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REMOTE SENSING OF EARTH RESOURCES USERS, PROSPECTS AND PLANS

BY

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PRESENTED TO THE

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REMOTE SENSING OF EARTH RESOURCES
USERS, PROSPECTS AND PLANS

Paper by

DR. W. T. PECORA
Under Secretary, Department of the Interior

PRESENTED BEFORE

THE COMMITTEE ON SCIENCE AND ASTRONAUTICS
U.S. HOUSE OF REPRESENTATIVES

AT ITS

THIRTEENTH MEETING WITH THE PANEL ON SCIENCE AND TECHNOLOGY, JANUARY 26, 1972, AT WASHINGTON, D.C.

Mr. Chairman, Members of the Congress, and Colleagues:

The printed program for this meeting begins with an explanation of the theme: Remote Sensing of Earth Resources, the first sentence of which states: "In recent years it has been increasingly recognized that information about the earth and its complex environment is highly important to the future of man."

This Nation is now undergoing a sharp reassessment of the quality of its life style. For many decades economic development and benefit overrode all other considerations of our land and resources and conservation essentially meant multiple use of our renewable and nonrenewable resource domains. Inevitably, because of its natural endowment, America prospered in material things and the United States led the world in GNP. Our land, water, and air were intensively used, but so misused in many cases that in grave concern the Congress passed the Environmental Policy Act of 1969. Since its enactment into law by President Nixon on January 1, 1970, it has become in my opinion the most significant legislation passed in many years. Environmental protection now shares front stage with economic development. The task now lying before this Nation is how to utilize its science and technology to maintain its economic vigor without unacceptable alternation of its natural environment.

Primitive man on earth found by observation and experience that his pristine environment contained many discomforts and dangers to his health and welfare. He banded together for safety, shelter, and greater success in food gathering. As his numbers increased on earth and as his communal living led to development of cities and major civilizations his uses of the natural environment increased by geometric proportion and his needs created major changes in natural ecosystems.

In this country three people can now supply the food needed by 100; and one penny's worth of gasoline can do the work of 25 men. Life expectancy is greater than in all history. It would be foolish to insist that man return to his primitive existence or to substitute the life style of Thoreau for that of 200 million Americans. Many developing nations are striving to reach the U.S. pinnacle of a standard of living which, for all of its environmental changes, is cause for envy and great admiration.

But what of the future? Land, and resources are not infinite. As the problems relating to mankind's basic needs on earth magnify at an exponential rate the means of solving them must become more sophisticated and the solutions must depend more than ever before on science and technology. The broad gaps in our information system on those four domains of man's environment—the lithosphere, hydrosphere, atmosphere, and biosphere—suddenly loom as intolerable ignorance in preparation for the future. If GNP has any meaning at all then a larger national effort must be expended in acquiring a base line of knowledge to keep GNP from turning into a Humpty Dumpty syndrome.

As sophistication in knowledge increases there comes a mounting problem of communication. Specialists pile on specialists, each speaking the jargon of his own specialty. Information that is expressed with widest understanding will, of course, be a major requirement for new knowledge.

Remote sensing of the environment offers a methodology that can benefit people throughout the world at a time when thorough understanding the environment, while using it, is a requisite for public choices and governmental policy. Sophisticated in program execution it is indeed; but the products of its efforts are practical and wide ranging—and understandable. This is as it should be; public choices can be prudent only if the public truly comprehends the issues and recognizes options and consequences of full use, partial use, and nonuse set-asides.

POTENTIAL USERS

In the session of yesterday afternoon, a group of our distinguished colleagues presented a discussion of the state of the technology of remote sensing of earth resources. I will therefore not dwell on the technical aspects, but will proceed to a consideration of potential users, future prospects, and operational plans utilizing satellites and aircraft.

First of all, let us examine the question? Who will use the information obtained from remote sensing of earth resources? In a sense, the question can be answered in one word: Everybody. For everybody will benefit, directly or indirectly, from the improvements in the quality of life that result from prudent land use and control of our environment.

Secretary of the Interior Rogers Morton has put it this way: "If we are to control the environment in the best interests of society, if we are to enjoy the benefits of our natural resources without despoiling them, we must begin by knowing what they are, where they are, and how extensive they are."

Between now and the end of the century, the total U.S. facilities "plant" will need to be replaced or duplicated, this can be done efficiently, safely, and within acceptable limits of preservation of environmental quality only if sound knowledge of the earth and its resources is available prior to decision making. To provide that necessary knowledge we would need to enlist the services of the broadest possible spectrum of earth scientists and technicians. These are the people who will use the remote-sensing data directly. They will constitute the link between the bank of sophisticated input information and "everybody", the rank and file who benefit indirectly from environmental control.

The kinds of direct users—earth scientists and technicians—who will work with the remote-sensing information are indicated by the following list of down-to-earth information needs that can be met by remote-sensing techniques:

- Water
  - —surface distribution
  - —distribution of suspended sediment
  - —subsurface landform in shallow waters
  - —pollution patterns

- Snow
  - —surface distribution
  - —water content
  - —melting rates
  - —flood potential
- Land
  - —landform analysis
  - —geologic structure
  - —land use
  - —soil moisture
  - —topographic expression
  - —soil type
- Vegetation
  - —natural vegetation distribution
  - —agricultural vegetation distribution
  - —relative vigor of vegetation
  - —seasonal changes and fire control
- Cultural features
  - —city outlines
  - —major transport networks
  - —growth patterns and planning
- Geophysical
  - —thermal feature of surface
  - —crustal magnetic anomalies

From this very general list we can readily foresee the involvement of hydrologists, meteorologists, land-use planners, geologists, physiographers, cartographers, foresters, botanists, agronomists, ecologists, urban planners, transportation planners, geophysicists, volcanologists, seismologists, geodesists, and oceanographers; and undoubtedly some members of Congress. Such interest groups already have made credible progress in adapting the remote sensing technique to real world needs.

Here are a few of the many projects now being implemented under Federal support:

- Detection of limestone and dolomite bodies from infrared imagery
- Identification of rock properties by remote temperature sensing
- Application of data from a space satellite to regional analysis of the earth's crust
- Rapid mapping of topographic geologic hydrologic and biologic features by computer processing of multispectral photography
- Location of ore deposit targets by remote sensing of trace contaminants in the atmosphere and effect of trace elements on vegetation
- Mapping of shoreline sediments and currents from aerial photography and infrared imagery
- Studies of geothermal and volcanic areas by aerial photography and infrared imagery
- Tracing of waterborne contaminants by Fraunhofer-line discrimination
- Sorting and identification of urban features by multispectral high altitude imagery
- Snow and ice assessment with passive microwave
- Remote sensing of thermal patterns in water bodies, for example in Yellowstone National Park and Connecticut estuary

- Detection of potential sinkhole collapse in limestone terrains
- Sorting influent and effluent streams with side-looking radar
- Infrared radiometric measurement of ground water discharge to streams
- Permafrost mapping
- Remote mapping of ecological features in the Everglades

Of course these are highly technical investigations and "*everybody*" would not understand the results; but "*everybody*" would benefit from improvements resulting from the studies, just as we have the benefits of television without understanding the circuitry.

In a special study conducted by the Department of the Interior to identify the potential customers of ERTS satellite imagery from its national data center, it was estimated that in excess of 20 million photographic prints will be required annually. About 75 percent of these, 15 million prints, will be for commercial users, foreign and domestic. State agences are expected to require nearly 2 million prints; local agencies 2¾ million; the Department of the Interior three-quarter million; and other users about one-quarter million.

Mineral extraction industries will use synoptic satellite images to define new target areas for exploration. Water power and resource groups will use images to monitor water sources for hydroelectric plants and to examine new sites to meet increasing demands for water or energy. Large paper and lumber companies will use such data to inventory tree crops and monitor seasonal conditions. Many companies may use it for market surveys and to determine site locations for plant expansion or new marketing facilities.

State governments have a need for up-to-date photography and maps for use in highway planning, economic development, property valuation, land-use analysis, historical record, and change analysis, to name a few.

Schools and universities will find remote sensing images to be useful in teaching geography, conservation, economics, and earth sciences. Satellite coverage will graphically display to our young people the complexities of our natural and cultural environment, and thereby give them a better understanding of the problems involved, and hopefully the opportunities for wiser solutions in the future.

There is a lively foreign interest in satellite data as was evidenced at the first International Workshop on Earth Resources Survey Systems this past spring at the University of Michigan. Forty nations sent representatives. Recently an agreement was signed with the U.S.S.R. to exchange earth resources data. The Department of the Interior has entered into a joint program with the Inter American Geodetic Survey to assist in the application of remote sensing technology in Latin American countries. These and other international implications are scheduled for more detailed discussion in the session of this meeting that follows.

Our current list of users are those that are easily identified. There are potentially many more for as marketing specialists know, the offering makes the market. The availability of data heretofore unavailable will undoubtedly result in numerous applications presently unforeseen.

FUTURE PROSPECTS

We can look forward to future technological developments that will bring an immeasurable increase in the information content of remote-sensing data and we can expect that improved procedures and hardware will result in lowered costs and better quality. But what are the prospects for meaningful use of the vast quantity of data that will be acquired? Will it sit on shelves and gather dust? Or will it be used by the resource community in the depth and breadth of its potential?

If we are going to get the maximum benefit from remote-sensing data, we have to get the resource community involved—not just the resource people of the Interior Department, or the Federal Government, or the universities. We need to establish a grass-roots appreciation of the powerful tool we have in remote sensing. Agencies of local governments concerned with resources have an important stake in the available information. The private sector, whether individual or corporate, has much to gain by effective use of the resource data. All of these users should be encouraged to express their needs for remote-sensing data in specific terms. They should be encouraged to define any technical problems they encounter or suggest possible solutions to the problems. Above all, the data should be made available to these users quickly, conveniently, and at reasonable cost.

One of the most challenging problems for the future in supplying remote-sensing data to the user is the need to keep the material simple, to deliver it in uncomplicated form, then make it easy to use. If a user must have a computer to decipher the data, the data will obviously be useless to him if he does not have access to a computer. This means that the agency furnishing remote-sensing data must be equipped with sophisticated imaging systems and computer facilities. This naturally brings up the question of the cost of supplying the user with the needed data.

The question of cost is tied in directly with the question of breadth of use. Image-processing systems and computers entail a one-time capital investment which can be amortized comfortably if there is a large demand for the products. With a large demand, the prices of the products can be maintained within a reasonable range and the entire operation could be on a self-supporting basis, including amortization of expensive equipment. With low demand, the operation could not be self-supporting; it would have to be subsidized on the basis that it performs a vital public service. The key conclusion is that there is every reason to have a large demand and it is incumbent on leaders in the resource field to stimulate proper use of the available information.

The basic concepts behind ERTS are sound. There is unprecedented interest in using the data as evidenced by the large number of experimenters. A real need exists for new and more timely sources of environmental and resource information. These combine to suggest that the ERTS–A experiment, barring catastrophic failure, should be highly successful.

Assuming success—what happens next? Continued experimentation is, of course, a requisite. But an operational program should be adopted at the earliest possible time. The Interior Department is contributing significant parts of its manpower and fiscal resources toward the conduct and evaluation of the ERTS experiment with the aim of providing the necessary information on which to base an operational decision midway in the life of ERTS–A. Assuming a favorable and timely decision, we are developing plans for an operational flight beginning in late 1975. This schedule is less than optimum and will leave a significant and undesirable hiatus in the data collection process. Perhaps this Panel can identify ways in which this interval can be shortened.

OPERATIONAL PLANS

As I see it, the approach to the problem of maintaining a proper balance between resources development and environmental protection begins with the assembly of complete information on resources and the environment. We have all read rather gloomy reports concerning the ability of this country to tackle the problem effectively. The National Science Board has warned, for example, that "environmental science is too difficult, too broad in scope and too near the beginning for an effective match with societal need to be achieved during this decade." Without discounting the seriousness and the sincerity of the NSB report, I submit that we must gird ourselves for this match, that we must generate the techniques, the manpower, the organization, and the funding to cope with the problem because we have no other choice. To do what needs to be done within this decade will require new techniques for environmental assessment which are better and faster. Let me describe what we are doing in this regard.

The Interior Department under the scientific leadership of the Geological Survey has implemented an Earth Resources Observation System program (EROS) to obtain data from satellites, aircraft, and other sources concerning the land and its total resource assessment. It is cooperating with NASA, Agriculture, Commerce, and other agencies in plans for the Earth Resources Technology Satellite (ERTS–A) soon to be launched by NASA. The experimental ERTS–A system will provide data to be analyzed and evaluated by scientists embracing a broad range of disciplines. These analyses and those related to ERTS–B which hopefully will fly one year later, and Skylab, are expected to form the basis for the design of future earth resource operational satellites and their supporting technology. We anticipate that operational satellite systems will be of key importance in meeting the Department's responsibilities for mapping, monitoring, and managing the vast resources and the extensive public lands of the United States. The Department has therefore a lead role in the application and uses of space data.

To process the information from the EROS program, the Department has established a national data center near Sioux Falls, South Dakota, with the timely help of the Office of Management and Budget and the General Services Administration. A temporary facility has already been set up and is now in operation at Sioux Falls, pending completion of construction at a permanent site donated to the Federal Government. The EROS Data Center will include a state-of-the-art photographic laboratory for the reproduction of images, a computerized data base for rapid retrieval of sensor images, and an opto-electronic facility for the routine extraction of thematic data from images, and a facility for assisting and instructing potential users of remote sensor data.

The photographic laboratory in this facility will be equipped with modern cameras, contact and projection printers, and processors to rapidly produce high quality reproductions in color and black and white. ERTS bulk and precision images will be produced in a variety of combinations of formats and materials. Aircraft imagery will be provided at contact scales and enlargements, in color or black and white, on film or paper.

Rapid access to the holdings of the Data Center is provided via a computerized storage and retrieval system, working in concert with a microfilm reference system. The computer will enable Center personnel to respond to inquiries by telephone, letter, and personal visit to the Center. Data request personnel will be able to inform users of the availability of Data Center imagery for any geographic area of interest. Persons visiting the Center will be able to preview the images on microfilm records in a "browse area", prior to ordering full size reproductions. Copies of these microfilm browse files will be available for viewing in a number of regional data centers across the country and organizations or individuals may purchase their own copies for reference. The microfilm files will enable the potential user to screen the images, determine the frames of coverage desired, and ascertain that the area of interest is cloud free before ordering reproductions.

An opto-electronic laboratory will enable Center scientists to rapidly analyze images to determine the presence or absence of selected objects which have a characteristic spectral "signature". Through a combination of electronic and photographic processing of the images, subjects such as snow cover, standing water, infrared reflective vegetation, and massed works of man will be "mapped" and analyzed for areal extent and seasonal changes.

Users of the data who visit the Center can receive assistance in techniques for interpreting and applying the data through consultation with the Center's scientific staff. Special equipment such as densitometers, additive color viewers, and stereo viewers will be available at the Center for inspection and analysis of remote sensor images. The scientific staff will periodically offer formalized instruction in remote sensor data interpretation to national and international users.

In the consideration of operational plans, we cannot overlook the benefits to be derived from implementation of the President's plan for a Department of Natural Resources. The proposed new Department would embody in its setup appropriate recognition and organizational structure for those activities concerned with the development and management of our Nation's resources. It would, for example, align the U.S. Geological Survey and the National Oceanic and Atmospheric Administration in an unprecedented scientific and technological base for the acquisition, interpretation, and utilization of remote sensing data for the wisest national overview of the earth's resources. I would urge this Panel to lend its support to this reorganization proposal.

CONCLUSION

Satellite data will not solve all our mineral and land resource or environmental problems. There always will be need for a great variety of earthbound studies and ground truth systems. We believe, however, that satellite systems will be powerful additional tools for use in continually inventorying and managing our national resources more effectively and in helping us to be more effective in preventing degradation of the environment. The broader perspective and rapid coverage available through this technology is essential for filling the quantitative gaps in understanding. Remote sensing from space has already demonstrated its value in many ways.

It has made possible, under the great leadership of NASA, successful landings of the moon, studies of outer space, and real time communications from satellites. Under the keen guidance of Dr. Robert White of the Department of Commerce, it gives man important timely information on the weather. Precise positioning on land or sea is now a simple geodetic exercise.

With the personal and active participation of co-panelists Dr. Robert Colwell and Dr. George Zissis, and a great number of other professional colleagues advisory to the Federal Government through the National Research Council and the National Academy of Sciences and Engineering, the great opportunity of the Earth Resources remote sensing program has been spelled out with controlled enthusiasm. It is a timely program as we enter the third century of the Republic. This symposium is a truly important benchmark.

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