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Some Shifting Relationships Between The User Community And The Earth Resources Program

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SOME SHIFTING RELATIONSHIPS BETWEEN THE USER COMMUNITY AND THE EARTH RESOURCES PROGRAM

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INTRODUCTION

The NASA Earth Resources Program has reached an important point in its development. Up to this point the program's major emphasis has been on the research and development of sensors and other technical hardware required to place a remote sensing capability in orbit. This research has been quite successful. There may be some near-term disappointments, but for the most part, the hardware required for ERTS A&B will be ready by early 1972.

On the other hand, recent statements by NASA officials indicate that if ERTS is to achieve the success desired for it, more effort is required to effectively link the user communities with the program. While numerous Principal Investigators have identified various applications for remote sensing technology, the long-term interfaces between the actual users and the ERTS systems have been developing much too slowly. At this time various spokesmen and others prominent in the field are emphasizing the need for a specific effort to expose users to remote sensor technology and to educate users on the optimal ways to employ this new technological tool. This will result in better specifications for the earth resources information system and should argue for a particular direction in R&D outlays.

MODIFIED DECISION MODELS

It is becoming increasingly clear that remotely sensed data does not just duplicate in greater detail or greater volume data that is now being employed by the user communities. In fact oceanographers, astronomers and others have had to be introduced to the type of data that will be generated by the Earth Resources Program and shown how that data can make a significant contribution to their work. As might be imagined with a new tool, its optimal use is not always immediately appreciated. This is true with respect to both the scientific and user communities.

In order to find the optimal use of remotely sensed data, it is first necessary to establish how data is now used in current decision models. It is most important to determine if there are possibilities for modifying current decision models. One can then explore in an iterative way the most effective combination of decision models and remotely sensed data. One of the things that has tended to emerge in this iterative process is a new view of nature on the part of the user. The oceanographer has become more aware of the value of surface measurements in developing his theories about oceans and their interfaces; the astronomer may be more convinced of the value of additional information on the Earth (and indirectly, near-by planets) in developing his theories of the universe.

This paper will address a couple of somewhat more homey, but very important, examples of the same phenomenon. It will be seen in the case of regional water management and wheat rust control that the remote sensors must generate quite different data than is usually requested and that, in modifying the user-decision model, a new view of nature is required.

Results of a NASA-funded study will be presented here to illustrate the type of analysis required to match user models with the potential capabilities of an aircraft/satellite remote sensing system. The hydrology study covered the users connected with the Columbia River water system in the Pacific Northwest and the wheat rust control study examined the needs of farmers from Mexico to Canada for controlling and eliminating wheat rust.

Hydrology Example

The area involved in the hydrology study is shown in Exhibit 1. The water managers responsible for operating the dams along the Columbia River system are oriented toward direct measurement of certain phenomena which assist in determining the flow of water into the system. For example, managers often feel that there is a prime requirement to measure the water content of the snow pack at the higher elevations so that predictions can be made on the expected run-off. However, it now appears that the sensors available in the near future will not be capable of making such a direct measurement. This same information can, however, be derived from using a series of indirect measurements of phenomena affecting the water run-off from the snow pack. In other words, the same important predictions can be made if the user is willing to adjust his decision process to utilize the indirect measurements that can be made from a satellite.

The snow pack water content and its rate of run-off results from changing conditions of nature

within the river basin. By monitoring some of these changes in nature the rate of snow build-up and its location can be determined. For example, sensors can identify storm movement into the region, measure the storm's water content, the area covered and actual precipitation in specific locations. By viewing the changing snow cover, ice cover and plant cover, the accumulation of snow can be estimated and a few ground truth checks can confirm these patterns. In the Spring the changing ground temperature, degree-days of sunshine and receding snow fields are measurements which assist in predicting the rate of snow melt and of increasing water flow. Computer programs can be used to maintain a continuing inventory of snow throughout the watershed.

Once water managers establish procedures to utilize this more voluminous but more accessible data, they will be able to achieve their prediction needs without actually measuring the water contents of the snow except in a few check cases. By studying the decision-making process of water managers, it was possible to identify the kinds of information needed and to adjust the requirements to correspond with the capabilities of an ERTS-type system. On the other hand, failure to have conducted a comprehensive study of the water management decision process could have resulted in a conclusion that sensing from satellites could not provide the data needed and described by a specific user within the foreseeable future.

Wheat Rust Example

A second user study funded by NASA was directed to the use of satellites for assisting in the control of wheat rust. Wheat rust causes significant damage each year in the United States and in some "epidemic" years causes major wheat crop losses. Presently, wheat rust is attacked by planting new varieties that are developed to be resistant to known strains of rust. Unfortunately, developing new varieties of wheat takes up to eight years after a new rust strain has been identified. If small "hot spots" could be identified, chemical sprays could be used to control the spread of the rust. It now appears that projected sensor capabilities will not be adequate to identify hot spots before they are

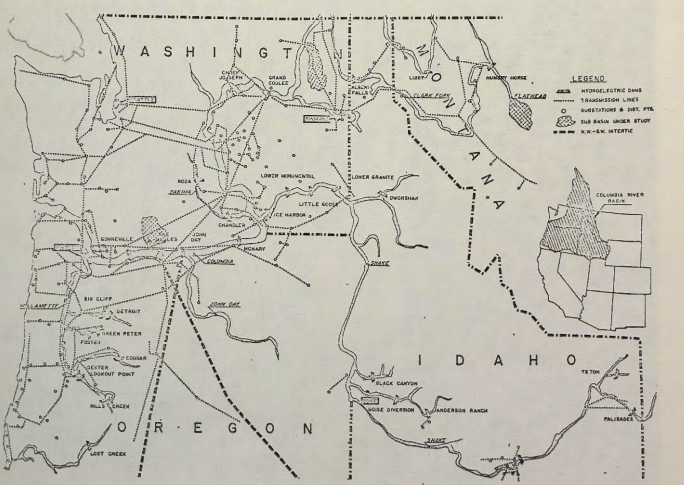

EXHIBIT 1. COLUMBIA RIVER POWER SYSTEM

of such a size as to involve major crop losses. On the other hand, there are a number of measurements which can be made from a satellite remote sensing system which will monitor the relevant natural factors causing wheat rust to develop and, in turn, assist in predicting the presence of rust in time for preventive spraying.

Wheat rust at a particular stage forms spores, which are carried by the predominant wind currents across the North American continent. In the winter, rust spores survive in the warm climates of Mexico and the Southwest United States. In the spring, northward air movements carry these spores north to the major wheat growing areas in the U. S. and Canada. The general patterns of these movements are understood and different plume patterns can be identified. Those shown in Exhibit 2 are indicative.

Lacking a capability to sense small hot spots, the remote sensing system can be used to make a large number of measurements that can be integrated through a computer program to predict the occurrence of rust. The extent of winter rust in Mexico can be detected in order to provide an initial estimate of the magnitude of next year's problem. Specific measurements of ground moisture and temperature, the stage of wheat growth, and local wind direction and velocity all indicate whether conditions are favorable to the formation of a spore cloud in Mexico. Since spores are usually precipitated out of the spore cloud by rain storms, it is possible to predict which storms are most likely to deposit spores and to determine if these deposits will be over areas when local conditions indicate vulnerability to rust. Finally, measurements of stage of wheat growth, daytime temperatures, nighttime temperatures and free moisture can be used to predict an outbreak of rust. Subsequent detection of rust can be used to reinforce the probabilities of infection further north.

This study illustrates again that the user decision models requiring direct measurements can often be modified to utilize information available from indirect measurements. However, these modifications require decision-makers to reorient their own decision-making processes in order to incorporate this new information into an effective rust control system. In the process, new patterns in nature (in this case the pathology of wheat rust) must be substantiated to use remote sensing techniques.

RESEARCH REQUIREMENTS

The same study which investigated user needs for water management and wheat rust control made estimates as to the level of research and development required to bring the operational satellite system into being. Up to now, there has been a strong tendency to emphasize sensor and related technical hardware development. It appears from reviewing R&D requirements in detail in these case studies that this portion should be more like 40 percent of the total effort. Instead of a predominantly sensor oriented program, it would appear that the bulk of the research effort should go into data management and processing systems and into the development of earth science decision models. The form of the management systems will be highly dependent on the form of earth science models and these two efforts must be closely coordinated.

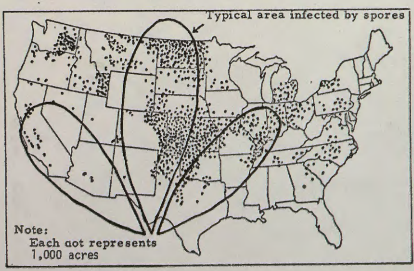

EXHIBIT 2. WHEAT ACREAGE IN THE UNITED STATES AND TYPICAL NORTHWARD MOVEMENT OF RUST SPORES

CONCLUSIONS

The changing priorities in the ERTS program indicate that new emphasis should be placed on identifying and describing the place of decision makers in the scientific and user communities in the program. As a result, there is a need to understand and probably modify existing user decision models in order to assure the optimal use of space technology in the earth resources area. Users must be encouraged to take a new look at nature in light of the unusual capabilities of remote sensing and computer technologies. Research efforts should move away from the pursuit of higher resolutions on the sensor side to improved decision models and data handling systems on the software side.

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