The Environment—Where Do We Stand?

From the Vantage Point of Space[1]

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Highlight

Remote sensing from satellite systems offers real potentials for data collection on rangeland problems, structure, and use. When techniques, now being tested at a number of locations, have been more fully developed, more information from remotely based sensors will be available for reducing the uncertainties surrounding daily policy and management decisions. Techniques under development are discussed.

A significant part of man's current concern about his environment can be traced to his reaction to the first, incredible, astronaut's-eye-view of this planet. The vision of "spaceship earth" drifting in lonely isolation has shocked millions of thoughtful citizens into a chilling awareness of the completely closed character of the life support system we live in. Casual acceptance of, or indifference to, the fact of our total dependence on a finite resource supply, and on a supporting environment of demonstrated yet unmeasured fragility, is now fairly generally recognized as a foolish and shortsighted posture. The "need to know" what is happening to our global environment—not just from one century to the next but almost from day-today—has become painfully evident.

Technical feasibility has been established, and launching of the first earth resources technical satellite (ERTS-A) is planned for later this year. Other more sophisticated projects, including Skylab and the space shuttle, will follow. What then are the potentials for these new intelligence systems?

First, let us discard the idea that one photograph or image will provide each of us the data we need for day to day management of the environment, for the seasonal or annual planning requirements, or for the major policy decisions faced at every level of government and corporate activity. Replacing the single highly skilled photo interpreter are teams of scientists studying sensor-signature codes, engineering teams perfecting an unlimited array of electromagnetic sensors, groups of data and image processing specialists looking for new ways to surface, automatically and routinely, the useful information which lies hidden in many forms and formats of imagery and electronic signals.

If we are past the show and tell stage, where are we? Modern remote sensing technology is unfolding opportunities which are staggering. Here are some of the opportunities:

The synoptic or big view.—From imagery taken 150 miles out in space we can view without distortion the entire State of Wyoming on 10 photographs.

Multistage sampling.—We now have the capability of extending useful sampling from the observation of a single blade of grass through larger samples to the limit of one face of the earth.

Repetitive imagery.—We can now repeat imagery at intervals which have air, soil, water or phenological significance.

Multiband imagery.—For most of man's existence on earth, we have had to limit our remote sensing to the 4/10's of a micrometer of the electromagnetic spectrum that the optic nerve responds to. Now we span most of the electromagnetic spectrum.

Image and signal enhancement.—We have just scratched the surface with a few developments in optical and electronic image and signal enhancement which allows maximum information retrieval for specific purposes and selective combinations of information from many sources.

Data handling and communications.—This technology is ahead of, or equal to, requirements that we in natural resources may place upon it. But as you develop a strategy for employing all of the above in concert, data handling may become limiting.

There is little new in the technology devices listed above. We can and have used them before the space age. Continuous use for many purposes over wide areas for practical application at reasonable cost is not possible without the space dimensions.

The most commonly invoked application of space information systems to rangeland problems is for the development of a complete inventory of our western wildlands. It is vitally important that we have an accurate, up-to-date knowledge of the structure, use, and condition of this immense area, but the job is of such magnitude, complexity, and cost that it has never been done.

But important as adequate rangeland inventories are, we must not fail to recognize the potential utility of a permanent or continuing space information system for documenting change. The capability to delineate on space photos major categories of land use has already been demonstrated. It presents an unparalleled opportunity for observing and evaluating, on a regional or even sub-continental scale, shifts in row-crop agriculture, irrigation, range grazing, new-town development, surface mining, and other similar activities. We can also expect to be able to detect the extent and severity of certain types of natural or man-caused environmental change, and to appraise its probable significance. The synoptic view will not give us a diagnosis of the causes of envi-

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ronmental degradation, but when we have learned what to look for, it will provide an environmental "early warning system." It will help establish a base level from which to judge, measure, and evaluate change. It will help explain locally observable phenomena which, out of context of the total mosaic, are meaningless.

The limiting factor, or pacing element, in useful application to range and other natural resources problems, is research. Thanks to the momentum of the Nation's total space effort, and to the technological achievements of the aerospace and electronics industries, the hardware engineering aspects of producing data from remotely based sensors are well advanced. What is lagging far behind is knowledge of relationships among earth resources phenomena and sensor response. These phenomena change over space and over time at varying rates for different phenomena.

Let us return to data handling, briefly. This will be serious enough with the relatively limited output of the experimental ERTS-A. But when a continuing satellite system becomes operational, the sheer volume of data will utterly swamp all available staff and facilities if we do not know by then how to sort, reduce, and process data automatically to extract specific needed information. Ways of doing this have been under study by a number of skilled and imaginative people. The Purdue University remote sensing lab has made excellent progress in automatic discrimination of agricultural crops. The random and heterogeneous patterns of range soils and vegetation represents a more difficult challenge. Techniques of scanning aerial or space photos using an automatic recording microdensitometer, being studied by Forest Service researchers at Berkeley and Ft. Collins, show considerable promise.

The success of data interpretation depends on identification of energy patterns in different bands of the spectrum that are uniquely characteristic of whatever it is that is to be discriminated. To produce discrimination keys for consistent and reliable recognition of range ecosystems, for example, the distinctive spectral features or "signatures" of each must be established. It is also necessary to know at what season of the year the characteristics differences can best be detected, on which kind of film, and using what filters. The influence of climate, site quality, current grazing regime, and other variables must also be isolated. Our staff at Berkeley has been building a microdensity image data bank for forest and rangeland classes using Apollo 9 infrared color photos, and multiband simulated space imagery representing several seasonal conditions.

Other important related research deals with such problems as optical properties of vegetation, recognition and possible diagnosis of stress symptoms in plants, and design of multistage sampling techniques for quantifying timber volumes and forage production. The National Aeronautics and Space Administration is taking the lead in helping to plan, coordinate, and fund research. The Departments of Interior and Agriculture and a number of universities are actively participating.

In considering the practical outlook for satellite information systems, it is difficult to avoid extremes of either optimism or skepticism. But if we accept the potential of the foregoing applications, two critical questions still remain: Who will use the information, and how will they integrate it into current decision making and program planning? There is not time, nor for that matter the experience-based judgment, to examine these questions in the depth that they deserve. Raw data from ERTS-A will be recorded on magnetic tape at central receiving stations, processed, and distributed to trained interpreters in Federal and State establishments, universities, and other organizations. They will have the responsibility of working closely with the people who will put this information to practical use. Gradually, as raw data are converted into maps, statistical summaries, and electronic printouts showing patterns of selected phenomena, a wide variety of user groups will become directly involved in adaptation to specific resource problems. These will include livestock producers, land managers, water user associations, advisory and regulatory boards, State and regional land-use planners, Federal agencies, and legislative committees. Decisions involving allocation of funds, choice of management strategies, and the scheduling of action programs should be made with greater assurance of success.

In the final analysis, information derived from remotely based sensors offers one more opportunity for reducing the uncertainties surrounding decisions that must be made every day. Those of us who are decision makers and policy planners will have more accurate indicators of change and a more rapid feed-back on environmental conditions.