Paper L 11

EVALUATION OF ERTS-1 IMAGERY FOR LAND USE/RESOURCE INVENTORY INFORMATION

Ernest E. Hardy, *Senior Research Associate;* James E. Skaley, *Project Coordinator* and Elmer S. Phillips, *Photography Consultant, (New York State College of Agriculture and Life Sciences, Cornell University, Ithaca, New York)*

ABSTRACT

The objective of this investigation was to develop a low cost, manual technique for enhancing ERTS-1 imagery and preparing it in suitable format for use by users with wide and varied interests related to land use and natural resources information. The goals of the project were: to develop enhancement techniques based on concepts and practices extant in photographic sciences, to provide a means of allowing productive interpretation of the imagery by manual means, to produce a product at low cost, to provide a product that would have wide applications, and one compatible with existing information systems.

Through the use of photography techniques, standardization of the 70mm film chip received from NASA is achieved. A subtractive color process is employed to produce step enlargements of the 1:3,300,000 images to scales up to 1:66,000. Diazo transparencies are then produced in magenta, cyan, and yellow for each of the four MSS bands.

Data retrieval can be achieved from any of many thousands of diazo color combinations. Each color diazo combination can provide a unique kind of information. Direct map transfer is readily accomplished at the scale of 1:250,000 and larger. Enlargement to much larger scales (1:50,000 to as large as 1:10,000) is feasible with quality overhead projectors.

Cost of preparation of the photographically enhanced, enlarged negatives and positives and the diazo materials is about 1¢ per square mile. Cost of creating and mapping a land use classification of twelve use types at a scale of 1:250,000 is only $1 per square mile. The product is understood by users, is economical, and is compatible with existing information systems. Hard copy mylar maps for reproduction are produced, from which information for computer manipulation is prepared. Many user applications of this system are already in use.

This is a report on the progress and some of the results of research carried out in relation to NASA Investigation No. 358, Evaluation of ERTS-A Imagery for Land Use/Resource Inventory Information. The research has been conducted by the New York State College of Agriculture and Life Sciences, by the Department of Natural Resources at Cornell University. A full-time professional research staff of five people assisted by consultants in photography and computer sciences has been responsible for the research work of this project.

Among the goals of the project were the development of photographically enhanced imagery at a low cost, suitable for use in manual interpretation of ERTS-A imagery. If produced in a format compatible with existing land use classification and computer graphic systems, this would provide an opportunity to develop a very wide range of applications.

In our approach to meeting the goals of the project, it was understood that photo enhancement was not satisfied by simply enlarging the imagery from the basic material as received from NASA. It was recognized early in the research program that photographic techniques, when carefully applied to both the positive and negative 70mm film chips, offered an opportunity to enhance the imagery to a very high degree. Enhancement at this stage of the work then lead to the development of processes that:

1. allow for extreme enlargement of scale while still maintaining suitable quality

2. provides an opportunity to produce a great array of color combinations

3. provides for color isolation of any particular form of resource information or land use

By obtaining large-scale images from the photographically enhanced images, at low cost, suitable means of manual interpretation of the data have been developed.

Experience has shown that the more sophisticated the method of processing resource information, the smaller is the number of potential users of that information. Most local officials who make the majority of the resource management decisions do not feel at ease with, or trust, information prepared in a manner they themselves cannot accomplish or duplicate. Therefore, the use of low cost, manual interpretation techniques, based on "hard copy" imagery, is proving to be the key to our widening range of applications.

In all stages of the research on this project, care has been taken to insure compatibility with present land use classification, referencing, and retrieval systems currently in use, especially the New York State Land Use and Natural Resource Inventory (LUNR).

Our approach was to use the LUNR information for our basic ground truth. Additional field checking was done to verify the degree of accuracy of LUNR data in specific areas and to record the rate of land use change in selected study areas. Staff members had previous experience as LUNR research technicians and this phase of the work was rapidly completed.

We then developed the photo enhancement techniques that have been the major factor in developing satisfactory techniques for the application of ERTS-A imagery to resource and land use classification and inventory.

New classification systems were developed, based on the capability of the photographically enhanced ERTS-A imagery. Suitable conversions of the LUNR classification were made, to enable comparisons between the two systems of data acquisition. Data from both sources were related to standardized map bases, and evaluation of accuracy levels were undertaken.

High correlations were obtained for classification systems developed for 8 to 12 land use categories. Many of our tests indicated over 90% correlation, but we consider 85% a more typical figure.

The high correlation figures encouraged us to consider other applications for use of ERTS-A imagery. Many have been tried successfully.

Within the photographic process, a number of steps and procedures should be mentioned. From the photographer's viewpoint, the imagery, as received from NASA, is out of balance. For accurate color reproduction, the density ranges should approximate one another. We realized that if we could use photographic processes to approximate false color reproduction, it would be feasible through the use of subtractive color theory to assign combinations of colors and bands, negative or positive, for clear demarcation in any desired color of any specific object.

Through experimentation, proper films, filters, and process techniques have been determined to provide images of more nearly balanced density. Through step enlargement procedures, the images may be enlarged from the 1:3,300,000 70mm chip up to 1:1,000,000 and then up to ratios of 1:150,000 or larger.

Carefully prepared, and by following prescribed calculations, positive transparencies from the negatives can be produced. These are then run through the diazo process, where any of the desired wavelengths may be produced in cyan, magenta, or yellow. To continue the original test to produce false color, band 4 was printed yellow, band 5 magenta, and band 7 cyan. When superimposed, they produced a high quality false color image.

As a further test of this process, the false color images were enlarged to scales as large as 1:66,000 and there was still suitable information for land use classification.

The photographic steps have shown that by using subtractive color theories to produce the desired false color, an extremely wide range of color combinations is possible. Although work needs to be continued on development of a prediction model of the possible combinations of color, and what they relate to, we have been able to identify any desired land use information by isolating it in a color of unique contrast with its surrounding areas.

The number of possible color combinations from any one frame of imagery is greater than 20,000. When imagery from two time periods is used, the number of possible combinations increases exponentially.

The diazo process enables us to use manual manipulation of spectral bands and hues to elevate the contrast level of any spectral category of interest. Then, by color coding desired density levels to approximate a desired classification unit, interpretation and geographic referencing of like spectral zones is a satisfactory way of applying the satellite imagery to a resource classification system.

We have not yet found major difficulties in geographic referencing. The imagery, as prepared, has high resolution capability, and boundaries between contrasting colors and hues are sharp. There is ample opportunity to use this imagery for direct transfer of data at ratios of 1:250,000 or 1:150,000 or even larger. Projection techniques and inexpensive equipment are readily available to provide excellent results at scales of 1:24,000 and larger.

Data takeoff techniques have proven satisfactory when relatively straightforward guidelines are followed. They are:

1. Prepare a base map at the desired scale with a few geographic references such as lakes or streams.

2. Trace regions of like hue identified as a homogeneous spectral category onto the overlay.

3. Construct a spectral map from different composites to fill in the desired information for the mapped area.

4. Relate areas to UTM coordinates and record on appropriate forms for computer storage and retrieval.

The results of this approach can be, and have been, verified by comparison with low-altitude photographs, existing geographically referenced land or resource surveys (LUNR), or by field checking. Results to date have shown a high degree of correlation, usually close to or over 90%.

The final hard copy map output from this process may be at practically any desired scale. Direct transfer may be made at ratios of 1:250,000 and 1:125,000 with map units of about 25 hectares and 10 hectares, respectively. When projected imagery is used, it is quite routine to go to scales of 1:12,000 with minimum map units of two hectares or less.

There is a major opportunity to make satellite imagery available and useful to large numbers of people through this processing approach. We have found it very productive as a source of data for such uses as:

1. updating previous inventories

2. analysis of seasonal change

3. compilation of new maps, such as forestry, drainage, agriculture

4. isolation of one specific land type or land use

5. generation of new kinds of data, such as sequential snow cover maps

Many other applications have been requested and are currently being tested. The apparent advantages of this process are found in:

1. low costs - as low as $1 per square mile for up to 12 classification units

2. that it does not require sophisticated or expensive hardware at any step of the process

3. that it limits subjective interpretation so it can be readily taught to non-technical users

4. the extremely wide range of color selections allowing adaptation for great numbers of applications

5. high accuracy levels achieved

6. letting the user select the scale of his choice for any application

7. the material being readily understood

8. the whole process able to be carried out anywhere in the world with equipment costs of $10,000 or less

9. that it is, or can be, compatible with existing resource information systems

Current applications include use by planning agencies, a number of state agencies, and by university faculty and students for research projects.

The potential for the future appears very great, with the inherent capabilities of the satellite system offering information that was previously unavailable. With the development of a suitable color prediction model, we can predict continuous rewards. Our current efforts at broadening the applications of ERTS-acquired imagery have been directed toward introducing the process to the local administrators of the state. To this end, the assistance of the Cooperative Extension Service has been obtained, and the development of a service organization, capable of introducing the use of ERTS imagery to anyone desiring to use it, is now underway.