STATE OF CALIFORNIA

COMBINING BASIC RESEARCH AND APPLIED USE OF ERTS, SKYLAB, AND SUPPORTING AIRCRAFT DATA FOR MORE EFFECTIVE RESOURCE MANAGEMENT.

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STATE OF CALIFORNIA

USE OF ERTS-A, SKYLAB, AND SUPPORTING AIRCRAFT TO ENHANCE RESOURCE MANAGEMENT

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INTRODUCTION

From the inception of the total ERTS program, State leadership quickly grasped the potential application and use of imagery to a variety of resource management problems. The truth is, the State envisioned a host of areas embracing land use planning, public works programs, forestry, geology, water and air pollution, water resource management, agriculture, health environment, engineering, flood control, fluid dynamics, master planning, coastal processes, soils management, and marine biology, all had direct application to utilizing ERTS and supporting aircraft data.

The initial surge was to be all inclusive, to grasp for any and every resource problem and to plumb it into the ERTS program. Upon closer examination, it became clearly evident the magnitude of the task was too great and exceeded the State's capabilities. Even with scaled-down participation, it was apparent that inherent limitations must be overcome if the State was to derive reasonable assurance of a successful endeavor.

. First, it was necessary to establish a priority of disciplines to be investigated.

- Secondly, the areas within the disciplines had to be kept in manageable levels.
- Thirdly, assistance would be required.

Against this backdrop and armed with this knowledge, the State triggered a series of actions to ensure successful participation. These include:

- Coordinating and integrating the State program with that of the University of California, Berkeley. The intent was to capitalize upon the considerable capabilities and proficiency developed by the university in the remote sensor field over the past few years.
- Establishing liaison and close working relationship with NASA Ames Research Center and Jet Propulsion Laboratory to use their expertise to conduct workshops and impart knowledge to the State's participating personnel.
- Developing the basis for an archive/library of imagery data. Without this type of facility and the identify, coding, filing, and storage and retrieval of information, the collection of imagery would be useless.

With the foregoing as background, the subsequent comments are capsulated summarizations of the State's activity and involvement with the ERTS program.

AGRICULTURE

The basic thrust of the effort was to evaluate satellite and supporting aircraft data and to determine its application

to crop inventory, land classification, and the delineation of agricultural land. The San Joaquin Valley and Imperial Valley were the designated test sites. Data were to be collected and assessed specifically to determine acreage and type of crop grown, whether agriculture land could be distinguished from other types of land use, and whether the collected data would provide reliable discrimination among major crop use.

The approach was neither unusual nor unique. It consisted of a combination of comparison techniques utilizing known factual data, a study of the remote sensor information, and obtaining ground truth. Since the ERTS observations were conducted on a recurring frequency over a sustained period, seasonal and pattern changes were discernably evident. Through experience and association, a series of identifying characteristics were developed from ERTS imagery that could be matched with existing conditions, and through this process refined identifying signatures were formed that contributed to more rapid data interpretation. The varying tonal shades of gray and color combinations from the multispectral scanner bands were keyed to identify a particular crop, land use pattern, pasture, rangeland, orchard, or man-made objects.

The results to date indicate that ERTS imagery has a variety of applications to agriculture. It does have utility value in developing crop inventory statistics, with particular

emphasis as a time-saver, once discriminating keys are established. Although opinion is divided on the reliability of the inventory data - estimates vary from 70% - 80% - it does point to an acceptable accuracy of substantial value for management techniques. Further, with greater individual interpretor proficiency and sharpened techniques, there is every reason to believe the accuracy should increase to 90% or greater.

There is additional evidence that ERTS imagery can aid in distinguishing and identifying soils. Also land use patterns such as those used for crops and type, rangeland, pasture, orchard, irrigated or non-irrigated were distinguishable from other types. In particular urban sprawl was identified comparatively easily thereby revealing land still available for agricultural purposes as well as disclosing the disappearance of former agriculture areas.

There is pervasive optimism that satellite imagery has significant value for agriculture resource management. The encouraging results warrant continuing emphasis and use of ERTS and aerial imagery, if for no other purpose but to expand existing knowledge and techniques. While we are doing this, and are refining and defining our effort, we also are looking to the future for an expanded program. In this connection we have already initiated a program to use imagery in the detection role of early location and delimitation

of pests deemed harmful to agriculture. The program includes detecting fungi on safflower and sugar beet crops, fireblight of pear, fusarium crown rot of tomato and pepper, grape virus disease, tristeza in citrus, phtophthora root rot in avocado, and dudaim melon infested fields.

WATER RESOURCES

The advent of the satellite and supplementary imagery resources platform provided an excellent opportunity to assess the application of remote sensor data to a wide array of hydrology and water resource management problems.

Already in being was an extensive State water resource management program. This included a network of implanted water sensing devices coupled with low-altitude aircraft with personnel using hand-held cameras, as well as a number of human resources involved in the effort. Consequently, the State had a solid basis for comparison purposes between data obtained from its system and that provided from ERTS observations.

The Feather River watershed, Sacramento and San Joaquin Rivers delta area, and San Francisco Bay were the selected test sites. These areas provided a varied terrain and climate complex to permit evaluation of watershed and snowpack run-off characteristics, water pollution, and siltation.

Overall, remote sensors portend great promise. The imagery provides a panorama of data of dimensions and characteristics for interpretive evaluation and comparison heretofore unavailable in the water resource management field.

It is quite evident that ERTS provided characteristics that distinguished watershed and drainage features, river and stream networks, irrigated and nonirrigated lands, stream turbidity, erosion, sediment deposits, mapping of flooded areas, and snowcover runoff.

We did experience difficulty in the snowpack expirement. This was attributed primarily to the sun angle and seasonal changes. It is also clearly evident that we need more experience with this type of endeavor in order to draw logical conclusions. Further, there is considerable opinion that the U-2 true color and infrared photography had greater value than the imagery furnished by the satellite platform. The larger scale and better resolution of the U-2 imagery combined for easier and more revealing interpretive evaluation.

This is not to say that the ERTS platform data had little value. On the contrary, we believe ERTS imagery has considerable potential, and provided us with a great deal of knowledge and information. We believe that the knowledge gained to date is but the precusor for better and greater results from ERTS type systems. Without reservation we believe the

system should be continued. This conclusion is based upon:

- ERTS imagery presents a synoptic view.
- The repetitive, cyclical coverage affords examination and study of seasonal changes.
- The multispectral band is adaptable to a variety of techniques for evaluation purposes.
- There was considerable spinoff into other hydrologic elements that need further study.
- The cost effectiveness of the system.
- We at State level are not sufficiently advanced in individual skills relative to digitizing ERTS data and computer enhancement techniques, and the usefulness of these methods as problem-solving, analytical tools.

FORESTRY

Preliminary indications reveal that ERTS and supporting aircraft imagery have substantial potential in fields of forestry such as vegetation, range and watershed protection, timber harvest, forest management, and fire mapping. However, our investigations to date have met with mixed success. In all candor, the U-2 imagery was preferred over ERTS data because the latter yielded less detail. The most serious problems involve timeliness of imagery, user requirements, lack of sophisticated equipment for interpretation purposes, and the low level individual interpretor skill combined to contribute to limited successful applications.

For example, there is no doubt ERTS imagery provided gross mapping of rangeland, it lacked detail for utility value at the forester, district manager use level.

On the other hand, ERTS imagery was most useful in monitoring rangeland vegetation through seasonal changes. This type of monitoring also was advantageous in determining fire hazard areas. Still, another bonus effect was the systems capability to reveal grassland and forage - when properly interpreted - and thereby schedule grazing.

It was also determined that ERTS data can be used in broad, quantitative categories for tree identification. Moreover, we are encouraged by the initial results with regard to timber inventory techniques, and believe there is good promise for the future. In both instances, timber identification and inventory, further investigation is needed for greater accuracy and reliability.

Based upon our current knowledge, ERTS data may be useful for strategic fire protection planning and fire damage assessment. Similarly, supporting aircraft data appears to have value for some aspects of fire management, and useful for fire damage assessment and rehabilitation. Once again these qualified limitations are conditioned upon user utility and timeliness, both critical to effective operations. In this connection we recently concluded arrangements with NASA- Ames

Research Center for U-2 flights during forest fire operations and post-fire activities for damage assessment. Hopefully, the methods and procedures established will lead to better utilization of supporting aricraft imagery in forest management problems.

While our success with ERTS and the U-2 platforms has been marginal, we are confident that it has far greater benefits than our experience shows. Given the time and circumstances to overcome the limitations mentioned previously, we believe the systems have potential for significant applications to forestry management.

HEALTH

At the initiation of the remote sensing operation, three areas of interest were identified:

- Inventorying flooded lands for mosquito abatement planning.
- Locating unauthorized dumping areas.
- Tracking waste discharge.

A review of the data generated indicates that it isn't useful in mosquito abatement planning, or in detecting illegal dumps. The small, illegal dump operations which may be of environmental concern, and which may be overlooked and unknown to land surveillance, are not of sufficient size to be detected by satellite imagery.

Mosquito abatement planning, to evaluate breeding potential, requires careful timing of the overflights-particularly where tidal influences are involved in the formation of shallowly flood marshes. The low flying aircraft used in our aerial reconnaissance mosquito abatement program provides much more useful data.

Perhaps our own inexperience and the tendency to rely on the accustomed, proven method (low-altitude aircraft) have been to the detriment of ERTS and U-2 imagery. And perhaps our expectations were too high regarding resolution quality and thus led to a premature conclusion that ERTS and U-2 data were unsuitable. Because of this, we are taking concerted action to dovetail our activities with those of the State Agencies involved in water resources and agriculture. Since their operations are much more comprehensive in the remote sensing field than ours, answers may surface that have been overlooked inadvertently.

PARKS AND RECREATION

ERTS data is being used relatively successfully in mapping statewide biotic communities, and in studies of coastal drift and of beach sand deposition.

U-2 imagery has been used in the Ten-mile Dune - Inglenook Fen watershed studies involving littoral drift and dune movement, vegetation analysis, and land use analysis. It

also has been used in plant succession studies, kelp identification and distribution, marsh deterioration studies, and pre-fire and post-fire vegetation succession and mapping.

As noted above, limited use is made of ERTS imagery. Among other reasons, this is attributed to limited experience and skills working with that type of data. Also, we find greater use for U-2 photography in resource management and park planning programs because of the larger scale which enables us to define plant communities, and in many instances individual species. This success is based in part on our prior knowledge of plant communities and species present in a particular area.

OUTLOOK

In retrospect, a great deal of the State's past effort was spent with experimenting and developing techniques; testing and extracting information from imagery. We have made good progress, perhaps conservatively. The few shortcomings experienced are clearly offset by the successes. The encouraging results achieved convince us that satellite imagery has a potential yet to be exploited. And the need for such a system is clearly manifested by the ever increasing pressures to provide accurate and timely information to those intimately concerned with the management, control and use of resources.

We recognize that these data have much greater application

than to the limited use described in this report. We know it can be applied to engineering and geology disciplines, flood control, all the ineractions associated with fluid dynamics, the array of problem areas linked to master planning such as land utilization and its attendant facets, coastal processes, and marine resources, just to mention a few.

Most assuredly the State is now in a much better position to develop comprehensive, integrated plans to use remote sensor data, all pointing toward more thorough and detailed programs. We are pursuing this vigorously.

One example, is the demonstration project being developed jointly with the University of California, Berleley. One of the basic purposes of the project is to increase the spread of interest to a larger number of people by providing evaluated feedback of remote sensor data to a greater number of users. In other words, we intend to fan the awareness of imagery and its utility value to more people and awaken their interest in its application as a management tool.

In this light, the recently formed California Department of Transportation has shown heightened interest in applying imagery to many of its functions and operations. In fact, this interest currently is being translated to a specified program which is being prepared with the assistance of NASA-Jet Propulsion Laboratory. Work is well underway also

to develop a dedicated program for disaster planning. We forecast similar programs being developed by other State agencies and departments based upon increased knowledge and greater acceptance of remote sensor data, and increased demand for these type data.

While remote sensor data are not a pancea or cure-all for every resource management problem, there is sufficient efficacy in the system to warrant its continuance. We are on the threshold for more efficient resource management through its use. Improved techniques, refined or new systems should enhance the resulting product.