of an Image Processing/Geographic Information System for the Government of Panama.

Mr. MacRae currently heads up the Technique Development Group within the Information and Processing Division. This group is responsible for the development of advanced techniques for the processing and integration of multisource data. These techniques include such problems as the correction of satellite and airborne scanner data to produce cartographic data bases, extraction and merging of various source data into georeferenced data bases, and the manipulation and utilization of this data.



MACRAE, BARRY D.

MANAGER, TECHNIQUE DEVELOPMENT GROUP

PROFESSIONAL MEMBERSHIPS

American Society for Photogrammetry and Remote Sensing
American Congress on Surveying and Mapping
International Society for Photogrammetry and Remote Sensing
Working Group IV/2 - Mapping Technology and Application for
Developing Countries

PUBLICATIONS

Co-author, "Agro-Climatic/Environmental Monitoring Project Assessment Final Report", Dhaka, Bangladesh, December 1985.

Co-author, "Development of Geographic Information Systems for Poorly Mapped Areas of the World," ASP/ACSM, Auto Carto 7, Washington, DC, March 1985.

Co-author, "Development of Geographic Information Systems for Developing Countries," EGLR-ASP Conference, Detroit, Michigan, December 1983.

Co-author, "Applications of Geographic Information Systems in Land Use Planning", 20th Annual URISA Conference, Minneapolis, Minnesota, August 1982.

Co-author, "Land Use Capability Assessment Using Geographic Information Systems", Auto-Carto 5, Crystal City, Virginia, August, 1982.

Co-author, "Makassar Straits Landsat Water Depth Analysis", Final Report, ERIM, 1982.

Operator's Manual, Bendix Multispectral Data Analysis System, Bendix, 1975.

Operator's Manual, Argentina Image Analysis System (STAI), Bendix, 1974.

Five (5) technical reports on Radio Astronomy experiments for space applications, University of Michigan.



MALILA, WILLIAM A.

RESEARCH ENGINEER IV

EDUCATION

BS Electrical Engineering, Michigan State University, 1956
 MS Electrical Engineering, Stanford University, 1960
 PhD Forestry (with remote sensing specialization),
 University of Michigan, 1974

EMPLOYMENT

Engineering Trainee, Bendix Missile Division, 1956
 Communications Officer, U.S. Air Force, 1956-1959
 Graduate Research Assistant, University of Michigan, WRL, 1960-1963
 Research Associate, University of Michigan, WRL, 1963-1968
 Associate Research Engineer, University of Michigan, WRL, 1968-1972
 Research Engineer, Environmental Research Institute of Michigan,
 1973 to present

EXPERIENCE

Dr. Malila has extensive experience in the development and testing of techniques to extract and quantify information from multispectral remote sensor data for earth resource survey applications.

He served as principal investigator for ERIM investigations under the Landsat-4 and -5 Image Data Quality Analysis Programs and for satellite calibration documentation for the International Satellite Land Surface Climatology Project. He participated in a five-week course in Nepal on Remote Sensing Applications in 1983; his primary teaching responsibility was for agricultural applications.

- He previously was Co-Investigator on Landsat-1 and Skylab (S-192) projects to develop techniques to compensate for atmospheric effects, preprocess to improve spectral recognition performance, and estimate proportions of unresolved objects. He also served for several years as a Task Leader on related Supporting Research and Technology investigations for the NASA/JSC Earth Resources Survey Program, including the Large Area Crop Inventory Experiment (LACIE), the Nationwide Forestry Applications Program (NFAP), and Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS). These tasks included development of spectral and temporal discrimination and recognition processing



MALILA, WILLIAM A.

RESEARCH ENGINEER IV

EXPERIENCE (Continued)

techniques, development of physical understanding of agricultural and forestry practices and remote sensing approaches through analysis of field measurement data, system simulation and modeling of atmospheric, scene reflectance and sensor effects, and development of radiation balance mapping, multi-aspect remote sensing, change detection and through-the-season crop inventory techniques.

His earlier experience on Air Force contracts dealt with target detection and threat warning techniques, including studies of spatial filtering, infrared radiation measurement and analysis, threat warning systems analysis and flight test planning and evaluation. Recent activities include investigation of mine detection using reconnaissance assets.

PROFESSIONAL AND HONORARY SOCIETIES

Tau Beta Pi
Eta Kappa Nu
Institute of Electrical and Electronics Engineers
Xi Sigma Pi



MALILA, WILLIAM A.

RESEARCH ENGINEER IV

PUBLICATIONS

Doctoral Dissertation

Information Extraction and Multi-Aspect Techniques in Remote Sensing, The University of Michigan, Ann Arbor, MI, Thesis Abstract 75-748, University Microfilms, Ann Arbor, MI, 1974.

Articles and Presentations on Earth Resource Survey Applications

Multispectral Techniques for Image Enhancement and Discrimination, Photogrammetric Engineering, June 1968.

How Multispectral Sensing Can Help the Ecologist, F. Polcyn, N. Soansail and W. Malila. Remote Sensing in Ecology, edited by P.L. Johnson, University of Georgia Press, 1969.

Preprocessing Transformations and Their Effects on Multispectral Recognition, Proceedings of the 6th Int'l Symposium on Remote Sensing of Environment, F. Kriegler, W. Malila, R. Nalepka and W. Richardson. Willow Run Laboratories and University of Michigan Extension Service, Ann Arbor, MI, October 1969.

Importance of Atmospheric Scattering in Remote Sensing, R.E. Turner, W.A. Malila and R.F. Nalepka. Proceedings of the 7th Int'l Symposium on Remote Sensing of Environment, WRL, University of Michigan, Ann Arbor, MI, May 1971.

Radiation Balance Mapping with Multispectral Scanner Data, in Remote Sensing of Earth Resources, Vol. I, edited by F. Shahrokhi, The University of Tennessee Space Institute, Tullahoma, TN, 1972.

Information Extraction Techniques for Multispectral Scanner Data, W. Malila, R. Crane, W. Richardson and R. Turner. Fourth Annual Earth Resources Program Review, Vol. II, Sec. 29, Manned Spacecraft Center, Houston, TX, January 1972.

Contributions to text used as foundation for the UNESCO/IGU Second Symposium on Geographic Information Systems, Ottawa, Canada, August 1972.

ERIM

INFRARED AND OPTICS DIVISION

MALILA, WILLIAM A.

RESEARCH ENGINEER IV

PUBLICATIONS (Continued)

Suitability of the Normal Density Assumption for Processing Multispectral Scanner Data, R. Crane, W. Richardson and W. Malila. IEEE transactions on Geoscience Electronics, Vol. GE-10, No. 4, October 1972.

Multispectral Remote Sensing of Elements of Water and Radiation Balances, W. Malila and T. Wagner. Proceedings of the 8th Int'l Symposium on Remote Sensing of Environment, Ann Arbor, MI, October 1972.

The Surveillant Science, Remote Sensing of the Environment, R.K. Holz, Ed., Houghton Mifflin Co., 1973, Chapter 40 is a reprint of "How Multispectral Sensing Can Help the Ecologist" referenced earlier.

Atmospheric Effects in ERTS-1 Data, and Advanced Information Extraction Techniques, W. Malila and R. Nalepka. Proceedings of the Symposium on Significant Results Obtained from ERTS-1, NASA SP-327, New Carrollton, MD, March 1973 (Also ERIM 193301-12-S/SA/J).

Correlation of ERTS MSS Data and Earth Coordinate Systems, W.A. Malila, R.H. Hieber and A.P. McCleer. Proceedings of the Conference on Machine Processing of Remotely Sensed Data, Purdue University, W. Lafayette, IN, October 1973 (Also 193300-18-SA/J, August 1973).

Advanced Processing and Information Extraction Techniques Applied to ERTS-1 MSS Data, W. Malila and R. Nalepka. Proceedings of the 3rd ERTS Symposium, Vol. I, pp.1743-1772, NASA SP-351, Washington, D.C., December 1973.

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First Results from the Crop Identification Technology Assessment for Remote Sensing (CITARS), F.G. Hall, M.E. Bauer and W.A. Malila. Proceedings of the 9th Int'l Symposium on Remote Sensing of Environment, Ann Arbor, MI, April 1974.



INFRARED AND OPTICS DIVISION

MALILA, WILLIAM A.

RESEARCH ENGINEER IV

PUBLICATIONS (Continued)

Influence of the Atmosphere on Remotely Sensed Data, R. Turner, W. Malila, R. Nalepka and F. Thomson. Proceedings of the SPIE 18th Annual Technical Meeting, San Diego, CA, August 1974.

Chapter 22, Crops and Soils, Vol. II Manual of Remote Sensing, Contributing author. American Society of Photogrammetry, Falls Church, VA, 1975.

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The Influence of Multispectral Scanner Spatial Resolution on Forest Feature Classification, F.G. Sadowski, W.A. Malila, J.E. Sarno and R.F. Nalepka. Proceedings of the 11th Int'l Symposium on Remote Sensing of Environment, Ann Arbor, MI, April 1977.

Multispectral System Analysis Through Modeling and Simulation, W.A. Malila, J.M. Gleason and R.C. Cicone. Proceedings of the 11th Int'l Symposium on Remote Sensing of Environment, Ann Arbor, MI, April 1977.

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Applications of Modeling to Analysis and Processing of Landsat Data, W.A. Malila, J.M. Gleason, F.G. Sadowski, R.C. Cicone and E.P. Crist. Proceedings of the 12th Int'l Symposium on Remote Sensing of Environment, Manila, Philippines, April 1978.



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Landsat Features for Agricultural Applications, W.A. Malila, P.F. Lambeck and E.P. Crist. Proceedings of the 14th Int'l Symposium on Remote Sensing of Environment, Costa Rica, April 1980.

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PUBLICATIONS (Continued)

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Investigations of Spectrum Matching Techniques for Remote Sensing in Agriculture (Vol. II - M. Spencer, W. Malila, R. Nalepka and J. Penquite; Vol. I - Contributor). Report No. 6590-9-F (II/I), Willow Run Laboratories (WRL), The University of Michigan (U of M), Ann Arbor, MI, November 1967.

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PUBLICATIONS (Continued)

The Use of ERTS Data for a Multidisciplinary Analysis of Michigan Resources, W. Malila, J. Sarno, T. Wagner, J. Lewis and J. Erickson. Report No. ERIM 197500-28-F/197600-27-F, September 1974.

Use of ERTS Data for a Multidisciplinary Analysis of Michigan Resources, W. Myers, G. Safir, A. Anderson, D. Mokma, E. Whiteside, H. Winters and R. Bieck of Michigan State University Agricultural Experiment Station, East Lansing, MI; and W. Malila, J. Sarno, T. Wagner, J. Lewis and J. Erickson of ERIM, Ann Arbor, MI, November 1974.

Final Report on the CITARS Effort by the Environmental Research Institute of Michigan, W. Malila, D. Rice and R. Cicone. Report No. ERIM 109600-12-F, NASA CR-141851, April 1975.

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Image Enhancement and Advanced Information Extraction Techniques, W. Malila, R. Nalepka and J. Sarno. Report No. ERIM 101900-63-F, NASA CR-143074, June 1975.

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Wheat Signature Modeling and Analysis for Improved Training Statistics, W. Malila, R. Cicone and J. Gleason. Report No. ERIM 109600-66-F, NASA CR-151002, May 1976.

Wheat Signature Modeling and Analysis for Improved Training Statistics, Supplement: Simulated Landsat Wheat Radiances and Radiance Components, W. Malila, R. Cicone and J. Gleason. Report No. ERIM 109600-66-F_S, NASA CR-151087, May 1976.



MALILA, WILLIAM A.

RESEARCH ENGINEER IV

PUBLICATIONS (Continued)

Investigation of Spatial Misregistration Effects in Multispectral Scanner Data, W. Malila, J. Gleason and R. Cicone. Report No. ERIM 109600-68-F, NASA CR-150999, May 1976.

A Technical Review of the US/USSR Joint Study of Vegetation, Soil, and Land Use, R. Nalepka, W. Malila, J. Colwell and D. Rice. Report No. ERIM 124000-3-T, October 1977.

Investigations of Spectral Separability of Small Grains, Early Season, Wheat Detection, and Multicrop Inventory Planning, W. Malila and J. Gleason. Report No. ERIM 122700-34-F, NASA CR-151553, November 1977.

Investigation of Techniques for Inventorying Forested Regions -- Volume I: Reflectance Modeling and Empirical Multispectral Analysis of Forest Canopy Components, F. Sadowski and W. Malila. Report No. ERIM 122700-35-F₁, NASA CR-151561, November 1977.

Investigation of Techniques for Inventorying Forested Regions -- Volume II: Forestry Information System Requirements and Joint Use of Remotely Sensed and Ancillary Data, R. Cicone, W. Malila and E. Crist. Report No. ERIM 122700-35-F₂, NASA CR-151575, November 1977.

The Threshold of Detection of Vegetation Canopies Using Remotely Sensed Data, D. Rice, W. Malila and R. Nalepka. Report No. ERIM 124000-5-P, January 1979.

Development of Procedure M for Multicrop Inventory, With Tests of a Spring-Wheat Configuration, R. Cicone, E. Crist, R. Kauth, P. Lambeck, W. Malila and W. Richardson. Report No. ERIM 132400-16-F, February 1979.

Application and Further Development of Remote Sensing Techniques for Forest Management, F. Thomson, C. Wilson, F. Sadowski, W. Malila and R. Dye. Report No. ERIM 138400-6-F, September 1979.

Development of Landsat-Based Technology for Crop Inventories, Q. Holmes, R. Horvath, R. Cicone, R. Kauth and W. Malila. Report No. ERIM 132400-29-F₁ (SR-E9-00404₁), December 1979.



MALILA, WILLIAM A.

RESEARCH ENGINEER IV

PUBLICATIONS (Continued)

Development of Landsat-Based Technology for Crop Inventories: Appendices, Q. Holmes, R. Horvath, R. Cicone and W. Malila. Report No. ERIM 132400-29-F₂ (SR-E9-00404₂), December 1979.

Applicability of Selected Wheat Remote Sensing Technology to Corn and Soybeans, D. Rice, E. Crist and W. Malila. Report No. ERIM 124000-9-F, January 1980.

An Algorithm for Estimating Crop Calendar Shifts of Spring Small Grains Using Landsat Spectral Data, E. Crist and W. Malila. Report No. 132400-41-T (SR-E0-00459), June 1980.

Development and Evaluation of an Automatic Labeling Technique for Spring Small Grains, E. Crist and W. Malila. Report No. ERIM 152400-3-T (SR-E1-04065), June 1981.

Research and Development of Landsat-Based Crop Inventory Techniques, R. Horvath, R. Cicone and W. Malila. ERIM Report No. 152400-21-F, NASA AgRISTARS Report No. MU-E2-04226, January 1982.

Investigation of Radiometric Properties of the Landsat-4 Multi-spectral Scanner, Final Report, D.P. Rice and W.A. Malila. ERIM Report No. 163200-3-F, August 1983.

Study on Spectral/Radiometric Characteristics of the Thematic Mapper for Land Use Applications, Final Report, W.A. Malila and M.D. Metzler, ERIM Report No. 164000-19-F, September 1985.

Satellite Data Availability and Calibration Documentation for Land Surface Climatology Studies, Final Report, W.A. Malila and D.M. Anderson, ERIM Report No. 180300-1-F, January 1986.



MALILA, WILLIAM A.

RESEARCH ENGINEER IV

PUBLICATIONS (Continued)

Publications on Defense-Related Topics

Detection, Location and Identification of Defensive Radars, W. Malila and P. Wierenga. Report No. WRL 4479-28-T, AD-340-288, August 1963 (Secret).

Passive Microwave Detection of Threats to Aircraft, J. Beard and W. Malila. Report No. WRL 4479-30-T, AD-344-892, October 1963 (Secret).

Threat-Detection and Target-Warning Techniques, J. King and W. Malila. Final Report No. WRL 4479-31-F, AD-344-888, October 1963 (Secret).

Investigation of Threat-warning Systems for High-Altitude Aircraft, O.A. Poree and W. Malila. Report No. WRL 5900-8-P, AD-349-689, May 1964 (Secret).

Radiation Suppression from the Standpoint of Threat-Warning Sensor Design, W. Malila and J. Beard. Proceedings of 4th Meeting on Infrared Countermeasures, IRIS Specialty Group on Infrared Countermeasures, December 1964 (Secret).

Investigation of Threat-Warning Systems for Low-Altitude Aircraft, W. Malila, J. Beard and O. Poree. Report No. WRL 5900-24-T, AD-360-902, May 1965 (Secret).

Measurements of Laser Cross Sections of Air-to-Air Missiles, W. Malila and D. Carmer. Report No. WRL 5900-40-T, September 1966 (Secret).

Threat-Warning Techniques Investigation, Volume I: Summary of Work Under the Contract, AFAL-TR-66-287. Report No. WRL 5900-49-F, AD-376-497, October 1966 (Secret).

Threat-Warning Techniques Investigation, Volume II: Measurements of Anti-Aircraft Rocket Radiation, W. Malila and G. Linquist. Report No. AD-382-315, June 1967 (Secret).

Investigation of Mine Detection Using an Airborne Infrared Laser Scanner, W. Malila, D. Carmer and D. Zuk. ERIM Report No. 158700-29-T, June 1982 (Secret).



MALILA, WILLIAM A.

RESEARCH ENGINEER IV

PUBLICATIONS (Continued)

Investigation of Mine Detection Using an Airborne Infrared Laser Scanner, W.A. Malila, D.C. Carmer and D.M. Zuk. Proceedings of the 31st National Infrared Information Symposium, ERIM, Ann Arbor, MI, May 1983 (Secret).

Remote Minefield Detection: Vol. II, Guidelines for the Commander and Mission Planner, W. Malila, C. Due, D. Griffith, H. McKenney, Y. Morita and R. Nalepka, ERIM Report No. 158700-104-F2, July 1984 (Confidential).

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MEIER, PHILIP E.

EDUCATION

MA	Murray State University	1983
BS	Carroll College	1980
Certificate	International Institute for Aerial Survey and Earth Sciences (ITC)	1981

EMPLOYMENT

Research Scientist, Image Analysis Division, 1986-Present
Metric Analyst, DBA Systems, Inc., 1983-1986
Research Assistant, Mid-American Remote Sensing Center, 1982-1983

SUMMARY OF EXPERIENCE

Mr. Meier is presently a Research Scientist in the Image Analysis Division at ERIM. Mr. Meier is involved in Data Collection planning, evaluation of sensor systems, and image analysis.

As a Metric Analyst for DBA systems, Mr. Meier's responsibilities included computer-aided and manual analysis in the areas of image interpretation, mensuration, and data reduction.

As a Research Assistant, Mr. Meier analyzed photographic and digital LANDSAT data for forest inventory, wildlife habitat, soil erosion potential, and archeological studies. Responsibilities included the georeferencing, enhancing/processing, and classification of digital imagery as well as production of output products.



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NORMAN E.G. ROLLER

Fourteen years of experience in program management, research, technology transfer, and teaching. Background in remote sensing of environment, forestry, wildlife biology, natural resources inventory, and statistics/experimental design.

EDUCATION:

BS	Wildlife Management	University of Michigan, 1969
BSF	Forestry	University of Michigan, 1969
MF	Forestry (Remote Sensing)	University of Michigan, 1974
	Currently PhD Candidate	University of Michigan, 1986

HONORS:

Member Xi Sigma Pi (Forestry Honorary)
NASA designated expert on Landsat technology and its applications

EXPERIENCE:

Program Manager: Prepare proposals, budgets and technical management plans; manage technical tasks; meet with sponsors; and, prepare final reports and journal articles.

Research: (1) Assess capabilities and limitations of existing resource inventory procedures, (2) develop new procedures to overcome limitations of existing or traditional techniques, and (3) investigate potential of new sensors and data analysis techniques for specialized user information requirements.

Scientific Oversight: Review articles for technical journals (e.g., Remote Sensing of Environment).

Teaching: Prepare and present technology transfer workshops both in US and overseas on remote sensing and resource inventory techniques.

Technical Expertise: Familiar with all aspects of remote sensing; including photo data-collection and interpretation; multispectral data analysis; digital image processing; radar data analysis; and geographic information systems.



CURRENT RESPONSIBILITIES

Director of Training for Applications Division; responsible for ERIM's visiting scientist training programs in remote sensing, resource inventory and GIS technology. Frequent Chief-of-Party for overseas training workshops; workshop subjects include fundamentals of remote sensing, agricultural and natural resources inventory techniques, and procedures for field measurements. Staff specialist in Applications Division for resource inventory design, photographic remote sensing and data analysis, and field data collection.

CURRENT INTERESTS

- (1) Training and technology transfer with regard to the use of remote sensing for resource inventory.
- (2) Design of optimized resource inventory techniques, including
 - (a) More fully integrated use of remote sensing data in estimation procedures;
 - (b) Exploitation of new sensors and combinations of sensors; and
 - (c) Detecting and monitoring change.
- (3) Preparation and manipulation of digital data bases using GIS technology for assessment of resource capability and suitability.
- (4) Wildlife habitat quality evaluation models.
- (5) Designing and implementing practical remote sensing based resource inventories in developing countries.

FOREIGN EXPERIENCE

Participation in agricultural and natural resource inventory projects in the following countries: Algeria, Bangladesh, Canada, Costa Rica, Iran, Nepal, Surinam, and Venezuela.

PUBLICATIONS:

Principal or Co-author of:

"Coarse Resolution Satellite Data for Ecological Surveys", with J. Colwell (in press), Bioscience.

"Studies in Support of the NASA Global Habitability Program", (with J. Colwell), (in press), ERIM Report 173900-1-F, ERIM, Ann Arbor.



PUBLICATIONS (continued)

"Regional Inventory of Irrigated Agriculture Through Joint Use of AVHRR and Landsat Data", (with A. Bhuiyan and J. Colwell), 1986. In Proceedings of Nineteenth International Symposium on Remote Sensing of Environment, ERIM, Ann Arbor.

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"Analyst Handbook for the Augmented U.S. Baseline Corn and Soybean Segment Classification Procedure (C/S-1A)," (with K. Johnson, J. Odenweller, and C. Hay), October 1981, NASA-AgRISTARS Report FC-E1-00723.

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"Comparison of Landsat MSS and Merged MSS/RBV Data for Analysis of Natural Vegetation," (with S. Cox), April 1980, In Proc. 14th International Symposium on Remote Sensing of Environment, ERIM, Ann Arbor.



PUBLICATIONS (Continued)

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"Quantitative Evaluation of Deer Habitat," October 1978, In Proc. EROS Pecora IV Symposium, Sioux Falls, South Dakota.

"Wetland Inventory and Condition Evaluation Techniques," (with J. Colwell), October 1978, In Proc. EROS Pecora IV Symposium, Sioux Falls, South Dakota.

"Bangladesh Training Program in the Processing on Landsat Digital Data for Land Accretion, Boro Rice Inventory, and Forestry Applications, (with members of the Bangladesh Landsat Centre, and F. Polcyn, et al.), October 1978, ERIM Report 500700-1-F.

"Quantitative Evaluation of Habitat Conditions for Effective Waterfowl Management by Computer Manipulation of Landsat Classified Data, (with J. Colwell, et al.), April 1978, In Proc. 12th International Symposium on Remote Sensing of Environment, ERIM, Ann Arbor.

"Airborne Multispectral Survey of Intertidal Vegetation in Alaska," (with F. Polcyn, et al.), April 1978, In Proc. 12th International Symposium on Remote Sensing of Environment, ERIM, Ann Arbor.

"A Landsat Inventory of the Agricultural and Forest Resources of Bangladesh," (with J. Colwell, et al.), April 1978, In Proc. 12th International Symposium on Remote Sensing of Environment, ERIM, Ann Arbor.

"Remote Sensing of Wetlands," March 1977, ERIM Report 193400-14-T.

"Analysis of Recreational Land Using Skylab Data," (with I. Sattinger and F. Sadowski), September 1975, ERIM Report 193300-60-F.

"Color Terrain Map of Yellowstone National Park Computer-Derived from ERTS-MSS Data," (with R. Root, H. Smedes, and D. DeSpain), April 1974, In Proceedings of Ninth International Symposium on Remote Sensing of Environment, ERIM, Ann Arbor.

And 15 other publications in the field of remote sensing of environment.



SELLMAN, ALBERT N.

RESEARCH MANAGER

EDUCATION

BA	Geography	The University of Michigan, 1966
MA	Geography	The University of Michigan, 1969

EMPLOYMENT

Research Assistant/Associate, Willow Run Laboratories, The University of Michigan, 9/69-12/72
Research Associate, Environmental Research Institute of Michigan, 1/73-5/75
Physical Scientist, Earth Resources Branch, Applications Directorate, NASA/Goddard Space Flight Center, 6/75-4/78
Research Scientist, Environmental Research Institute of Michigan, 4/78-6/84
Research Manager, Environmental Research Institute of Michigan, 6/84-present

SUMMARY OF EXPERIENCE

Mr. Sellman has been employed in the field of remote sensing research and applications for seventeen years, and has over fifty publications on all phases of applied remote sensing. He has had personnel project design and management responsibilities for work in the U.S., Argentina, Costa Rica, Italy, Panama, Peru, and Sudan. He currently supervises work in an additional dozen or more countries. Mr. Sellman has taught university level courses on the use of remote sensing for environmental planning at The University of Michigan/Flint Campus and Eastern Michigan University. He spent one year in Italy as a consultant to Telespazio on a national agricultural research program using remote sensing, and has consulted for UN/FAO as well. Mr. Sellman's overriding interests are in the international transfer and use of remote sensing technologies and the corresponding systems (institutional) effects that result from adoption of the technologies.



SELLMAN, ALBERT N.

RESEARCH MANAGER

RELEVANT FOREIGN EXPERIENCE

Project manager for AgRISTARS ground truth requirements in Argentina and Brazil. Headed field work team in Argentina in 1981 (February-March).

One month consultancy (November-December 1981) for UN/FAO funded Remote Sensing Program to provide training on Digital Image Analysis Methods for Crop Area Estimation at CNIE (Comision Nacional de Investigaciones Espaciales) in Buenos Aires Argentina.

Program manager on two-year USAID funded program in Peru on Land Use Inventory and Environmental Planning, which involved training on remote sensing, design and installation of a computer-based geographic information system, and support to various natural resource investigations in Peru.

Currently program manager on Interamerican Development Bank funded project in Panama to establish national remote sensing program. This will include the design and implementation of a digital image processing system in Panama, over fifty man-months of formalized training, and over a year of field work and data processing activities on three major resource mapping and assessments projects in Panama.

Speak (fair-good), understand (good-excellent), and write (fair) Spanish.

Member of Society of Latin American Remote Sensing Specialists (SELPER).



SUITS, GWYNN H.

SR. RESEARCH ENGINEER

EDUCATION

BS Physics, The University of Michigan, 1947
MA Physics, The University of Michigan, 1948
PhD Physics, The University of Michigan, 1955

EMPLOYMENT:

Teaching Fellow, The University of Michigan, 1974-51
Research Assistant, The University of Michigan, IST, 1951-54
Research Associate, The University of Michigan, IST, 1954-58
Research Physicist (Head, Infrared Laboratory), The University of Michigan, IST, 1958-64
(Leave of Absence, to serve on the staff of the Institute of Defense Analyses, Arlington, VA, 1964-65
Research Physicist, Program Planning Staff, Willow Run Labs (WRL), The University of Michigan, IST, 1965-73
Professor of Remote Sensing, Forestry, School of Natural Resources, The University of Michigan, 1968-73
Research Physicist, Environmental Research Institute of Michigan (ERIM), 1973 -
Adjunct Professor of Remote Sensing, School of Natural Resources, The University of Michigan, 1973 -
Associate Editor, Remote Sensing of Environment, 1972 -
NRC Committee on Recommendations for Army Basic Research, 1980-83

EXPERIENCE

Dr. Suits has worked in electronics (high-frequency) and pulse techniques, in solid state-physics, in physical optics and optical spectroscopy and laboratory administration. He prepared and presented lectures on quantum detectors for the course of Fundamentals of IR Technology, The University of Michigan Engineering Summer Conferences and conducted courses dealing with the subject of Remote Sensing. He has done research in remote sensing for both military and civilian applications employing a wide variety of radiative transfer models of natural and artificial objects in the optical, thermal infrared (including heat transfer and microwave spectral ranges).

SUITS, GWYNN H.

SR. RESEARCH ENGINEER



SUITS, GWYNN H.

SR. RESEARCH ENGINEER

PROFESSIONAL AND HONORARY SOCIETIES

American Physical Society
Sigma Xi
American Society of Photogrammetry

LISTED IN

American Men of Sciences

PUBLICATIONS

- Doctoral Dissertation: "Metal-Insulator-Metal Junction", University Microfilms, Ann Arbor, MI, 1955, 80 pp. The official publication of the doctoral dissertation.
- Excess Noise in InSb, co-author, J. of Applied Physics, Vol.27, November 1956.
- A Single-Crystal Photoconductive Tellurium Detector, co-author, 2144-240-T, February 1958.
- Atmospheric Absorption Effects on Radiometer Response, co-author, 2144-380-T, 1958.
- Exact Current-Voltage Relation for the Metal-Insulator-Metal Junction With a Simple Model for Trapping of Charge Carriers, J. Appl. Physics, April 1977.
- Notes on Methods of Obtaining Resolution Finer Than the Instantaneous Field of View of a Scanning Device, co-author, Proc. IRIS, Vol.4, No.4, October 1959. (SECRET)
- The Nature of Infrared Radiation and Ways to Photograph It. The University of Michigan, No. 36943-9-S, February, 1960. Published in Photogrammetric Eng'g., December 1960.
- Report on Scan Correction, co-author. The Univ. of Michigan, No. 2900-256-S/Sa, March 1961; Proc. IRIS, Vol.6, No.2. (CONFIDENTIAL)
- Fundamentals of Infrared Technology, co-author. MacMillan Co., 1962.
- Foliage Penetration Experiment, No. 2900-430-I.
- Spectrum Matching and Imaging Device, co-author. IRIS Paper, 2900-488-J.
- Infrared Study of Lunar Surface Details, co-author. The Univ. of Michigan, No. 6194-1, March 1964.
- Air Launched Anti-Tank Weapons, co-author, 1965. (SECRET)
- Theoretical Comparison of Visual Aid and Night Equipment, 1965. (CONFIDENTIAL)
- Considerations for Declassification of Airborne Infrared Remote Sensing Devices. The Univ. of Michigan, No. 36943-75-S, February 1966; Paper No. 252, ACSM-ASP Convention, March 6-11, 1966.

SUITS, GWYNN H.

SR. RESEARCH ENGINEER



SUITS, GWYNN H.

SR. RESEARCH ENGINEER

PUBLICATIONS (Continued)

- Declassification of Infrared Devices, Photogrammetric Eng'g., November 1966.
- Remote Sensing of Southern Corn Leaf Blight, co-author. American Phytopathological Society Meeting, 1971.
- Introduction to Sensors. Int'l Workshop on Remote Sensing, Ann Arbor, MI, 1971.
- Remote Sensing Interpretation. North Central Regional Meeting, Amer. Phytopathological Society, E.Lansing, MI, 1971.
- Remote Sensing Techniques for Oil Slick Measurements, co-author. Int'l Symp. on Identification & Measurement of Environmental Pollutants, Ottawa, Canada, 1971.
- Spectral Reflectance and transmittance of Blighted and Healthy Corn, co-author. Phytopathology, 62, 1210, 1972.
- The Calculation of the Directional Reflectance of a Vegetative Canopy, Remote Sensing of Environment, 2, 117, 1972.
- Infrared Fluorescence of Corn Leaves Infected by *Helminthosporium maydis*. Phytopathology, 64, 615, 1974.
- Directional Reflectance of Vegetative Canopies, co-author. Presented at Optical Society of American, Ann Arbor Section, 20 January 1972.
- Prediction of Directional Reflectance of a Corn Field Under Stress, co-author. 4th Annual Earth Resources Program Review, NASA, MSC, Houston, January 17-21, 1972.
- The Cause of Azimuth Variations in Directional Reflectance of Vegetative Canopies. Remote Sensing of Environment, 2, 175, 1972.
- Verification of a Reflectance Model for Mature Corn with Applications to Corn Blight Detection, co-author. Remote Sensing of Environment, 2, 183, 1972.
- Application of a Directional Reflectance Model to Wheat Canopies Under Stress, co-author. Presented at Int'l Conference on Remote Sensing in Arid Lands, Tucson, AZ, November 1972.
- The Nature of Electromagnetic Radiation. Chapter III, Manual of Remote Sensing, Amer. Society of Photogrammetry, 1975.
- Yield Prediction by Analysis of Multispectral Scanner Data, co-author. No. CR-ERIM 109600-17-F, May 1975.
- Optical Modeling of Agricultural Fields and Rough-Textured Rock and Mineral Surfaces, co-author. No. 31650-78-T, November 1973.
- Report of Optical Ground Truth Measurements for 5 August 1973, Test Site No. 548532, in Support of the Skylab Multispectral Scanner, co-author. ERIM, No. NASA CR-ERIM 101700-10-X, January 1974.
- Spectral Reflectance and Transmittance of Corn Leaves Infected With *Helminthosporium maydis*, co-author. Phytopathology, 62, 10, p.1210, 1972.
- Optical Properties of Satellite Materials, co-author. ERIM, No. 194100-6-F, July 1973.

SUITS, GWYNN H.

SR. RESEARCH ENGINEER



SUITS, GWYNN H.

SR. RESEARCH ENGINEER

PUBLICATIONS (Continued)

- Optical Properties of Satellite Materials, First Satellite Signature Symposium, November 6, 1973, Washington, D.C. (Sponsored by ARPA [Strategic Tech. Off.] DOD).
- The Scientific Basis of Remote Sensing. Presentation at the ASP Washington Meeting, February 24, 1976.
- Perceptibility Analysis of Marine Corps Protective Structures, co-author. ERIM, No. 126300-1-F, March 1977.
- THE INFRARED HANDBOOK, Chapter 3, "Natural Sources" and Chapter 14 "Photographic Film", 1978.
- Problem Areas that Require Vegetative Canopy Spectra for Solution and the Role of Canopy Reflectance Modeling. Crop Spectral Workshop, 1-3 February 1977, Ecosystems Int'l, Inc., Gambrills, MD.
- Basic Remote Sensing Investigation for Beach Reconnaissance, co-author. ERIM 108900-9-P, September 1977.
- Basic Remote Sensing Investigation for Beach Reconnaissance - Beach Sand Environment, co-author, ERIM 108900-12-F, August 1978.
- Targets and Background, co-author. Report T-78-71, U.S. Army Missile Research and Development Command, July 1978.
- Thermal Modeling of Natural Features. Invited paper, 13th Int'l Symp. on Remote Sensing of Environment, April 1979.
- A Low Cost Classification Algorithm for Developing Countries, co-author. Poster Session, 13th Int'l. Sympo. on Remote Sensing of Environment, April 1979.
- The Potential Use of Remote Sensing for the Determination of Beach Sand Parameters, co-author. Poster Session, 13th Int'l. Symp. on Remote Sensing of Environment, April 1979.
- Identification and Screening of Remote Mine Detection Techniques, co-author. ERIM 138300-22-T, June 1979.
- General Test Plan and Procedures for Vehicle Perceptibility Tests With Low Light Level TV Systems, co-author. U.S. Army TACOM Technical Report 12508, May 1980.
- General Test Plan and Procedure for 1.06 um Laser Vehicle Reflectance Measurements, co-author. U.S. Army TACOM Technical Report 12509, May 1980.
- Improved Blackout Security Interior Lighting System for U.S. Tanks, co-author. U.S. Army TACOM Technical Report 12561, February 1981.
- The Extension of a Uniform Canopy Reflectance Model to Include Row Effects. Presented at the SR Quarterly Technical Interchange Meeting of AgRISTARS, JSC, October 6, 1981, NASA No. SR-E1-04065, NAS9-15476, December 1981 and Remote Sensing of Environment, Vol.13, p.113, 1983.
- Focal Plane Array Technology - Volume I, co-author. IRIA State of the Art Report, 160800-8-T(I), January 1983.

SUITS, GWYNN H.

SR. RESEARCH ENGINEER



SUITS, GWYNN H.

SR. RESEARCH ENGINEER

PUBLICATIONS (Continued)

Remote Mine Field Detection: A Photointerpreter's Guide, co-author.
ERIM 158700-48-T, March 1984.

Extension of a Uniform Canopy Reflectance Model to Include Row Effects.
Remote Sensing of Environment, Vol.13, pp.113-129, 1983, Elsevier
Science Publishing Co.

A Versatile Directional Reflectance Model for Natural Water Bodies, Sub-
merged Objects, and Moist Beach Sands. Remote Sensing of Environ-
ment, Vol.16, pp.143-156, Elsevier Science Publishing Co., 1984.

Remote Minefield Detection: Volume 1, Guidelines for Image Interpreta-
tion, co-author. ERIM 158700-104-F, March 1984.

An Analysis of Spectral Discrimination Between Corn and Soybeans Using a
Row Crop Reflectance Model. Remote Sensing of Environment, Vol.17,
pp.109-116, Elsevier Science Publishing Co., 1985.

Patent 4 469 779, September 1984

"Infrared Color Photographic Film", G.Suits.

SUITS, GWYNN H.

SR. RESEARCH ENGINEER



TANIS, FRED J.

RESEARCH SCIENTIST

EDUCATION

BS	Mathematics	University of Michigan, 1964
MS	Mathematics	University of Michigan, 1966
MS	Water Resources Management Advanced Studies in Ocean Science	University of Michigan, 1973 University of Michigan, 1986

EMPLOYMENT

Research Assistant, The University of Michigan, IST, 1964-67
Associate Mathematician, Cornell Aeronautical Laboratory, 1967-70
Training Fellow, Environmental Protection Agency, The University
of Michigan, 1970-72
Research Scientist, Environmental Research Institute of Michigan,
January 1973-Present
Visiting Scientist, Naval Ocean Research and Development Activity,
NSTL, MS, November 1984-June 1985

EXPERIENCE

Current research has concentrated on the extraction of bio-optical parameters from remote sensing data. Research studies include the development, testing, and evaluation of water parameter extraction algorithms and have utilized simulation techniques to model and analyze ocean color effects from subsurface scattering and absorption processes. Developed a combined atmospheric and ocean radiative transfer model to simulate satellite radiance and investigate optimal sensor requirements. Developed quantitative remote sensing algorithms for mapping and charting water depths and for water constituent concentrations.

SELECTED PUBLICATIONS

Measurement of Sea Surface Upwelling Radiance in the Gulf of Mexico Using the Nimbus-G Coastal Zone Color Scanner, 14th International Symposium on Remote Sensing of Environment, San Jose, Costa Rica, April 1980.

Use of Airborne Data to Support Validation of the Coastal Zone Color Scanner in the Gulf of Mexico, prepared for NOAA, December 1980.

TANIS, FRED J.

2/87



TANIS, FRED J.

RESEARCH SCIENTIST

SELECTED PUBLICATIONS (Continued)

Verification of Reflectance Models in Turbid Waters, ERIM 137000-39-F, co-author, April 1981.

Development of Great Lakes Algorithms for the Nimbus-G Coastal Zone Color Scanner, ERIM 150000-4-F, co-author, June 1981.

Radiance Calculations for Optimization of Sensors Designed for Remote Bathymetry, author, prepared for Naval Research Laboratory, ERIM Report No. 155800-1-F1, July 1982.

Multi-Temporal Analysis of Landsat Imagery for Bathymetry, co-author, prepared for Naval Research Laboratory, ERIM Report No. 155500-2-F, May 1983.

Comparison of Atmospheric Correction Algorithms for the Coastal Zone Color Scanner, presented at 17th International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, May 1983.

Simulation of Thematic Mapper Data for Remote Bathymetry, co-author, prepared for Naval Research Laboratory, ERIM Report No. 163100-7-F, October 1983.

Evaluation of Landsat Thematic Mapper Data for Shallow Water Bathymetry, Eighteenth International Symposium on Remote Sensing of Environment, Paris, France, October 1984.

Phase II Development of Great Lakes Algorithms for Nimbus-7 Coastal Zone Color Scanner, NASA; NAS3-22892, Ann Arbor, Michigan, 1984.

Optimization of Multispectral Sensors for Bathymetry Applications; Nineteenth International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, October 1985.

Detection of Bottom-Related Surface Patterns on Visible Spectrum Imagery, co-author, IGARSS 86, Zurich, Switzerland, September 1986.

Influence of Scattering on the Diffuse Attenuation Coefficient in the Asymptotic Region. Ocean Optics VIII, SPIE, Proceeding No. 637, 1986.

Over ten reports and journal articles in geophysics and seismic energy propagation.

TANIS, FRED J.

2/87



TORRES-ROLDAN, VICTOR

PHOTOGEOLOGIST

EDUCATION

BS	Biology	UNAM, Mexico	1980
MS	Geology	University of Michigan	1983
PhD	Candidate Geology	University of Michigan	1984

EMPLOYMENT

Photogeologist, ERIM, 1986 - present.
 Research Assistant, University of Michigan, 1983 - present.
 Teaching Assistant, University of Michigan 1984 - 1986.
 Tecnico Academico, Instituto de Geologia, UNAM, 1980 - 1981.

SUMMARY OF EXPERIENCE

Mr. Torres has a comprehensive background in Earth Sciences, including Biology, Geology, and Geophysics. He has extensively used aerial photography and remote sensing products for geological purposes. During 12 years he has acquired field experience while working in Mexico, USA, Belize, and Panama. For his dissertation research he became interested in continental scale tectonics and its bearing on the occurrence of mineral and energy resources in Mexico, study that greatly benefited from the use of Landsat data. Mr. Torres is experienced in the management and analysis of data: parametric and non-parametric statistics, experimental design and computer applications to geology. He is knowledgeable in the use of microcomputers with MS-DOS system and graphic programs (WW, Peachtree, Lotus, etc.). Mr. Torres has taught both U.S. and Latin American students and he is familiar with the learning requirements of these groups.



TORRES-ROLDAN, VICTOR

PHOTOGEOLOGIST

PROFESSIONAL AND HONOR SOCIETIES

American Association for Advancement of Science
Geological Society of America
National Geographic Society
Society of Economic Paleontologists and Mineralogists.

LANGUAGES

Spanish - mother language
English - proficiency
French - good
Portuguese & Italian - translation and reading.

PUBLICATIONS

Torres, Victor, 1985, Stratigraphy of the Eocene Willwood, Aycross and Wapiti formations along the North Fork of the Shoshone River, North Central Wyoming: Contributions to Geology, The University of Wyoming, v. 23, n. 2

Torres, Victor and Phillip D. Gingerich, 1983, Summary of Eocene Stratigraphy at the Base of Jim Mountain, North Fork of the Shoshone River, North Western Wyoming: Wyoming Geological Association, Guidebook, n. 34, pp. 205-208.

Ferrusquia-Villafranca I. and Victor Torres-Roldan, 1982, (Mesozoic and Cenozoic mammalian record in Baja California, Mexico) El registro de mamíferos terrestres del Mesozoico y Cenozoico de Baja California: University Nat. Aut. de Mexico, Inst. Geol., Revista, v. 4, p. 56-62.

Torres, Victor and Ismael Ferrusquia, 1981, (Cerdocion sp. nova A, [Mammalia, Carnivora] in Mexico, its evolutionary and zoogeographic significance to South American canids) Cerdocoyon sp. nova A (Mammalia, Carnivora) en Mexico y su significación evolutiva y zoogeográfica en relación a los cánidos sudamericanos: Anais II Congresso Latino-Americano Paleontologia, Porto Alegre, Brasil p. 709-719.

Torres, Victor and Shelton P. Applegate, 1979, (First record of six gilled shark Hexanchus vitulus in Mexican waters) Primer Registro del Tiburon de seis branquias Hexanchus vitulus Springer y Waller, 1969, en aguas mexicanas: III Congreso Nacional de Zoología, Aguascalientes, Resúmenes p. 971.



TORRES-ROLDAN, VICTOR

PHOTOGEOLOGIST

Nunez I., Arredondo S., Torres V., Lopez-Cortez A., Coutino R. 1978, (Altitud effect on pine tree growth) El gradiente altitudinal y su relacion con las dimensiones de Pinus hartwegii en la zona del Ajusco, D.G.: Resumos dos Trabalhos, II Congreso Latinoamericano de Botanica. XXIX Congreso Nacional de Botanics, Sociedad de Brasil, p. 371 (Resumen).

PAPERS SUBMITTED FOR PUBLICATION

Torres, V., P.D. Gingerich, W.S. Bartels, Early and middle Eocene vertebrate faunas from the Wapity Valley, North Fork of the Shoshone River, Park County, Wyoming: to be published in the Contributions from the Museum of Paleontology, The University of Michigan.



TRICHEL, MILTON C.

RESEARCH SCIENTIST

EDUCATION

M.S., Rice University, Space Science, 1967
B.S., Rice University, Electrical Engineering, 1963
B.A., Rice University, Engineering, 1962

SUMMARY OF EXPERIENCE

1985 - Present Research Scientist, ERIM (Washington Office)

Manager of Teal Ruby, HICAMP II and SDIO Support activities. Established Teal Ruby Diagnostic (VAX 11/780 based) Center in Los Angeles, technical leadership in Teal Ruby Radiometric Calibration, roles in Teal Ruby Mission Planning and Simulation; roles in HICAMP II data analysis and archival.

1970 - 1985 NASA Johnson Space Center, Earth Sciences and Applications Division

NASA Headquarters, Program Manager for NASA Terrestrial Ecosystems Research (under one year Career Development Program assignment). Head, Fundamental Research Section. First automated Landsat data analysis system; rationale for Landsat-D orbit selection; design, implementation, operation of first large scale Landsat data analysis system (LACIE); first early season crop acreage estimation; Acting Manager, AgRISTARS Supporting Research project; creation of research data analysis environment; creation of research data base; university/industry research program in Landsat analysis; data recovery/hardware repair of Skylab multispectral scanner, consultant in development of first multispectral imaging spectrometer for earth resources.

1967 - 1970 Aerospace Technologist, NASA Johnson Space Center
Space Physics Division

Manager/Coinvestigator for Electron Accelerator Rocket Experiments. Major role in definition of Atmospheric/Magnetospheric science laboratory for Space Shuttle.



V. INVENTORY OF AVAILABLE LANDSAT DATA AT ERIM FOR
COLOMBIA, JAMAICA, AND PERU

ERIM's in-house inventory of Landsat data relative to the study areas is mainly confined to Peru. Areas covered include central Peru, southeastern Peru, the Pacific coast south of Lima, and parts of the eastern interior. All available ERIM data are Multispectral Scanner (MSS) acquisitions. No Thematic Mapper (TM) CCT's of Peru are in-house. Cloud cover percentages within individual Landsat scenes for Peru vary from zero to forty percent depending on location, with central Peru having the greatest cloud cover. ERIM has two acquisitions of Colombia of which one is a TM negative. No Landsat data of Jamaica are available in-house as ERIM has not undertaken any projects there to date. Figure 11 indicates relevant in-house Landsat data in detail.

INVENTORY OF AVAILABLE LANDSAT DATA AT ERIM FOR COLOMBIA, JAMAICA, AND PERU

<u>COUNTRY</u>	<u>SENSOR</u>	<u>PATH/ROW</u>	<u>SCENE ID</u>	<u>DATE</u>	<u>AREA</u>
COLOMBIA	MSS	8/53	271614170	7 JAN 77	VALLEDUPAR
COLOMBIA	TM	8/53	Y5006614382X0	6 MAY 84	VALLEDUPAR Band 3 Negative Only

JAMAICA
(No Data In-House)

PERU	MSS	2/70	218814024	29 JUL 75	PUNO (North)
	MSS	2/71	220614023	16 AUG 75	PUNOIL. TITICACA
	MSS	3/68	2031514055	3 DEC 75	MADRE DE DIOS
	MSS	4/67	201541413	25 JUN 75	MADRE DE DIOS
	MSS	4/69	219014134	31 JUL 75	NW OF CUZCO
	MSS	5/67	640414202	24 AUG 81	PALCAZU
	MSS	5/70	215514202	26 JUN 75	NAZCA LINES
	MSS	6/63	150214320	7 DEC 73	S. OF IQUITOS
	MSS	6/66	640614200	24 AUG 81	PUCALLPA
	MSS	6/66	8140614200	24 AUG 81	PUCALLPA
	MSS	6/67	8140614202	24 AUG 81	PUERTO BERMUDEZ
	MSS	6/67	640614202	24 AUG 81	PUERTO BERMUDEZ
	MSS	6/68	659614173	6 JUN 79	TARMA
	MSS	6/68	7915714174	NO DATE	TARMA
	MSS	6/69	166414304	18 MAY 74	SE OF LIMA
	MSS	6/70	164614314	30 APR 74	PISCO
	MSS	7/67	714114300	3 JUN 78	UPPER HUALLAGA
	MSS	7/68	2039114275	17 FEB 76	LIMA
	MSS	11/63	1023715040	17 MAR 73	NW PERU

FIGURE 11