

USE OF DATA FROM SPACE FOR EARTH RESOURCES EXPLORATION AND MANAGEMENT IN ALABAMA

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Introduction

The University of Alabama, the Geological Survey of Alabama, and the George C. Marshall Space Flight Center are involved in an interagency, interdisciplinary effort to use remotely sensed, multi-spectral observations to yield improved and timely assessment of earth resources and environmental quality in Alabama. It is the goal of this effort to interpret these data and provide them in a format which is meaningful to and readily usable by agencies, industries, and individuals who are potential users throughout the State.

In order to assess the full range of potential users of these data in Alabama, a study was conducted by the University and the Geological Survey in 1971. During this study the several hundred potential users, contacted by project personnel, were informed of the remote sensing applications which can make use of observations from NASA's Earth Resources Technology Satellite (ERTS) and associated aircraft flights. These contacts were made by telephone calls, letters, personal conferences, and two symposia (one in Tuscaloosa and one in Mobile). The potential users were informed as to the possible applications of remote sensing from space in the areas of land use, resource inventory, environmental control and others. Only a few of the people contacted were already familiar with some aspects of remote sensing while the majority had no prior knowledge concerning this tool and its areas of applicability. In spite of this, the responses were enthusiastic and indicated that there would be a large amount of use of remotely sensed data after some degree of interpretation had been accomplished.

To give some idea of the breadth of possible users, categories, and uses in Alabama, the following results of this user study are given below.

Professionals who said they could use the data beneficially included urban planners, regional planners, foresters, geologists, ecologists, hydrologists, agronomists, biologists, physicists, astronomers, chemists, agriculturists, civil engineers, chemical engineers, agricultural engineers, mining engineers, geographers, limnologists, entomologists, architects, archeologists, demographers, lawyers, and university faculty members.

Possible categories of use were estimated to include land use, cartography, hydrology, geology, transportation, ecology, forestry, fisheries, mineralogy, meteorology, morphology, agriculture, oceanography, archeology, topographical mapping, demography, planning, and wildlife studies.

Detailed uses which were included as potentialities are flood control, soil studies, resource inventory, surface water studies, mineral exploration, ground water studies, water temperature studies, growth trends, surveying and mapping, air quality management, water quality management, disaster detection, damage evaluation, sediment transport, traffic studies, erosion control, irrigation, zoning, crop conditions, recreation, management, urban and regional planning, and pesticide studies.

The enthusiastic response from potential users, as described above, indicated that the planning of varied statewide applications of remote sensing oriented toward a broad base of grassroots users would be a timely and beneficial effort in Alabama.

Therefore, The University of Alabama, the Geological Survey of Alabama, and the Marshall Space Flight Center (MSFC) joined efforts to utilize this tool in statewide applications.

Objectives

The objectives of this effort are:

1. To determine the applicability of remotely sensed data from ERTS for inventory and management of the natural resources and for the improvement of the quality of the environment in Alabama.
2. To apply photographic-interpretation techniques and statistical data management techniques to remotely sensed, multispectral observations and ground truth measurements of pertinent resource characteristics and environmental parameters to yield improved and timely assessment of the State of Alabama resources and environmental quality in an appropriately condensed format, which is meaningful to and readily usable by individuals in the various cooperating user agencies throughout the State of Alabama.
3. A long-range objective is to develop an effective procedure for processing and interpreting the remotely sensed data so that information in forms most suitable for ultimate users can be extracted and communicated to them. It is anticipated that the ultimate users will be public policy technicians and decisionmakers, as well as private industries.

Discussion of Objectives

On the basis of the evaluation of the Apollo IX photographs it is anticipated that ERTS imagery could aid in the following areas related to water resources:

1. Determining areas of ground water movement
2. Determining areas of ground water discharge
3. Determining areas of ground water recharge
4. Determining areas of future sinkhole development
5. Determining areas of anomalies of low flow in streams
6. Determining areas of possible pollution through malfunction of salt water lines in oilfields
7. Determining changes in thermal patterns of reservoir and streams
8. Defining surface drainage and runoff patterns
9. Determining changes in sediment load in reservoirs
10. Locating lineaments, fault trends, domal structures, and other geological features.

Several additional aspects of the proposed project will be of particular interest to those engaged in traditional environmental engineering activities. For the sake of classification, they can be described as falling into one of the following problem-application areas.

1. Potamology
2. Lacustral Systems
3. Estuarine and Marine Systems
4. Predictive and Evaluative Hydrology
5. Atmospheric Pollution.

The water quality management studies related particularly to the rivers will be to determine the impact upon practical water resource management which can be effected by diurnal reporting of such parameters as stage, discharge, temperature, dissolved oxygen concentration, specific conductivity, pH, turbidity, and wind velocity by the strategically located Data Collection System (DCS) platforms.

Significant lacustral studies are made possible by the existence of relatively large navigation and hydroelectric impoundments on the rivers in the study area. The multispectral data for the impoundment areas will be evaluated for use in the preparation of isoplethic maps of depth, as well as for areal delineation. The data will also be assessed for their utility in monitoring remotely detectable types of extraneous materials, including turbidity and pollutants. It may be possible to detect, identify, and continue to observe benthic colonies of interest in the impoundments. The thermal infrared (IR)

data may also furnish leading indications of known and expected thermal lacustral process occurrences important for effective water resource management.

Mobile Bay and adjacent portions of the Gulf of Mexico will be the site of estuarine and marine studies similar to the lacustral studies described above. In addition to their use for the determinations of depth, shoreline, and current mapping, the ERTS data will be used to monitor projected oil drilling activity in Mobile Bay for the occurrence of possible oil spills. Their utility for monitoring other pollutional sources already existent there is anticipated. The effect of this repetitive data of greater areal extent than any ever before available upon the effective management of these water resources will be assessed.

In the areas of predictive and evaluative hydrology, it is intended to relate spectral data to parameters obtained from ground-based instruments to provide better means of predicting discharge rates of the rivers. Also, similar data will be used to evaluate the accuracy of areal flood extents so predicted.

The improvement of prediction of stream discharge rates will be sought first by extrapolation of sparsely instrumented precipitation surveillance networks by use of the remotely sensed data. All resolution elements that look essentially the same to a photographic or electronic sensor will be grouped by MSFC's unsupervised classification algorithms. With such a classification it is anticipated that a few precipitation readings can then be extrapolated throughout a large area by identifying all other resolution elements which look spectroscopically similar to the element sampled by the ground-truth reading. A major electric utility having hydroelectric facilities in the study areas has indicated intense interest in the use of such improved predictive and evaluative methods.

Within the duration of the proposed study, existing State and Federal laws will begin to take effect for the abatement of significant air pollution problems within the study area. It is planned to use the ERTS data, insofar as it is possible, to indicate the magnitude of improvement which those abatement efforts produce. Birmingham and Mobile are the two major urban areas which will be studied in regards to air pollution, but there are other significant isolated pollution sources as well.

The conceptual approach to the use of remote sensing data in social and economic planning centers around communications and distribution. This emphasis complements other aspects of this effort which are concerned with collecting, organizing, and reporting in useful form hydrologic, geologic, oceanographic, and other environmental and earth resources data. Research described above resulted in an accurate identification of potential users and user categories. One major problem, however, will be in the transmission of data from analyst to the end user. There is an immediate need to translate the items of data output into a form usable by state agencies and law makers. The technical literature is virtually meaningless to public policy technicians and decisionmakers.

Only recently has the need for better management of the State's resources been recognized. Former policies, in regard to resource development, have been limited to discovery and advertisement of the assets which provide jobs and wealth; now, greater emphasis is placed upon technical analysis of the problem of economic growth and development and the need for appropriate legislative control over resources, land use, and other aspects of an orderly development process. The State's primary planning office, the Alabama Development Office (ADO), and its regional counterparts in the State's multicounty development district are just beginning to become operational.

The primary need within these planning units, beyond the considerable accomplishment of recognizing the need for organization in the first place, is for useful and current data relevant in managerial decisions. High on this list of data required is information on land use and water quality and quantity. Analysis of existing data is admittedly amenable to the understanding and forecasting necessary for establishing a policy on environmental quality, but data useful in the day-to-day implementation of a policy is still a major operational bottleneck in sound regulation. The possibility that ERTS-acquired data could eliminate this bottleneck will be investigated.

Planning agencies have a clear responsibility to document the extent and causes of environmental damages over extensive areas and place industrial expansion damage in proper perspective. Data from ERTS could probably be effective in such documentation. Moreover, managerial data generated,

analyzed, or distributed by planning agencies is not limited in usefulness to the public sector. These agencies could provide a useful outlet for dissemination of information from ERTS and other sources to private industries, which would support and enhance their operations. These usages of ERTS data will require the closing of the communication gap between the scientific and the resource manager or public policymaker who will use the information digested from the remotely sensed data.

Since the long-range objective of the project is to develop an effective procedure for processing and interpreting the remotely sensed data and disseminating meaningful information to users (Fig. 1), the fact that information will be distributed to appropriate users from several intermediate stages of processing and interpretation is emphasized. Feedback from the users (Fig. 1) will be very important in refining the interpretation and processing in order to obtain the most useful form of the output.

Figure 2 is a diagram of data and information flows which emphasizes the disciplines which will be brought to bear in interpretation and evaluation at the University of Alabama and the Geological Survey of Alabama. This diagram shows that explicit evaluation and management of information flows will be performed on all information output to users. The indicated feedback will serve to allow an iterative approach to the preparation of the optimum formats for the output information.

Description of System for Collecting Ground Truth

The investigation will extend throughout the entire State of Alabama, which is encompassed by the latitude and longitude values as shown in Figure 3. Ground truth by conventional means and by DCS platforms will be collected throughout the State during the investigation. Field data in support of these studies will be obtained primarily by direct field investigations and from existing data sources.

Ten DCS platforms, fully instrumented with appropriate sensors, are being planned for this investigation. Their locations are indicated on Figure 3. Three of the platforms will be on buoys in Mobile Bay and, in addition to contributing to this proposed study, will also contribute to the additional comprehensive study of Mobile Bay, which is being planned by the Marine Science Institute of the University of Alabama.

It is intended that each of the 10 DCS platforms be instrumented with eight sensors chosen to measure appropriate parameters which may be included in, but not necessarily limited to, the following list: precipitation, air temperature, soil temperature, humidity, soil moisture, river water level and discharge, ground water level, turbidity, salinity, pH, dissolved oxygen, specific conductivity, wind velocity, current direction and velocity, wave height, and tidal depth. Parameters to be measured at each of the 10 strategically located platforms will be chosen to give the most meaningful information at the particular location. The parameters for a particular platform may change during the investigation.

Multistage Sampling Techniques

Multistage sampling utilizing satellite data, multispectral photography from aircraft flights, and ground truth data, with emphasis on the data obtained from the DCS platforms, will be performed over specific problem areas within the State. These are (1) a corridor from Tuscaloosa to Birmingham and (2) a corridor from Mobile Bay to the confluence of the Alabama and Tombigbee Rivers. Each of these corridors is approximately 60 miles long. The widths of the corridors will be variable depending upon the number of lines of flight that can be scheduled at each sampling time. It is anticipated that a minimum of three and a maximum of six flights over each area will be necessary for application of the multistage sampling techniques. The dates of flights will be scheduled to detect seasonal variations in vegetation and pollution, and the number of lines of flight in each corridor will be determined according to the availability of equipment and the sampling requirements. The time of day of the flights will be scheduled so that the aircraft data will provide an optimum supplement to the satellite data.

The choice of the Tuscaloosa-Birmingham area and the Mobile Bay area for the application of multistage sampling techniques stems from two main reasons, namely:

1. They both are principal growth areas in which environmental problems are increasing rapidly.
2. The first area is in the central part of the Warrior-Tombigbee drainage basin (outlined in Figure 3), which constitutes a complete hydrologic and geologic unit convenient for study. The second area is at the mouth of this river system, and all influents into the system must pass through this area.

It should be noted also that the ultimate use of the data from all levels will be to furnish information to planners, regulatory agencies, and private enterprise for the conservation, development, and use of the resources of Alabama. The 10 DCS platforms will be used to determine whether the automated collection of ground-based data from selected sites can be combined with aircraft and satellite data so that timely interventions (which otherwise might be impossible) may be accomplished to conserve resources and improve environmental quality.

Expected Results of Investigation

It is anticipated that the results of this investigation will determine the feasibility of using remote-

ly obtained spectral data in land use, planning, in inventorying and managing natural resources in Alabama, and in improving the environmental quality control in the State.

It is also anticipated that the participation and close liaison among the University of Alabama, the Geological Survey of Alabama, the George C. Marshall Space Flight Center, and the Alabama Development Office will be effective in developing a method and procedure for translating the remotely sensed data into information which can be effectively used by governmental agencies and industry by integrating it into the decisionmaking processes for environmental control, resource management, and land use.

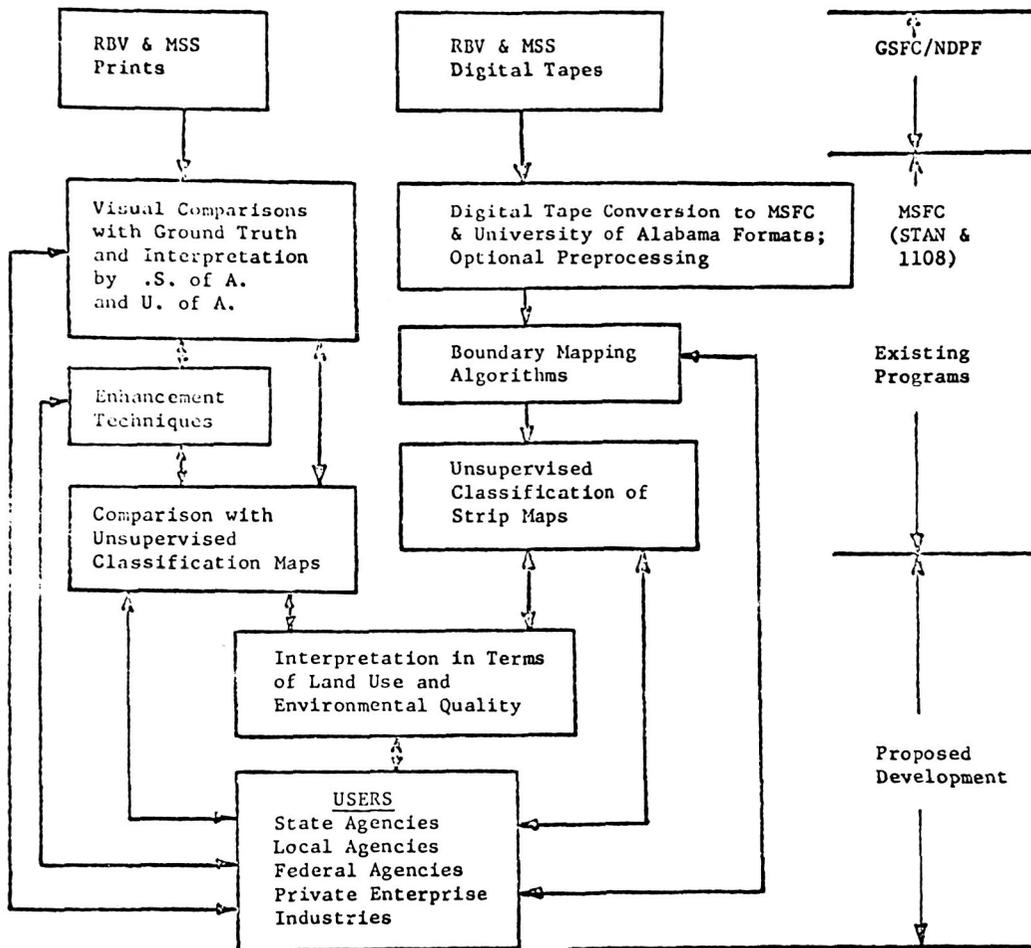


Figure 1. Block diagram of data flow.

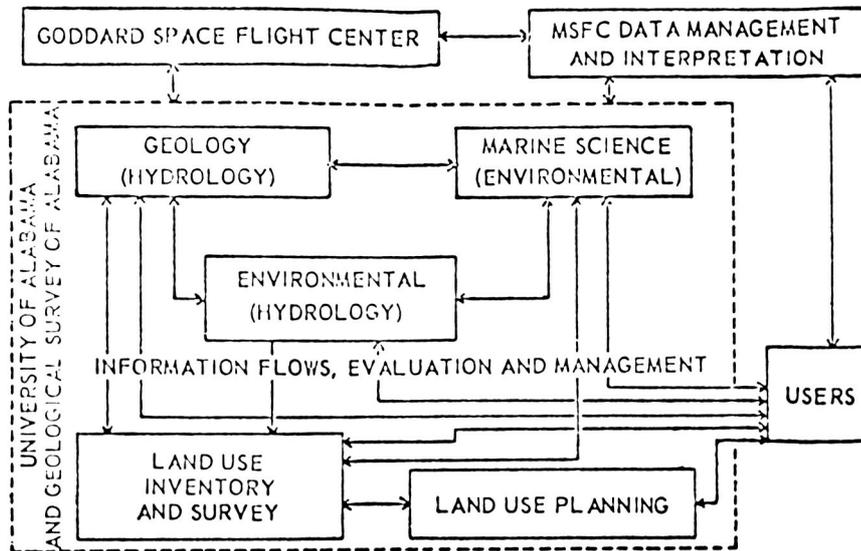


Figure 2. Diagram of data flow emphasizing disciplines, information flow evaluation, and feedback from users.

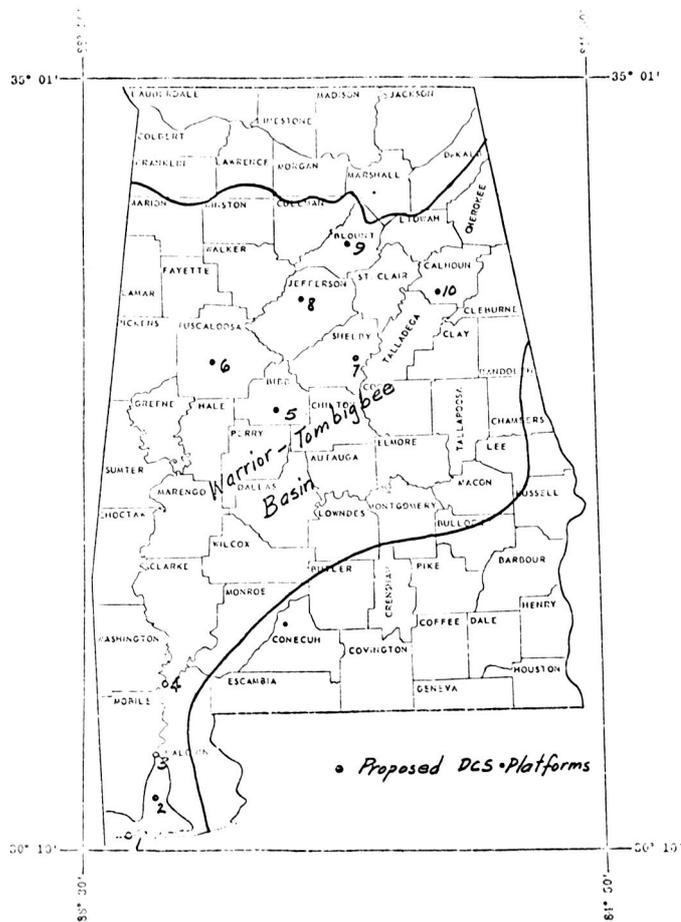


Figure 3. Location of test area (the entire State of Alabama).