

REMOTE SENSING, COMPUTERS, AND LAND USE PLANNING

By Harry C. Hitchcock¹

During the past decade, increased emphasis has been placed on land use planning at state, regional and national levels. A thorough knowledge of present land use is prerequisite to planning future land use. In other words land use inventory or classification is a primary stage in comprehensive planning at all levels.

Remote sensing provides a tool for producing accurate and efficient land use classifications on a regional basis. Remote sensing can be described as the acquisition of information about a portion of the earth's surface by using sensing devices operated from a remote location (Hoffer, 1971).

Aerial photography is probably the remote sensing system most familiar to foresters. The large majority of graduate foresters have at some time used air photos for stratifying or typing timber stands. Making distinctions between forested and non-forested lands can be considered a basic form of land use classification.

During the last decade sophisticated non-photographic remote sensors have been developed which offer several advantages over camera systems. One of these is the multispectral scanner (MSS) which allows a broader spectral range than a photographic system and provides superior spectral resolution. (Coggeshall and Hoffer, 1973).

Remote sensing instruments basically measure electromagnetic solar energy reflected or emitted by earth surfaces. It is differences in the amount and type of energy reflected or emitted that allows differentiation between objects by remote sensing systems.

Conventional aerial films sense electromagnetic energy in the visible wavelengths, or about $.4\mu\text{m}$ to $.7\mu\text{m}$. Special films, such as color infrared (CIR), can sense slightly longer wavelengths in the near-IR region, or up to $0.9\mu\text{m}$. Multispectral scanners can simultaneously sense energy through a broader range including the visible, near-IR, middle-IR, and thermal wavelengths, or about $0.3\mu\text{m}$ to $14.0\mu\text{m}$. They can also sense in narrow wavelength bands which provides good spectral resolution.

A multispectral scanner consists of a multi-band spectrometer whose instantaneous field of view is scanned across the scene perpendicular to the flight line. At any instant the scanner is receiving energy from a single ground resolution element (Lindenlaub, 1972).

¹ Research Assistant, Laboratory for Applications of Remote Sensing (LARS), Purdue University, West Lafayette, Indiana 47906. The activities described in this paper were supported by NASA Grant Number NGL-15-005-112,

The total reflected and emitted electromagnetic energy from a ground resolution element may be thought of in terms of an energy vector. A multispectral scanner mounted in an aircraft or spacecraft has the ability to break this vector into its components and simultaneously record the relative spectral response in each of several bands. The energy vector is resolved through a prism for the visible wavelengths and a grating for the longer wavelengths.

The strength of a spacecraft-mounted multispectral scanner system is due in part to five facts:

- (1) An extensive geographic area can be scanned
- (2) in a relatively short time.
- (3) A broad range of the electromagnetic spectrum can be sensed with
- (4) high spectral resolution (narrow wavelength bands).
- (5) The quantitative nature of the data lends itself to analysis by high speed computers.

Computer-Aided Analysis

The Laboratory for Applications of Remote Sensing at Purdue University (LARS/Purdue) has developed a system for the computer-aided analysis of remote sensing data. The primary thrust of the effort at LARS is the analysis of MSS data using pattern recognition techniques, which will be described here.

The computer uses digitized values from each MSS channel to construct a spectral response profile for each ground resolution element. The next step in the analysis is known as "training" the computer (Coggeshall and Hoffer, 1973). An analyst familiar with the area will designate training fields to the computer. A training field is simply an area on the ground whose cover type or ground condition at the time of the flight was known. Several training fields will be selected for each class of interest (i.e., corn, wheat, water, forest, etc.). The computer will then construct a statistical response profile, or spectral pattern, for the designated classes. The number and type of classes will be dependent on the objectives and scope of the analysis.

Having trained the computer, the analyst may now have the area of interest classified point by point. The computer will compare the response profile of the points to be classified to the profiles of the selected training classes, and using a pattern recognition algorithm, will classify each resolution element in the area of interest.

After classification, the computer can present the results in a number of formats. For example, the analyst can request a printout with the classified data represented by alphanumeric symbols, such as an "F" for forest or a "W" for water, or the

results may also be projected on a video digital display unit with contrasting colors. Another feature of the system is tabular output which provides such information as acres per class and accuracy achieved.

What has been briefly described is only the basic concept of pattern recognition techniques. A multitude of variations are available to the remote sensing analyst. The point to remember, however, is that the analyst with an excellent knowledge of his discipline is an integral part of the total system and is in fact essential. The LARS approach to remote sensing optimizes human/computer interaction which in turn enhances the technique's versatility.

APPLICATIONS

The combination of computer-aided analysis of remote sensing data and earth resources satellites offers immense potential in land use planning. Two of the most familiar of these satellites are the Earth Resources Technology Satellite (ERTS) and the manned SKYLAB spacecraft.

SKYLAB contains, among other sensors, a 13-channel MSS and several conventional cameras. ERTS contains a 4-channel MSS. The ERTS "pictures" that many people have seen are simply composite images reconstructed from MSS data through color projection techniques.

Computer-aided analysis of ERTS and SKYLAB MSS data has many applications in resource management and land use planning. Some of the applications are operational or presently being refined, while others are still in the planning phase. Three general applications will be described here:

- (1) Land Use Maps - Many types of land use maps may be constructed. A common type is an integrated classification of urban areas. These maps describe present residential and urban patterns as well as growth trends. Information derived from monitoring urban growth can serve as an aid in efficient city and regional planning. For example, the amount of forest land being converted to urban acreage is an important indicator of urban growth.
- (2) Vegetation Cover Type Maps - Pattern recognition techniques can aid in the production of accurate cover type maps. These can be produced in some cases on a species level, and in the future may be produced by density class. With periodic satellite data, extensive areas can be mapped in a timely fashion yielding much-needed data concerning harvesting, reforestation, burned acreage, site conversion, and recreation usage.

- (3) Strip Mines - The computer can be trained to identify and locate areas of strip mine activity. It can also be trained to recognize several spectral classes within the strip mines. The value here is not only in the initial location of strip mines, but also in the monitoring potential. Repetitive data acquisition and computer-aided analysis should yield data on new mine openings, reclamation activity, site conditions, and acreage estimates. Water quality information may also be obtained.

The preceding were only three of the many areas where computer-aided analysis of remote sensing data may be applied to land use classification. Some other areas are in agronomy, geology, geomorphology, and hydrology.

What has only been very briefly described here in a few pages is a dynamic system that has taken hundreds of people and many years to develop to its present state. The objective of this paper has been solely to create an interest in remote sensing among the readers and to point out a few present and potential applications in the area of land use planning. Those who desire a LARS bibliography or more detailed information on computer-aided analysis of remote sensing data should write:

Dr. David Landgrebe,
Director
Laboratory for Applications
of Remote Sensing
1220 Potter Drive
West Lafayette, Indiana 47906

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