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I. Agriculture

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INTRODUCTION

The United States has always been able to meet its demands for food, fiber, and timber. There was always more land to cultivate; fertilizers and other agricultural chemicals have increased the food producing capacity of land already under cultivation; hybrids and new plant strains grow faster, produce more, or are hardier; and cheap energy has replaced horsepower to operate mechanized farm equipment, which has replaced much manpower.

For the future, one important new tool is remote sensing. It has potential applications in four areas: crop reporting, range management, forest management, and soils surveys.

APPLICATIONS

Users and potential users include persons who are oriented to applications research, those who are implementing remotely sensed data into their operations, and government or managerial people who require various levels of information for their decisionmaking. Several levels of information that can be extracted from remotely sensed data and a number of applications for the information have been identified. Much of this information can be acquired at a relatively low cost per acre.

Crop Reporting

Several papers reported the ability to identify crops and to inventory acreages, as well as to spot areas of plant damage (by weather, insects, or disease), using processing techniques on Landsat data.

In one test area composed of small grains (95 percent wheat), sod, and fallow land, remote-sensing techniques identified the small grains with 98 to 99 percent accuracy, sod with 96 to 97 percent accuracy, and fallow land with 91 percent accuracy. This success encourages a broader use of Landsat data (when combined with information on soils, weather, and previous crop yields) to supplement nationwide or perhaps even worldwide estimates of crop production. A need exists for such information on a worldwide basis to improve the orderly marketing of feed and grain supplies and to provide early warning signals for distress so that corrective action can be taken in various parts of the world.

For that purpose, a large area crop inventory experiment (LACIE) has been undertaken jointly by the U.S. Department of Agriculture (USDA), the National Oceanic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Administration. The LACIE effort is concentrated on the application of remote-sensing technology to locate, identify, and measure wheat acreage. (Wheat was chosen as the experimental crop because of its importance in human nutrition and international trade.) The experiment will combine crop area measurements obtained from Landsat data and meteorological information from NOAA satellites and ground stations, designed to relate weather to yield assessment and, ultimately, to production forecasts. The USDA will study incorporation of the experimentally derived production estimates into its crop reports. If the activity is successful and the results prove useful, the application will be extended geographically and, ultimately, to other crops.

In another potential worldwide application, Landsat data have been used in field trials for mapping natural vegetation at a scale of 1:1 000 000. The United Nations Educational, Scientific, and Cultural Organization has established a uniform classification system that can be used more or less directly with Landsat-generated maps because of the small scale. The theory is that natural vegetation is the best clue to the cultivated crops an area will optimally support.

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Range Management

Techniques for estimating and predicting the available forage for range animal consumption were demonstrated in several major rangeland areas. The sandhills region in Nebraska is a unique area for using Landsat data in estimating vegetative biomass for managing this 20 000 square statute miles (52 000 square kilometers) of rangeland. The uniform soils of this area minimize the variances in radiance caused by soils variability. Correlation coefficients of 0.9 for radiances to biomass were achieved using band 5 of the multispectral scanner and automatic data processing methods. The ability to monitor annual grasslands was demonstrated in the intermountain region of California. By use of Landsat data, the investigator was able to correlate plant growth stages and forage production with climatic and other environmental factors. Image characteristics and spectral reflectance data were then related to forage production, range condition, range site, and changing growth conditions.

Landsat data appear to be adequate to determine, with a high degree of confidence, the available forage in selected rangelands. This information could be of great value to range management agencies (such as the Bureau of Land Management, the Forest Service, or regional groups) in determining how many animal units can be put on a specific piece of rangeland and when to take them off. For this use, the data are needed promptly (within 5 to 10 days after collection) and frequently (at 9-day intervals). An operational system needs to be devised and implemented to test this demonstrated technology for cost effectiveness and feasibility for full-scale ongoing operations.

Forest Management

Forest lands, both public and privately owned, also cover large areas, and efficient management is essential to capture their greatest productive capacity. Speakers discussing forest-related applications demonstrated various ways of converting data from Landsat and high-altitude sensors to useful information.

One speaker showed how the data were used to update maps of clear-cut forest areas, to map cutting rates, and to better manage forest areas. A representative of a large paper and timber company described how, on a limited budget, his company was developing simple techniques to help determine the location, type, quantity, and quality of available timber supplies. Another speaker demonstrated how Landsat data can be used to classify timber with as high as 95 percent accuracy for types of trees and as high as 80 percent accuracy in defining the conditions of the forest stand.

Landsat data were converted to information depicting the available fuel for sustaining fires in the Santa Monica Mountains in southern California. Here, 1.25 million acres were mapped for a cost of less than 3 cents per acre. This information was used as input to an operational model, which aids in reducing and controlling forest fires and in preserving the forest.

The results of a study of gypsy moth infestation demonstrated that Landsat data can be used to discriminate between defoliated and healthy vegetation in Pennsylvania and that digital processing methods can be used to map the extent and degree of defoliation.

Soils Surveys

Soils mapping, from a broad synoptic view down to the soil association level, was demonstrated in the papers presented. Soils mapping was used to help satisfy state tax legislation in South Dakota. Soils association maps keyed to productive capacities and land values were developed for the state. Cost for producing such low-intensity surveys was approximately 2 cents per hectare.

At the Purdue University Laboratory for Applications of Remote Sensing, digital data were analyzed to identify a specific soil association that had not been detected in previous soil surveys. This soil association was a continuity of a narrow, meandering strip of prairie soil in an area of predominantly timber soils. It is believed to be a buried valley of the glacial age.

These examples demonstrate that first-echelon soil mapping can be done from satellite data at a very low cost per unit area. Of course, supporting classes of soils must be mapped in the conventional manner.

Skylab data were used to delineate possible avenues of travel of citrus pests between Mexico and the United States. Also identified through Skylab S190B data were various crops and frost damage.

A speaker described how his company used remotely sensed data to manage various crops, especially cotton, in an effort to get an early determination of plant stress, disease, weed or insect infestation, and faulty irrigation. With such information on a timely basis, corrective action can be taken soon enough to actually improve the yields. It was stressed that such applications, to be useful, must be cost effective and very timely.

CONCLUSIONS

The workshop participants generally agreed that the technology exists to extract useful information, but several problems must be overcome before an operational system can be implemented. First, one must remember that remotely sensed data do not provide a total information base but are complementary to existing systems. One of the biggest tasks ahead is to design the optimum information mix for each user need. Second, the data should be supplied to a user in a format and quantity for his particular needs and parameters, rather than being supplied in bulk and excessive to his needs. Furthermore, costs to the user must be realistic.

The timeliness of data is probably the most critical problem inhibiting the implementation of an operational system. Those dynamic applications requiring data within 9 days of acquisition cannot be functional at this time. By contrast, applications requiring data seasonally or annually can be implemented immediately.

It appears that organizations which acquire and supply data must work in conjunction with those who extract information and those who use it to identify the best information, format, analysis system, and time frame for each potential application.

Interest is high in generating useful information from remote-sensing data for all four areas of agriculture. The technology does exist and it can be a valuable tool in producing and distributing food, fiber, and timber to a growing population.