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REGIONAL ENVIRONMENTAL ANALYSIS
AND MANAGEMENT: NEW TECHNOLOGIES FOR CURRENT PROBLEMS*

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This paper discusses advances in data acquisition and processing procedures for regional environmental analysis. Automated and semi-automated techniques employing Earth Resources Technology Satellite (ERTS) data as well as conventional data sources are presented. The following comments summarize our experience in this area:

Comment #1 — The ERTS Computer Compatible Tapes provide a very complete and flexible record of earth resources data and represent a viable medium to enhance regional environmental analysis research.

Comment #2 — Most ERTS research has focused upon the data acquisition potential of the system rather than how ERTS data may be incorporated into existing information systems for environmental analysis and management.

Comment #3 — Most research directed toward the design of automated and semi-automated spatial data acquisition systems has ignored the importance of referencing the data to an earth grid.

Comment #4 — One of the greatest needs in regional environmental analysis and management is a quick and reliable means to acquire and process large volumes of spatial data.

Discussion of Comment #1

The U.S. Department of Interior has established at Sioux
Falls, South Dakota, United States of America, the Earth Resources
Observation Systems (EROS) Data Center which provides to the
public reproductions of ERTS and Skylab earth resources data and
reproductions of aerial photography taken by NASA aircraft. A
partial list of ERTS and Skylab data available for New Zealand
has been distributed. Persons interested in specific images
for personal use should direct their requests to the EROS Data
Center. An example of one of the better ERTS scenes of New
Zealand is illustrated (Slide I). Examples of Skylab photography
of New Zealand are also shown (Slide II, Slide III and Slide IV).

In certain instances, hard copy reproductions of ERTS and
Skylab data will suffice for many data needs of researchers,
particularly if costs and sophisticated analysis capabilities
are limited. The digital tapes of ERTS images in computer com-
patible tape (CCT) form presently cost $160.00 (U.S. dollars) per
scene and may represent a major expenditure for small research
projects. For detailed analysis, however, the CCT's represent
the most versatile form of ERTS data. There are several reasons for
this conclusion. Many agencies have addressed the problem of improving
the quality of the ERTS bulk scanner data by removing radiometric and
geometric distortion inherent in the system. For example, the Federal
Systems Division of IBM Corporation located at Gaithersburg, Maryland has
not only succeeded in removing most of the distortion in the ERTS CCT's but

also has developed the capability to electronically superimpose an earth grid onto the tape record (Bernstein, 1973).

In addition to removing image distortion, IBM also has designed a system to enhance the resolution quality of the image record and remove shadow effects. A comparison between the normal EROS color composite and the IBM product dramatizes the improvement (Slide V).

The IBM technology, though singularly important, has greater significance when combined with automated interpretation technologies developed at several research centers in the United States, such as that developed at George C. Marshall Space Flight Center in Huntsville, Alabama (Bond and others, 1974). The system performs in the following manner: Known ground control points recognizable on the photographic record are referenced to the data address of corresponding single resolution elements (pixels) on the digital tape. A linear transformation between original and corrected image coordinates is used to correct for image distortion. Land use may be interpreted on a pixel-by-pixel basis by comparing the properties of the spectral data with the spectral signatures of known land uses. The result is a geometrically registered record of interpreted land use which may then be displayed in hard copy form (Slide VI).

Another advantage of using the CCT's rather than the photographic record relates to the visual limitations of the human eye. The spectral reflectance of each pixel is received in four wavelength ranges (0.5 to 0.6 micrometers, 0.6 to 0.7 micrometers, 0.7 to 0.8 micrometers and 0.8 to 1.1 micrometers), each of which

may be represented by one of 256 gray tone levels. The human

eye cannot compete with the interpretation capabilities of most

automated systems simply because of the volume of data.

Discussion of Comment #2

Recent evaluation of research involving the use of ERTS

data reveals a tendency for investigators to stress the inventory

capabilities of the system rather than the potential of the

system for augmenting environmental systems analysis. Many types

of data were discovered to be potentially derivable from remote

sensing systems. The usefulness of remote sensing as a data

acquisition and inventory tool has been well documented. The

integration of remote sensing technologies with environmental

assessment technologies remains to be accomplished.

In many instances complex simulation models must be con-

structed in order to anticipate environmental impacts. The

structure of these models is often incomplete simply because

of the lack of current data or insufficient existing data. Because

remote sensing procedures fill this gap, our experience in developing

environmental analysis has led us to the conclusion that the greatest

value of data acquisition systems such as ERTS is not the inventory

capabilities but rather its potential to complement regional environmental

analysis and management.

Discussion of Comment #3

Computer resources are necessary to assess and analyze the complex

natural and cultural systems which characterize a geographical region.

To facilitate computer analysis, spatial data must be referenced to some

type of grid. Bounded areas are usually described in one of two ways: by polygons or by aggregations of cells. The traditional approach to store and manipulate large volumes of spatial data has been to use grid systems in which data are inventoried and stored on a cell-by-cell basis for the entire area of study.

In recent years polygon systems have been developed to handle spatial data. Using this approach the borders describing different polygon types are digitized either automatically or manually stored. This system is efficient for digital storage and accurate graphical display of spatial data but is cumbersome for complicated analysis for multiple variable modeling.

We are developing a hybrid system which combines the ideal characteristics of both. The major problem is to develop efficient software to convert polygon-described data to cell-described data. Very few research organizations have approached this problem. Most automated and semi-automated digitization work has sought only to streamline graphics capabilities to produce cartographic products. Few researchers have sought to augment information system analytical capabilities.

Discussion of Comment #4

During the past four years the National Science Foundation/ RANN program has funded an interdisciplinary research effort at Oak Ridge National Laboratory in Oak Ridge, Tennessee to develop environmental planning and management technologies. The project was entitled Regional Environmental System Analysis. The primary

objectives of this research were to assist decision makers:
(1) in forecasting and simulating future changes in the land-
scape; (2) in evaluating the consequences of alternative plans;
and (3) in determining the optional solution to a given problem.

The emphasis of the research was the development of export-
able regional analysis and management procedures. The total
regional simulation analysis is composed of a collection of func-
tionally related models describing the socioeconomic, sociopo-
litical, land use, and natural subsystems. The objectives of
each of these sections were as follows:

1. Socioeconomic analysis — To develop a model capable of
making base-line as well as conditional forecasts of aggregate
regional activity in terms of population and employment.

2. Land-use analysis — To develop a model capable of
spatially allocating the aggregate regional activity described
by the base-line and conditional socioeconomic forecasts. In
addition, the model should be capable of describing the effects
of a wide range of management actions such as implementation
of land-use policies and the choice of public-facilities locations.

3. Natural systems analysis — To develop a model capable
of predicting the effects of patterns of change on the natural
environment. This requires specifying the distribution of society's
effluents and their effects.

4. Policy and social impact analysis — To develop models
to describe the reciprocal impacts between the populace and the
forecasted economic, land-use, and environmental changes. In

addition, the models should describe the management strategies used by society to respond to these impacts.

The collection of data and its transformation to a form compatible with other data sets turned out to be a very thorny problem. The ready availability of data at the proper scale and resolution level (census tract, 40 acre cells, etc.) is essential for the testing of model theory, calibrating of model algorithms and running of simulation routines.

Our experience with modeling real world processes is that the researcher's need for data can seldom be satisfied completely by existing sources. It is in real world problem-solving that the significance of data becomes apparent. There is a direct correlation between the usefulness, accuracy and completeness of data with the comprehensiveness of any environmental analysis.

It is our opinion that world resources problems will never be solved by inventory technologies alone. Decision makers have become increasingly concerned about the total impact of man's activities and must be provided information and alternatives derived from sophisticated tools in order to make responsible evaluations. Our comments have been directed toward this goal.

Author's Note — Copies of the slides utilized in the presentation of this paper may be obtained from the authors for the cost of reproduction.

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