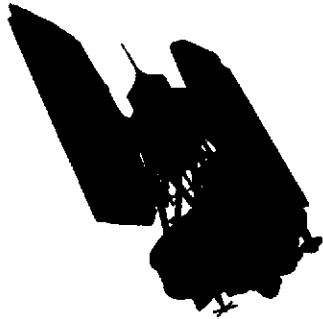


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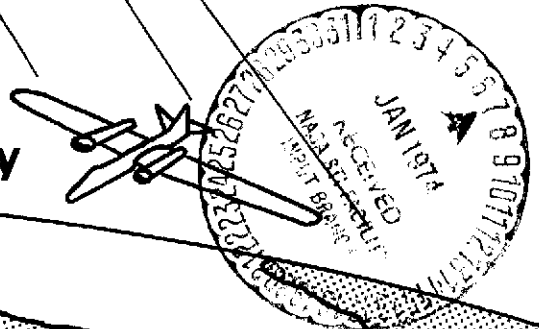
REMOTE SENSING IN LAND USE POLICY FORMULATION

MICHIGAN STATE UNIVERSITY



PROCEEDINGS of the CONFERENCE ON PRACTICAL APPLICATIONS OF REMOTE SENSING

May 15-16, 1973
Michigan State University



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ABOUT THE SPONSORS OF THIS CONFERENCE

Late in 1971, the University Affairs Office of the National Aeronautics and Space Administration funded a project to develop and carry out practical applications of remote sensing to land use policy in Michigan. The Environmental Research Institute of Michigan (ERIM) which was then the Willow Run Laboratories of the University of Michigan, was to work with Michigan State University to achieve the project's stated goal.

At ERIM, the research has been directed by Richard Legault, with Irvin Sattinger the Principal Investigator. Available to them, in addition to the 275 highly trained research scientists of ERIM, is some of the most advanced remote sensing equipment in the world. Much of the equipment has been designed and built at ERIM. ERIM has full capability for both manual and computer assisted processing, interpretation, and analysis of satellite, high altitude, and low altitude remote imagery. ERIM has been a pioneer in establishing the application of multi-spectral scanning systems (MSS), side looking airborne radar (SLAR), and other highly specialized sensing systems.

At Michigan State, the research has been directed by Myles Boylan and Raymond Vlasin as Principal Investigators. They have been assisted by staff from the MSU Departments of Resource Development, Forestry, and Crop and Soil Sciences as well as the School of Urban Planning and Landscape Architecture. Remote sensing efforts at MSU are under the coordination of Axel Andersen of the Agricultural Experiment Station.

Their conference, planned as an early step in expanding the use of remote sensing within Michigan agencies, is an important part of the NASA sponsored program.

The joint ERIM-MSU research team, in the last year or so, has undertaken several case applications of remote sensing to problems of environmental impact assessment, wetlands and game management, land use inventory updating, resource inventorying, and statewide land use mapping. A number of additional applications are planned for the next few years. If you would like to be kept informed of the work of the NASA sponsored team, just drop a line to either of the addresses below. We'd be especially interested in knowing of problems you have which we might help you solve.

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PROCEEDINGS
OF THE
CONFERENCE
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PRACTICAL APPLICATIONS
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REMOTE SENSING

May 15-16, 1973

MICHIGAN STATE UNIVERSITY

THE KELLOGG CENTER FOR CONTINUING EDUCATION

Sponsored By
Michigan State University
And The
Environmental Research Institute of Michigan
Through Assistance From The
Office Of University Affairs
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ACKNOWLEDGEMENTS

The success of this conference was due in large part to the efforts of Charlene Higgins, D. Mary Daup; and Peter Gibson of the MSU Project for the Use of Remote Sensing in Land Use Policy Formulation. They were responsible for development of the program and coordination of the workshop sessions. They were assisted by Mr. Edward Farmer of the Continuing Education Service.

These proceedings were edited and compiled by Ken Keifenheim and Stephen Schar with assistance by Emily Knight. The Proceedings, as well as the Conference they report, were made possible by grants from the National Aeronautics and Space Administration Office of University Affairs to Michigan State University (NGL 23-004-083) and the Environmental Research Institute of Michigan. Grateful appreciation is expressed to Joseph Vitale, Office of University Affairs, Technical Monitor for these grants, for his participation in the conference.

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INTRODUCTION

These proceedings have been divided into two sections to parallel the conference format. Section I presents papers authored by conference speakers on a variety of applications ranging from the principles and systems of remote sensing to its specific problem solving capabilities within the realms of urbanism, agriculture, forestry, and environmental impact assessment. Where papers were not submitted, summaries of the presentation are provided. Section II summarizes the second day of the conference which was devoted to workshops within these problem areas. Here, conference speakers organized "hands-on" seminars in which participants were shown methods for using various types of remote sensing for selected problems.

The conference was intended to provide opportunities for participants to explore specific applications of remote sensing which might be used in their day-to-day public agency operations. The hoped for expansion of the use of remote sensing by these agencies is the chief measure of success for such a conference. The technology of remote sensing is available; what remains is bridging the communication gap between these potential users and the technician. Hopefully, this conference has added a few wise words to that convention in Michigan.

PART I
PRESENTATIONS
May 15, 1973

174-14069

BASIC PRINCIPLES OF REMOTE SENSING

James L. Clapp
Professor
Department of Civil and Environment Engineering and Institute for Environmental
Studies
University of Wisconsin
Madison, Wisconsin

Professor Clapp earned the B.S. degree in Civil Engineering in 1956, his B.S. degree in N.S. in 1956, and a M.S. degree in Civil Engineering in 1961, and his Ph.D. degree in 1964. He received all of them from the University of Wisconsin.

From 1956 to 1969, Professor Clapp served as an Engineer Officer in the U.S. Marine Corp. In 1960 he joined Dravo Corporation as a Construction Engineer. Professor Clapp became associated with the University of Wisconsin in 1964 as an Assistant Professor, in 1967 he became an Associate Professor, and in 1970 a Professor.

Professor Clapp is a Registered Professional Engineer and a Registered Land Surveyor in the State of Wisconsin and is a member of the American Society of Civil Engineers, the American Society of Photogrammetry, the American Congress on Surveying and Mapping, NSPE, and the Geological Society. Since 1968, he is the Director of the University of Wisconsin's Remote Sensing Program founded by NASA; and in 1972 he was named Director of the Environmental Monitoring and Data Acquisition Group of the Institute for Environmental Studies.

Dr. Clapp submitted the following selected bibliography in lieu of a paper on this topic. The 1970 paper by Kiefer and Scherz on "Applications of Airborne Remote Sensing Technology" provides a detailed summary of the content of his presentation. Copies of the paper are available from the authors at the University of Wisconsin.

REMOTE SENSING: Basic Principles and Sensing Systems

A Selected Bibliography

Ralph W. Kiefer¹ and James L. Clapp¹

May 1973

This bibliography contains selected references dealing with remote sensing of the environment. Emphasis has been placed on choosing works that deal with the fundamental aspects of the subject and which appear in readily available form (principally books, major journals, and USGPO publications).

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CHARACTERISTICS OF REMOTE SENSING SYSTEMS

Ralph W. Kiefer
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Professor Kiefer, a native of Clinton, New Jersey, received the B.S., M.S., and Ph.D. degrees in Civil Engineering from Cornell University, Ithaca, New York. Prior to his association with the University in 1962, he served as a Geological Engineer with Geotechnics and Resources, White Plains, New York; Assistant Highway Engineer, New Jersey State Highway Department; and Installation Engineer, U.S. Air Force. During the 1970-71 academic year, he was a Visiting Associate Professor at the University of Hawaii, Honolulu. Professor Kiefer has numerous publications in the area of remote sensing, with special emphasis on air photo interpretation as applied to land use planning.

A Registered Professional Engineer in the State of Wisconsin, Professor Kiefer is a member of the American Society of Civil Engineers, American Society of Photogrammetry, Highway Research Board, and the American Society for Engineering Education.

SUMMARY

Dr. Kiefer did not submit a separate paper for the conference. The bibliography provided as a part as Dr. Clapp's presentation details the references from which this material is drawn. The presentation by Dr. Kiefer has been summarized by Emily Knight.

In this speech, Dr. Kiefer discussed four types of remote sensing systems:

- 1) Photography (with a range slightly broader than the human eye.)
- 2) Thermal Scanner and Multi-Spectral Scanner
- 3) Radar
- 4) ERTS Satellite

The visible light spectrum contains the three primary colors: blue, green, and red. All other visible colors are mixtures of these colors. The reason an object appears to be a certain color is that it reflects back light of that color.

Black and white panchromatic film is sensitive to visible light. Normal color film consists of three emulsion layers: blue, green, and red. Each layer represents its respective color on the image. However, on color infrared imagery, infrared energy appears red on the photograph. Anything which is actually red looks green and anything actually green appears as blue.

Color infrared film is of most value when used with a filter to selectively block out one or more of the wavelengths. For example, water vapor in the atmosphere causes scattering of the blue and ultraviolet light, making the photograph appear unclear. This problem can be eliminated by using color infrared film with a yellow filter which blocks out blue and ultraviolet light. Thus a yellow filter enables color infrared film to effectively penetrate haze. In addition the haze penetration, another advantage of using color infrared film is that since shadows appear darker

and more sharply drawn, vegetation is seen more clearly.

The amount of information which can be gleaned from a photo will depend on when the photo was taken. For example, if a photograph is taken just after a heavy rain, it is difficult to determine which areas are naturally moist. Also, if a corn field is photographed in September, the corn will have grown so high that it will be difficult to determine the condition of the soil.

At this point, Dr. Kiefer injected the fact that while color infrared film penetrates more deeply in water, regular color film may be more effectively used to see the bottom of a water body.

There are camera systems which can photograph several bands simultaneously. One such system consists of putting two Nikons together. Another device uses four Nikons put together, with different filters on each one. Also there are multispectral cameras with multiple lenses. However, they are very cumbersome and impractical; there are only two of these in existence in the entire world.

The multi-spectral scanner is a more effective way to photograph several bands simultaneously. It is capable of looking at up to 24 channels, and it uses a computer to keep track of what is happening in all channels simultaneously.

Multi-band photography can provide maximum contrast with the use of various filter combinations. Also, black and white photography can be turned into color photography by shining it through projectors with appropriate color filters for each band. This process is called additive color viewing and it can also be used to simulate color infrared photography from regular color photography. One advantage of additive color viewing is that you can emphasize or de-emphasize any desired band by strengthening or weakening the filters.

Radar images are another useful remote sensing system. Radar is an active system in which you carry your own energy, send out signals, and get results. This is a contrast to photography, which is a passive system. In photography, you must depend on the sun's energy and record what is there. One of the outstanding aspects of radar is that it can penetrate up to 10,000 feet of clouds and still get an image. Furthermore, it can be used day or night.

One specialized category of radar is side looking airborne radar. This operates by sending out signals in short pulses, which are then reflected back to the plane. The side looking aspects of this method give the terrain a shaded relief map look which results from the angle of the signal from the airplane. The side looking aspects are good for a structural geological overview; also good continuity for overview of large areas is provided.

For very large areas, the best remote sensing system to use is imagery from the ERTS satellite. One ERTS image covers an area of 115 miles x 115 miles. It shows town and country roads as well as interstate highways. From it, six classes of urban area land use can be determined.

Dr. Kiefer ended this presentation with the observation that: "Remote sensing gives us new eyes to see the world!"

NY-14071

REMOTE SENSING AND THE URBAN ENVIRONMENT: AN ASSESSMENT OF USEFULNESS

Dr. William A. Howard
Linda B. Driscoll
University of Denver

Bill Howard received his B.A. in History and Philosophy followed by an M.A. in Geography, both from the University of Denver. His Ph.D. in Urban Geography and Regional Planning was received from the University of Edinburgh, Scotland. Professor Howard has completed advanced graduate work at John Hopkins University in Regional Economics, Political Science and Geography.

Professor Howard's professional background includes resource planning for the Denver Metropolitan area. He has directed five research contracts related to Remote Sensing from United States Geological Survey; NASA; HUD (San Antonio, Texas); Bureau of Outdoor Recreation, Title I of Education Act, State of Colorado; planning consultation and research for new town developments and growth strategies in the United States and Europe.

This paper is based upon research presently under way by the authors for National Aeronautics and Space Administration, NASA Marshall Space Flight Center, Huntsville, Alabama; the Pilot Cities Program United States Geological Survey; and the Department of Housing and Urban Development (Texas R-1441 (CR).

I. INTRODUCTION

It is necessary to establish at the outset the perspective of this paper; it has been developed almost exclusively from the urban planning point of view.

The urban planning profession is being forced by social and economic circumstances to take on an ever-encompassing scope of responsibility. The so-called "urban crisis" has dictated that planners can no longer be primarily concerned with the physical environment. There is the necessity for planning now to assume responsibilities in the social and economic areas of city functions.

As this new mantle of responsibility is acquired, the informational needs incident to the new scope are being multiplied many times over. One can get some impression of these new informational requirements by considering some of the problem areas with which planning in general is attempting to cope. For example, there are programs relating to highway beautification, highway planning and construction, public works and economic development, advance acquisition of land for various uses, code enforcement programs, community renewal, neighborhood facilities, open space, urban beautification programs, mass transit, planning assistance programs, and urban renewal.

From a consideration of these one can surmise that with such a variety of programs the attempt by planners to view the city as a unit becomes very difficult. Thus there is the necessity to expand the data base significantly to include a wider spectrum of information. Increasing dependence is placed on digital information. Efforts are underway in almost every major urban center in the United States to establish some kind of information and retrieval system. At present, so far as the authors have been able to determine, there is not a fully operational system in operation in any major urban area.

II. TRADITIONAL TYPES OF DATA USED IN URBAN PLANNING

Typically, the urban data base consists mostly of out-of-date census tract and block reports of population and housing derived from the U.S. Census. Census data on manufacturing and business are also usually included. These data date back two or more decades. Lastly, there is a land use inventory, compiled from random maps or tax assessment records.

In general, the urban data base is static in conception. It is largely an inventory of discrete observations, rather than a monitor of ongoing processes. In order to illuminate social and economic realities, the data should monitor the key factors over time. Unfortunately, at the present, much of the data provide only static, cross sectional views and even if statistics in time series were available, they may be out-of-date by the time they appear. There is often a considerable lag between the time of collection and the time of publication. All too often decay characterizes the typical urban data base.

Even when the data included in a data base are relatively current, they are often singularly unrevealing for analytic purposes. Usually about all that can be presented are cross sectional views of net changes between two widely-spaced time periods, which tell or reveal little about changes during the intervening period. It becomes extremely difficult to analyze causal relationships among changes in such things as in-and-out migration of people, new construction, alterations and demolitions of buildings, and housing market conditions as compared with changes in the job market and industrial activity. It is doubtful that anyone would argue that a sharper focus on these activities would greatly aid in policy formulation. (Holleb, 1969)

Among the main constellations of data essential for a good urban data base are the following:

1. population and vital statistics
2. housing statistics
3. transportation statistics
4. economic performance data
5. education statistics
6. social welfare statistics
7. health statistics
8. public safety statistics
9. environmental quality statistics
10. leisure time activity statistics

How many of these specific data sets can remote sensing techniques provide as inputs to the urban data base? The remainder of this paper explores this particular question.

III. SOME EXAMPLES OF HOW REMOTE SENSING TECHNIQUES

ARE PRESENTLY UTILIZED IN URBAN SETTINGS

If we include black and white aerial photography under the rubric of remote sensing, as it very properly should be, then the uses of this form of data acquisition are not wholly unknown to planners. Of course, the degree of usage varies quite widely among local authorities. In a recent research study for the Geographic Application Program of the U.S.G.S. a rather long tradition of using aerial photography within the metropolitan area of Denver and extending into many of the state agencies was found. (Howard and Kract, 1971). A description of the

various agencies and their specific uses helps to illustrate and point to the various way that planning agencies may utilize remote sensing techniques.

State Planning Office. The Planning Division of the Department of Local Affairs of Colorado uses aerial photography to a very limited extent at the present time. It has no imagery of its own for in-office uses, and there is no systematic attempt to secure full coverage for the state. While this may seem surprising, this situation exists because of the peculiar function of the planning division in that it acts mainly as an agency charged with the dispersal of state and federal funds to local communities based upon proposals submitted by local communities. Any photography used is usually large scale of relatively small areas.

As the State Planning Division assumes additional responsibilities by actually planning for local and regional development, the role of small scale black and white aerial photography and other remotely sensed imagery will assume increasing importance as a data source which is both current and comprehensive. The division has already begun exploratory methods for integrating remote sensing imagery with a digital storage and retrieval system with a graphic display mode.

Colorado Land Use Commission. The Colorado State Land Use Commission was originally established to supplement the efforts of the State Planning Division. The ultimate function of the commission's efforts include a state-wide land use inventory into four or five major categories; the establishment of a state land use information system and the selection of appropriate sources of data to be contained in it; the detection of change in land use and general growth patterns; and a proposal of a state-wide zoning ordinance in any attempt to direct and control land use. Remote sensing imagery is being seriously considered as a primary data input with imagery requirements within the scale range of 1:100,000 to 1:250,000.

Denver Regional Council of Governments. The Denver Regional Council of Governments attempts to coordinate the planning efforts of the City and County of Denver and the surrounding counties and municipalities. Remote sensing is utilized to acquire land use information, which is compiled into land use maps by the Division of Land Use and Transportation Planning. The land use data are acquired at a one-digit level of detail utilizing the following categories:

1. residential
2. commercial
3. services
4. industrial
5. transportation
6. public and quasi-public
7. communications and utilities
8. parks and recreation
9. agricultural
10. vacant

The digital storage and retrieval system presently employed by the DRCOG uses aggregates of land use information by census tract, while the maps prepared aggregate the land use information by dominant usage in a city block. Where blocks are not patted, a two-acre minimum is used.

Black and white aerial photographs at a scale of 1:12,000 are utilized for acquiring much of the land use information. These records are supplemented by assessor's records, city directory information, and windshield surveys in the field.

Regional Transportation District and State Highway Commission. Although the function of these two agencies varies, their information needs are fairly similar. Large scale aerial photography is used by both, chiefly for alignment studies. The identification of structures or major physical features in the path of proposed streets or throughways is the chief use of the photography. Engineering studies utilize topographic sheets and ground surveys rather than aerial photography. Traffic counts are conducted almost exclusively by on-ground counters rather than from the use of remote sensing techniques.

The City of Denver Planning Office. By far the greatest utilization of remote sensing is found in the City Planning Office. Every two years the City Planning Commission purchases reproducible black and white aerial photographs at a scale of 1:12,000 from a private firm. The planning staff utilizes these photographs for:

1. zoning change cases
2. highways and street alignment studies
3. population estimates
4. housing counts
5. illustrations for planning proposals
6. calculation of population densities
7. as a substitute for drafted maps
8. the location and selection of sites for various new developments

The black and white photographs purchased by the City Planning Office, enlarged to a scale of approximately 1:2,400 have proven very useful in identifying land use to the one and two digit level of detail for most of the categories contained in the classification system employed by the Planning Commission. Beyond the second digit level of detail, however, it is extremely difficult to obtain land use information with any great degree of reliability.

The City Planning Office staff uses the black and white photographs to integrate photographic representations of portions of the city with information plotted on maps. Land use maps are put together in a cut and paste manner and are composed in part of the conventional color coded system and in part of the black and white photographs. Photographs are used primarily to show industrial areas in the city, and the various industries are labeled with the firm's name. The utility of using these photographs is that the shape and size of buildings can be readily identified, and the amount of parcel covered by the building and by parking space is obtainable with little effort. Non-conforming uses can usually be easily identified and noted.

Other agencies utilizing remote sensing techniques. The following additional city agencies have specialized uses for remote sensing records. Most of the agencies purchase black and white aerial photographs at a scale of 1:12,000 from a commercial aerial photography firm. The agencies then use the photographs at that scale or have them enlarged to various scales to meet their individual needs. A few agencies, e.g., Urban Renewal, Model Cities Program, and the Community Renewal Program have only limited or periodic needs for photography. These agencies may obtain photography by arranging a loan of appropriate coverage through the City Planning Office.

Assessor's Office. Aerial photography is used by the Assessor's Office to detect new buildings or additions to previously existing structures. Violation of building permits and structures without permits are usually readily detected. Square footage measurements of new structures are made directly from the photographs, thus saving much laborious field work.

City Engineer's Office. The City Engineer's Office has many diverse uses for aerial photographs as their office acts as a supplier of information for many other city agencies.

Aerial photographs are used by the City Engineer to locate township and range line tie points. These may be indicated by such physical markers as telephone poles, light poles, or manhole covers.

Flood control areas, plans for street modification, and sewage lines by size of pipe are plotted directly on the photographs. Rough indications of the physical terrain are also gained from the photography, but detailed data are gathered by ground survey teams.

Waste Water Control and Urban Drainage and Flood Control. The Waste Water Control Board and the Urban Drainage and Flood Control Commission take a broad look at the metropolitan area. These two agencies are primarily interested in drainage basin characteristics, specifically, local relief, run-off potential, amount and type of development, and detection of change in land use.

By knowing the run-off characteristics for a given drainage basin, and by detecting changes in land use and new development from photographs, it is possible to modify run-off coefficients and to predict the run-off under the new conditions. This has important implication for planning in terms of channeling, culvert size, and ponding.

Traffic Engineer's Office. The Traffic Engineer's Office uses aerial photography as a source of information for recommending existing street modification or for proposing new alignment studies. The major use of photographs is as a substitute for a map.

Zoning Board. The Zoning Board uses aerial photography for two purposes, to graphically illustrate zoning change proposals and for violations of the zoning code.

City Water Board. The City Water Board uses black and white aerial photographs as a substitute for both drafted maps and diagrammatic sketches. Water lines, pumping facilities, and size of mains are all plotted directly on the photographs. The Board also uses sequential photographic coverage in areas of residential growth to gain an indication of possible demand for water.

Urban Renewal Authority. The Urban Renewal Authority has specific information needs related to its function. Many of these requirements can be partially fulfilled by the use of aerial photographs. Photographs serve as a data source for building counts, parking counts, investigations into the socio-economic characteristics of neighborhoods, and as a basis for calculating square footage contained in buildings in renewal areas. Photographs are helpful for before and after comparisons and are often used as maps.

Model Cities Program. The Model City Program uses aerial photography for basic information such as dwelling unit counts, site locations, land selection, and

planning for new community facilities. Some use of aerial photography has been made in terms of the physical characteristics in Model City areas. Quite frequently aerial photography is used as illustrations for proposals and reports.

Community Renewal Program. The Community Renewal Program requires essentially the same information from aerial photography as does the Model City Program. Basically, this is for dwelling unit counts, general land use, and in appraising the quality of housing.

IV. SENSORS FOR ACQUIRING PLANNING INFORMATION

The authors do not contend for one minute that the level and variety of uses of remote sensing techniques found in the Denver Metropolitan area characterizes the other urban areas. In fact, we suggest that the obverse is more nearly the case. Underlying each of the uses identified in the Denver area is the necessity for accounting for change. As was pointed out earlier, the data that planners normally have at their disposal represent discrete observations rather than accounting for ongoing processes. Remote sensing techniques represent a means whereby some of these ongoing flows can be monitored. We are not suggesting that all the constellations of data identified earlier as a good urban data base can be acquired through remote sensing. Indeed, far from it. It is extremely difficult to see how sensors, no matter what kind and how sophisticated, will be capable of providing the planner with data relative to such urban data sets as economic performance, education, social welfare, health, and leisure time activities. Indirect indicators could possibly be identified and utilized; however, it must be borne in mind that the planner's subject of study represents a complex-specific environment and therefore for many programmatic concerns highly generalized information has limited usefulness. This gives rise to the question as to the best combination of sensors for use in urban environments to acquire the most reliable data possible through such techniques.

It is obvious from the survey of the Denver Metropolitan area that the old standby of black and white panchromatic photography represents the standard. One could say that every other sensing device is measured by it. Cameras, film, and processing labs are available and quite widespread so that its reliability is readily accepted. However, due to man's tampering with the environment, the usefulness that black and white photography once had is being reduced. Atmospheric pollution has virtually made it impossible to get good quality imagery for certain urban areas. Yet, where the atmospheric conditions permit, black and white photography still has immense utility. It is unrivaled in utility as a stereoscopic form and as a continuation of previously recorded sequent images.

Like black and white photography, conventional color has both advantages and disadvantages. Its chief advantage is the color contrasts of areas within the urban environment which definitely aids the interpreter in his tasks. As a low level sensor it rates with the best. However, the "smog" problem associated with black and white also applies to conventional color.

The single most useful imager of the urban environment is color infrared photography (CIR). Recent experiments in filter combinations and processing techniques indicate that it will remain so for some time to come (Pease and Bowden, 1968). CIR is unsurpassed as a high altitude sensor that will penetrate haze when the proper filter and exposure techniques are used. It is also unsurpassed in vegetative enhancement as well as pattern differentiation. Its chief limitation which it shares with black and white and conventional color is that it is restricted to daytime utility. The advantages which it possesses in terms of

imaging the urban environment has prompted one researcher (Bowden, 1968) to suggest that CIR will doubtless become the "standard" of the future, replacing black and white panchromatic.

Multiband and multi-spectral photography has often been held up as the ultimate sensor for urban applications. Unfortunately, where attempts have been made, the results suggest that no further information is derived from this form of imaging than in using CIR.

Airborne infrared scanning systems offer great possibilities for urban studies and research, however, in terms of planner's immediate needs it seems limited. The greatest advantage offered by thermal infrared (TIR) is its daytime-night-time capabilities and spectral range. As yet, the city at night is not of much interest to the planning community. It is of more interest to the police as a subject of inquiry.

Side Looking Airborne Radar (SLAR) seems to potentially offer an alternate or back-up to photographic images. Much of the information derived from radar images is redundant to that obtained from CIR in terms especially of land use information. However, radar's well known all-weather, daytime-nighttime capability is of importance when other sensors are not usable due to cloud cover or time conditions. However, the usefulness of this sensor seems remote indeed to the needs of the planner, chiefly due to the fact that few radar systems exist outside the military. Also, costs would certainly have to be taken into account, and the cost advantage certainly favors color infrared imagery over radar.

Television offers the dynamics and rapid image return necessary for such interests as traffic mobility. The ultimate usefulness of this sensor along with passive microwave imagers deserves further study,--the latter in terms of the energy budget of cities and the former in terms of processes that require rapid image returns for data records.

V. SUGGESTED APPLICATIONS THRUST

Without question the way that remote sensing can aid the planner in accounting for change is in terms of the acquisition of land use information. Such information is required for many programmatic needs. Functional use categories can readily be discriminated on imagery, at least in a generalized sense. Despite its potential there seems to be a notable paucity of examples where remote sensing capabilities in this regard have been demonstrated, especially within the context of a planning program. Some suggestions are offered here as to why this is so.

The demand for land use information and the necessity for the analysis and interpretation of the information prior to making planning proposals requires the integration of two basic tool systems: a system of land use classification and a system for data storage and retrieval. Some limited encouragement can be offered with respect to the first of these.

The Inter-Agency Steering Committee on Land Use Information and Classification has established a land use system that is accepted by and supported by the National Aeronautics and Space Administration and the Department of the Interior (Anderson, Hardy, and Roach, 1972). It is designed to be receptive to conventional sources, high altitude aircraft, and satellite platforms and would be capable of forming

the framework for more detailed land use studies by regional, state, and local agencies. It consists of very generalized first and second digit information capable of further refinement for more extensive-intensive use. While this classification is so general as to be very compatible with small-scale imagery, it has few guidelines for classifying at the level of information needed by planners in an urban area; it seems far more appropriate to large area classification rather than the complex-specific urban environment. However, this system does represent some attempts at standardization of land use classifications to be used by those having remote sensing inputs.

To realize the possible importance of remote sensing in terms of its application to the urban planning function, what must be developed in addition to the land use classification system is a land use information system which relies on remote sensing imagery as a primary data source. To develop such a system requires an appropriate storage and retrieval system.

As has been pointed out earlier, data storage and retrieval systems are being designed throughout the country. A general characteristic of these systems is that they are not being developed with the idea of using remote sensing imagery as a source of data. Many systems require data which are impossible to obtain from remotely sensed imagery. Other systems use sources of data which require laborious collection techniques when such information could be obtained much more easily with the use of remote sensing techniques.

Many of these "planned" as well as partially operational data storage and retrieval systems do and will fulfill many needs. Many of them, in fact, are very sophisticated, incorporating such components as plotters into their design so that data can be graphically displayed and analyzed. Storage of information with geographic coordinates facilitates visual inspection of data as well as digital analysis. Despite these features, however, these systems are not directed toward the use of remotely sensed imagery as a source of data input, nor do they use graphic and digital output for comparison with remote imagery.

The critical need in applying remote sensing techniques more widely in urban planning is the study of the interface of digital, graphic, and imagery display modes. The partial contribution of each, either individually or in combination with other display modes, must be assessed closely and analyzed within actual planning situations. Planners and researchers in the field of remote sensing must interact more closely to determine the requirements in terms of scale, format, and type of input.

While the directions outlined above can give remote sensing research in terms of urban areas a more realistic thrust, these alone will not demonstrate its full potential. Workers in the area must assume more hybridized approaches to problem areas than is presently apparent. Workers in the area of remote sensing must acquire a better understanding of planning directions and programs. This will enable them to be more persuasive in making the planner aware of how remote sensing can be a helpmate in his tasks. Planning is fairly tradition-bound and as a result the onus falls on the remote sensing researcher to effectively break down methodological barriers.

It is necessary for researchers to quarry the planners in order to ascertain exactly what information the planning function needs, and it may need to be the researcher's responsibility to determine whether remote sensing can provide this information.

If so, the next step is operationalizing and then providing the planner with the imagery. Most often the researchers possess the imagery and it never gets in the hands of those who could use it for the benefit of the public at large. Thus far, research in remote sensing as applied to the urban scene has been making unrealistic claims of the quantity and quality of data that could be of use to the planner. In fact, in many cases remote sensing is viewed as a panacea for the urban dilemma which many people feel is caused simply by inadequate data. It must be understood that remote sensing is but a tool--as is a map--and not a solution in itself. By making remote sensing a practical applied tool through operational efforts in a planning program, it may in fact become of major importance to the planning effort. The next major problem is, of course, acquisition of remote sensing imagery by those not involved in research.

It occurs to the authors of this paper that possibly the most expeditious way that an effective interface can be established between the urban planner and the remote sensing specialist is for the National Aeronautics and Space Administration to routinely provide small-scale photographic imagery in the range of 1:50,000 to 1:100,000 to large urban areas. The remote sensing specialist can inform the planner of the possibilities that the data acquisition system offers, and the planner can become more familiar with this. At present most planning agencies are reluctant to change their methods of acquiring data and hesitate to turn to the possibilities that remote sensing offers, because they fully recognize that the data source is only on a catch-as-catch-can basis. If the imagery is made available on a routine basis, then the interest level is there. It must be recognized, though, that the planner is first and foremost interested in the operational possibilities that remote sensing offers.

VI. NEEDED RESEARCH

The single most promising area for application of remote sensing in urban areas lies with environmental quality assessment. Whereas environmental quality has been of interest to planners in the past, they have been primarily dependent upon indirect indicators or required to construct a "talking" datum. Yet, most human social behavior normally occurs within physical structures such as dwellings, manufacturing establishments, schools, etc. The attitudes and values of the persons who occupy the physical structures may be reflected in the overall physical surroundings. These conditions become subtle in their manifestation and are best studied from an overall perspective. The "talking" datum approach is very time consuming and extremely expensive; what is needed is an approach where the overall perspective is included and the subtleties of the environmental conditions are enhanced. One such approach is through the means of remote sensing.

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THE GREATER NEW ORLEANS STAR PROJECT

N74-14072

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Mr. Smollen attended the U.S. Naval Academy and received his B.S. degree from Mississippi State University in 1958. Prior to joining NASA in 1962, his industrial experience covered a wide range of projects in the instrumentation, electronics, missile systems, and aerospace fields.

His early responsibilities with NASA included assignments as Test Programs Project Engineer and Reliability Project Engineer on the SATURN Program. Following the Apollo Five, he was made Systems Safety Officer at the Michovel plant and received a special NASA award for his work in this and other fields.

Currently, Mr. Smollen functions as Technical Director of the Greater New Orleans STAR Project and as part of the Environmental Applications Office of the Director of Science and Engineering, Marshall Space Flight Center.

I will attempt to describe in words that in its very essence is a visual presentation- I will not use a thousand words for each picture.

The New Orleans STAR Project began several years ago when the City Health Officer placed a telephone inquiry to the author to see if any of the current NASA technology might be employed at City Hall in more mundane tasks. A series of meeting and experiments have led to this presentation.

The latest two experiments to grow out of the project are not included because time was not available to prepare the results properly. They are (1) A land use and housing quality analysis of Gerttown studied jointly by Xavier University in New Orleans and Michigan State University, and (2) Utilization of Remote Sensing Techniques in the Flooding Crisis in the Mississippi River Valley.

It is no secret that every urban center in America is experiencing a series of crises or problems. It is further understood that overspecialization on urban problems has created other problems i.e. the solution to a traffic problem may create a housing decay, business, or environmental problem worse than the problem we initially attempted to solve. In the STAR project, we feel that no one has a complete and comprehensive understanding of the complex problems of urban America, let alone any solutions or partial solutions utilizing today's methodology.

As the project's participants examined problem after problem (some of them had nothing to do with remote sensing), a common thread began to emerge into the foreground. Whenever a politician or a professional in city government was called upon to make a major decision he never had enough information available to him that was accurate, up to date, or germane-that is to say-the city in major things was being run by seat of the pants decisions. The desire for something to back up the decision is strong-but the cost for an efficient information gathering and digesting system is beyond the budgets of our cities at present.

In STAR, our primary objective is to develop the system to provide urban leaders with the information they want with extreme speed and accuracy as a national

demonstration.

This should be done on a National Scale as the problem is national and the national government that helped create it should help solve it. Secondly, at the national scale rather than become a money burner to a single city or group of cities, STAR begins to be inherently capable of reducing part of the overall cost of government.

As a secondary objective-with absolutely no promises to anyone-we would hope to learn enough about the complex interactive effects of the urban problems to begin to predict their effects upon each other.

A series of views of New Orleans are presented from decreasing altitudes and the demographic and geographic features displayed-from satellite altitudes to low level aircraft.

One of the more fascinating subjects explored here and by many others previously is that of housing quality. While everyone seems to have done a sample demonstration in his own backyard (as we have)--no one has ever attempted: (1) to automate the process completely or (2) to try a complete inventory and gray-scaling of a major metropolitan area. Some preliminary work by Fowler at Tulane indicate a possibility with ERTS Data--the results are not conclusive as yet.

A second series of slides depict the Superweek '72 experiments. As the Superbowl in New Orleans brought with it the Goodyear Blimp, the opportunity for experimenting was most excellent. Primary results shown are those of measuring traffic parameters (speed, velocity, flow, density, etc.) using time lapse photography and a semi-automatic data reduction device. The results were quite successful, but they began in pure technical measurements and ended in the behavioral sciences! Subsequent traffic experiments suggest this technique as a replacement eventually of most of the current analytical methods employed.

Further Superweek indicators or vectors involve the possibility of economic indicators and social indicators--dubbed "AGES Data" by Dr. Gordon Saussy of LSUNO--Aeronautically Gathered Economic and Social!

The use of color infrared photography in certain public health experiments is discussed as well.

A description of the STAR System boils down to Platforms and Sensors--Data Extraction, Collation, and Presentation into products for specific users who hopefully will take action on a problem.

A brief description of the Laser Scanner as an element of Automated Data Extraction is presented.

With plans for the ultimate organization of many private, state, federal, and local talents the STAR Project can and will become a reality in the not too distant future. It may be argued that good information won't solve the current urban crises. My argument is it sure won't hurt it and it might even help.

A LAND USE & ENVIRONMENTAL IMPACT ANALYSIS
OF THE NORFOLK-PORTSMOUTH SMSA^{1,2,3}

N74-14073

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Introduction

The importance that remote sensing can play in assessing the impact of environmental parameters was established last year in the Central Atlantic Regional Ecological Test Site (CARETS) project of the Geographic Applications Program, U.S. Geological Survey. Techniques perfected in this project were integrated into a regional-ecological framework and the Norfolk-Portsmouth Standard Metropolitan Statistical Area (SMSA) was selected as a sub-regional test site for a pilot study in 1971 (Figure 1). The demonstration project was designed to test the feasibility of using high altitude aircraft and satellite remote sensing data for: (1) identifying various heirarchical levels of land use ^{3/}(Figure 2), (2) monitoring land use changes on a repetitive basis, (3) assessing the impact of competing land uses, and (4) identifying areas of potential environmental deterioration.

High altitude aircraft photographs (scale 1:120,000) acquired in 1959, 1970, and 1972, plus Earth Resources Technology Satellite (ERTS-1) color composite images acquired in 1972 were used for the land use and environmental assessments. The high altitude aircraft photography, as expected, was successfully used to map Level I, Level II, as well as some urban Level III land use categories. However, the detail of land use analysis obtainable from the ERTS imagery exceeded the expectations for the U.S. Geological Survey's land use classification scheme which originally proposed Level I categories for ERTS imagery and Level II

^{1/}Publication authorized by the Director, U.S. Geological Survey.

^{2/}The authors would like to express their appreciation to James Anderson, Chief Geographer, U.S. Geological Survey, Robert Alexander, Principal Investigator or the CARETS Project, plus Ivan Hardin, Dierk Rhynsburger, Peter DeForth, Katherine Fitzpatrick, and Harry Lins of the Geographic Applications Program.

^{3/}U.S. Geological Survey's Level I and II land use classification system, plus selected categories for a proposed Level III ordering.

CENTRAL ATLANTIC REGIONAL ECOLOGICAL TEST SITE

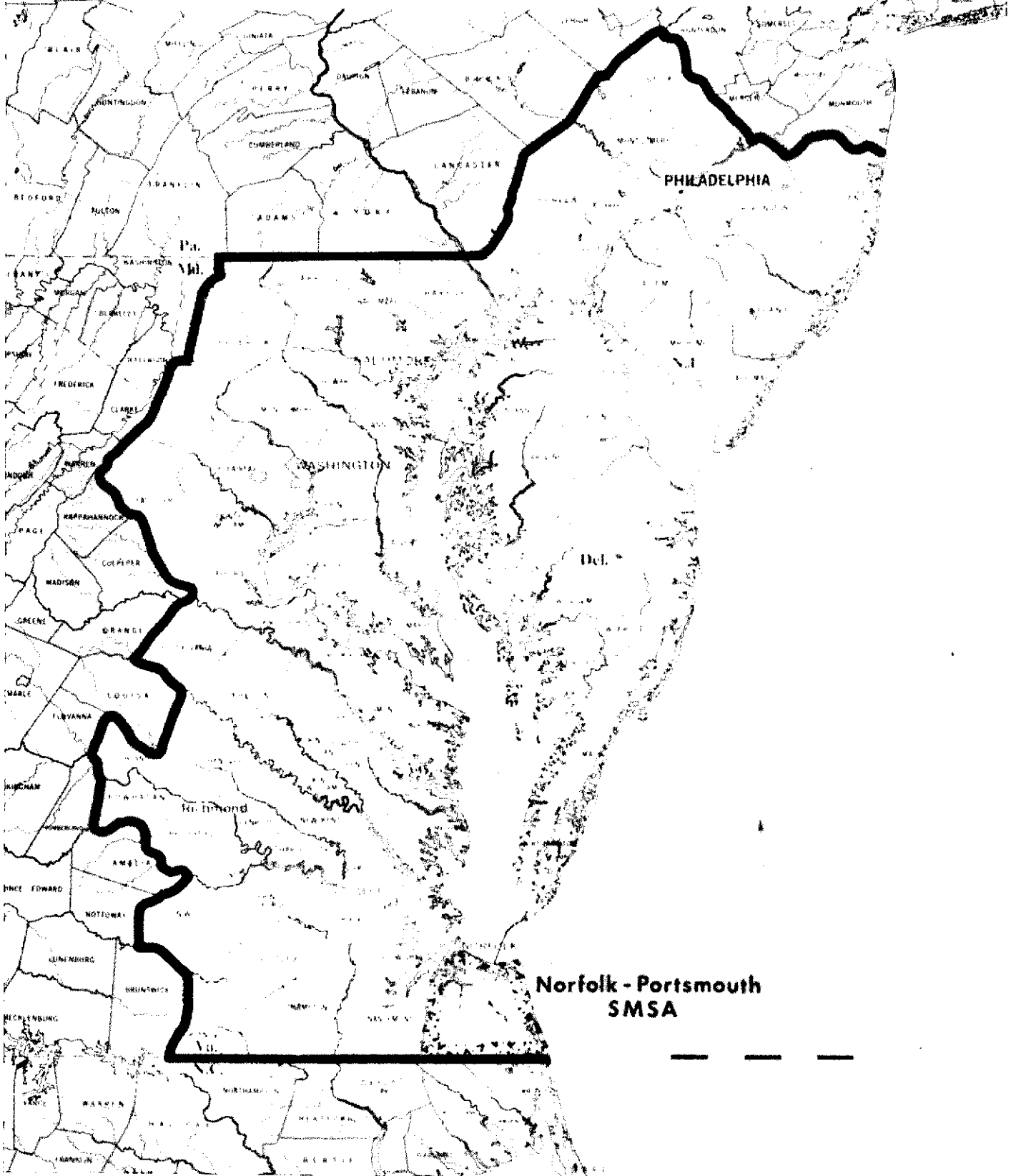


Figure 1. The Central Atlantic Regional Ecological Test Site (CARETS) showing the Norfolk-Portsmouth Standard Metropolitan Statistical Area (SMSA).

LAND USE CLASSIFICATION SYSTEM FOR USE WITH REMOTE SENSOR DATA

LEVEL I CATEGORIES LEVEL II CATEGORIES

01 URBAN AND BUILT-UP

- 01 RESIDENTIAL
- 02 COMMERCIAL & SERVICES
- 03 INDUSTRIAL
- 04 EXTRACTIVE
- 05 MAJOR TRANSPORT ROUTES & AREAS
- 06 INSTITUTIONAL
- 07 STRIP & CLUSTERED SETTLEMENT
- 08 MIXED
- 09 OPEN & OTHER

02 AGRICULTURAL

- 01 CROPLAND & PASTURE
- 02 ORCHARDS, GROVES, BUSH FRUITS,
VINEYARDS & HORTICULTURAL AREAS
- 03 FEEDING OPERATIONS
- 04 OTHER

03 RANGELAND

- 01 GRASS
- 02 SAVANNAS (PALMETTO PRAIRIES)
- 03 CHAPARRAL
- 04 DESERT SHRUB

04 FORESTLAND

- 01 DECIDUOUS
- 02 EVERGREEN (CONIFEROUS & OTHER)
- 03 MIXED

LEVEL I CATEGORIES LEVEL II CATEGORIES

05 WATER

- 01 STREAMS & WATERWAYS
- 02 LAKES
- 03 RESERVOIRS
- 04 BAYS & ESTUARIES
- 05 OTHER

06 NON-FORESTED WETLAND

- 01 VEGETATED
- 02 BARE

07 BARREN LAND

- 01 SALT FLATS
- 02 SAND (OTHER THAN BEACHES)
- 03 BARE EXPOSED ROCK
- 04 BEACHES
- 05 OTHER

08 TUNDRA

- 01 TUNDRA

09 PERMANENT SNOW AND ICE FIELDS

- 01 PERMANENT SNOW & ICE FIELDS

categories for high altitude aircraft photography. In addition to perttainable Level I categories, certain Level II and selective Level III units were identifiable on the ERTS images.

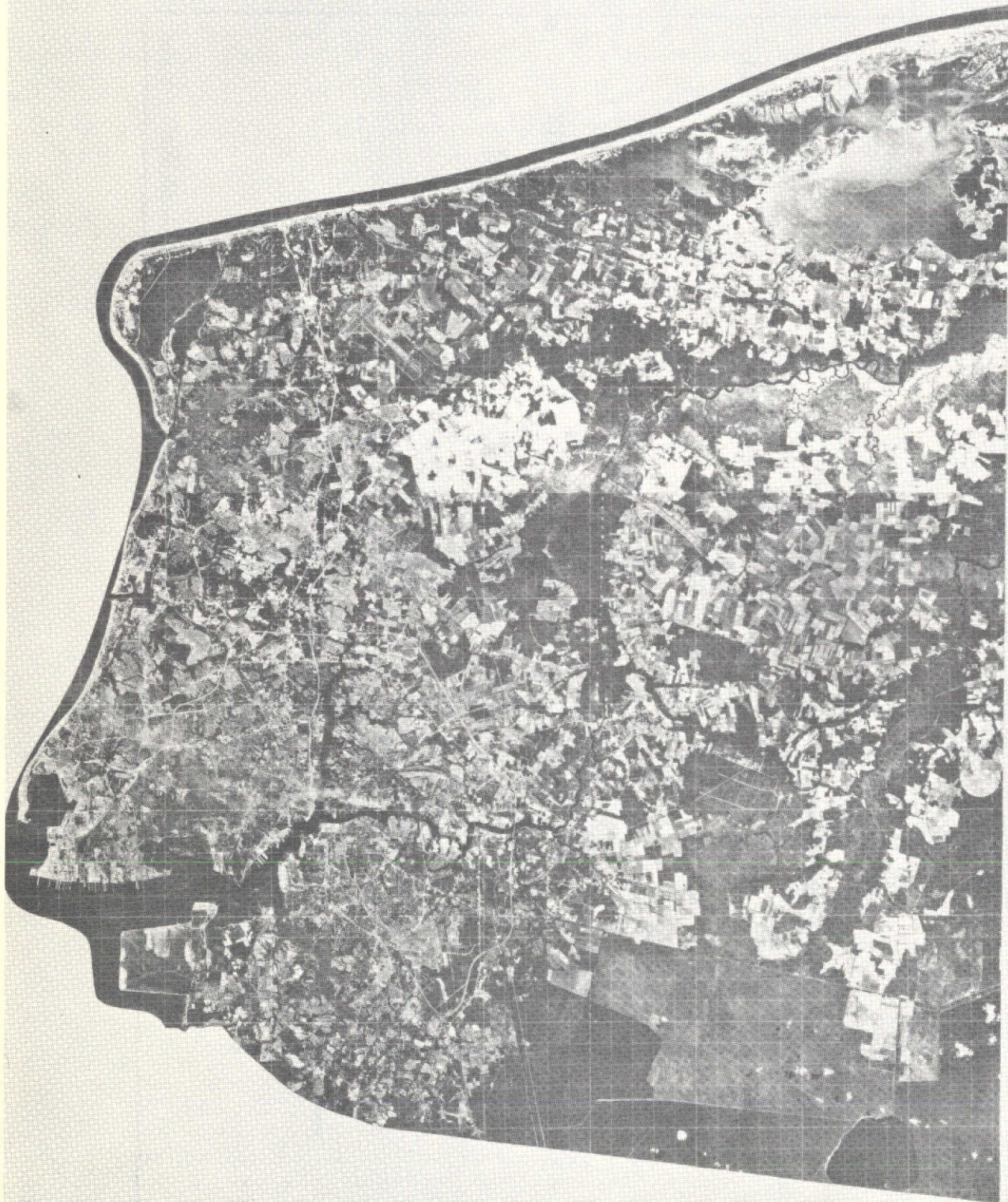
Significant land use changes, which pose possible environmental impact problems for the Norfolk-Portsmouth SMSA were identified and mapped at I and II Levels using both the ERTS and aircraft data. Level II and Level III land use categories for selected areas within the SMSA are currently being analyzed by computer techniques to determine the frequency of land use areal associations and the magnitude of the environmental impact of those associations. Additional computer analysis is being made of the linear interfaces separating land uses in repetitive time periods and according to directions of impact.

High Altitude Aircraft Land Use Analysis

The Norfolk-Portsmouth SMSA (1911 square kilometers) was selected as a sample sub-region to test land use mapping and change techniques because of its complex land use base, ranging from highly urbanized to coastal wetlands, agricultural, and forested areas. Color infrared transparencies at a scale of 1:120,000 were acquired in October 1970 and October 1972 for interpretation purposes; a black-and-white UTM gridded and rectified mosaic was compiled at a 1:100,000 scale from the 1970 photography and served as the land use mapping base (Figure 3). Perttainable land uses exceeding a threshold level of two square millimeters were successfully identified and mapped at the Level II ordering for 1970. A Level I land use map was then completed by collapsing the Level II units into six categories (urban & built up, agricultural, forestland, water, non-forested wetland, and barren land). Approximately three man weeks were required for interpreting, transposing and editing the Level II data. The land use data sets have been verified by a Geographic Applications Program research team.

In order to test land use change capabilities, 1959 photography of the test site was obtained. Level I categories were mapped and area measurements were derived by dot grid planimeter and compared with the 1970 data. These comparisons indicate that there was a rapid increase in urbanization largely at the expense of agricultural and forestland. The types and amounts of change have been depicted in a land use transition matrix (Figure 4). The non-diagonal matrix cells render Level I land use changes for the period 1959-1970, while the diagonal represents land uses that did not change. During this period, 184 square kilometers (63%) of agricultural and forest land changed to urban uses. An additional 32 square kilometers (10.3%) of forestland were cleared for agricultural pursuits, and eight square kilometers (4.3%) of non-forest wetlands were removed from the land use system.

Land use change mapping has also been completed for the period 1970-1972, and the amount of Level I change amounted to 36.2 square kilometers. Similar to the 1959-1970 study, urban land use expanded at the expense of others, especially agricultural and forest land. The change to urban use alone totaled 19.6 square kilometers or 54.2% of all land use change. The agricultural decline in favor of urban use totaled 12.6 square kilometers (63.9%) and for forestland 6.1 square kilometers (31.2%).



NORFOLK-PORTSMOUTH SMSA
RECTIFIED AND GRIDDED MOSAIC

1970

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Figure 3. Mosaic of Norfolk-Portsmouth SMSA, original at 1:100,000, UTM grid squares are 1 km².

NORFOLK-PORTSMOUTH
SMSA

LAND USE LEVEL I
CHANGE MATRIX
1959-1970

In km²

		1970									Total 1959
FROM \ TO	TO	1	2	3	4	5	6	7	8	9	
	1		286	2		1	-	-			
2		80	549		19	1	-		-		650
3											
4		34	32		495	2	2		-		566
5		-			-	244	3				244
6		2	1		5		129				138
7								24			24
8		-			-		-				
9											
Total 1970		402	584		520	247	134	24			1911

6561

USGS/NASA Geographic Applications Program

Figure 4. Land use Level I change matrix for the period 1959-1970. Refer to Figure 2 for land use category titles. Note the 24 km² listed at matrix cells 8-8 should be located in matrix cell 7-7.



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Figure 5. December 1972 black-and-white ERTS image of the Norfolk-Portsmouth SMSA subregional test site.

The results of this study are consistent with the initial investigation which determined Level I land use change to be 16.7 square kilometers per year. For the 1970-1972 period, the change per year averaged 18.1 square kilometers. Preliminary examination by the staff of the Southeastern Virginia Planning District Commission indicates that these data sets might serve to satisfy portions of a U.S. Department of Transportation (DOT) requirement for transport demand forecasting. Conventional land use surveying costs, which satisfy DOT regulations, are being compared with costs for using the remote sensing data analysis method.

ERTS Land Use Analysis

An important portion of the CARETS project is concerned with testing the usefulness of ERTS imagery for making land use and environmental assessments. A preliminary study, using two ERTS multispectral scanner false-color composites generated on 10 October (bands 4, 5, 7) and 3 December 1972 (bands 5 & 7) has been completed for the Norfolk-Portsmouth SMSA (Figure 5). This specific study was designed to ascertain the feasibility of using ERTS imagery for identifying Level I and Level II land use changes for the period 1970-1972, and the analysis centered on three foci: (1) the 1972 enlarged ERTS images and the 1970 Level II land use map (both having 1:100,000 scales) were compared to find areas where changes might have occurred; (2) if a possible change was delineated it was assigned to a Level I or II land use category; and (3) reference was then made to the 1970 and 1972 high altitude aircraft photography to determine whether a change had occurred and if the ERTS interpretation of that change was correct. The time required for image signature familiarity and interpretation totaled approximately 32 man hours.

The results proved to be quite encouraging even though only two images from the fall season were utilized. Not only were Level I land use categories identified, but several Level II and proposed Level III units were also detected (Table I). It is anticipated that Level III category extensions will occur as more seasonal imagery becomes available.

Encouraging results were also obtained for Level I land use area measurements and to a lesser extent for Level II measurements (Table II). Level I land use changes from 1970 to 1972 (verified from aircraft photography) totaled 36.2 square kilometers (73.2%) were visible on the ERTS imagery. The verified change for Level II amounted to 39.2 square kilometers, and 57.3% of the change was identified on the ERTS imagery.

ERTS interpretation was responsible for 64.3 square kilometers of "false" land use change identifications (Table II). However, 97.6% (62.8 square kilometers) of the erroneous change was accountable to falsely identifying dormant agricultural areas as urban land. Bare fields had bluish-gray signatures that closely matched those from urban areas on the October and December imagery. Imagery generated during the growing season will undoubtedly alleviate this problem because the fields will be highly reflective to solar infrared radiation, and the signatures will be in hues of red; the urban signatures will remain bluish-gray.

TABLE I

LAND USE CATEGORIES IDENTIFIED ON ERTS IMAGERY--NORFOLK--PORTSMOUTH SMSA*

LEVEL I	LEVEL II	LEVEL III** (PROPOSED)
1 Urban & Built Up	11 Residential 12 Commercial & Services 14 Extractive 15 Transportation, Communications, & Utilities 17 Strip & Clustered Settlements 19 Open & Other	Single Family Residential Retail Trade Area Sand & Gravel Pits Airports, Highways, Power Line Rights-of- Way
2 Agricultural	21 Cropland & Pasture	
4 Forestland		
5 Water	51 Streams & Waterways 52 Lakes 53 Reservoirs 54 Bays & Estuaries	
6 Non-Forested Wetland	61 Vegetated 62 Bare	
7 Barren Land	74 Beaches	

*Numbering system from Geological Circular 671

**Level III units are listed only for Level I, "Urban Built Up."

TABLE II

1970-1972 LAND USE CHANGE DETECTION--NORFOLK-PORTSMOUTH SMSA

SMSA Total Area Analyzed	1,911 km ²	737.6 mi ²
Total Aircraft Land Use Change-Level I	36.2 km ²	13.97 mi ²
ERTS Identified Land Use Change-Level I	26.5 km ²	10.23 mi ²
% of Level I Change Identified by ERTS	73.2%	
Total Aircraft Land Use Change-Level II	39.2 km ²	15.13 mi ²
ERTS Identified Land Use Change-Level II	22.4 km ²	8.65 mi ²
% of Level III Change Identified by ERTS	57.3%	
"False" Change-Eroneously Indicated by ERTS	64.3 km ²	24.82 mi ²

Environmental Impact Analysis

Recently two developments in Washington indicate the increasing awareness of the impact of land use upon the environment. The awareness is of the danger of the haphazard and ill-planned spread of homes, factories, commercial developments, and transportation facilities to suburb, exurb and beyond which threaten valuable open spaces, forests, wetlands, and scenic coastlines. Land developers already level and pave almost 500,000 acres of open land in the United States each year, while highway construction occupies another 200,000 acres. One development which documents this growing awareness and concern is the report of a Presidential task force headed by Laurance Rockefeller that recommends a wide range of measures for more rational land use in both city and rural areas. In addition, last year's Jackson bill which would fund state land-use planning efforts has cleared committee and headed for a floor vote with reportedly good chances of passage. The legislation proposes that states inventory their land and develop statewide land-use and regulatory plans. Specifically, areas would be reserved for large-scale development, preservation of environmental quality, and public facilities. Prior to these developments, of course, The Environmental Policy Act of 1969 has directed all agencies of the Federal Government to "identify and develop methods and procedures which will assure that presently unquantified environmental amenities and values are given appropriate consideration in decision making along with economic and technical considerations." The Council on Environmental Quality, in furtherance of Section 102 of the Act, has set forth guidelines for the preparation of the required environmental statements which include an assessment of the "probable impact of the proposed action on the environment." Largely because of the requirement for environmental impact statements in relation to developing land use, there was generated considerable interest in available techniques and methodologies designed to assess the impact of various land uses upon the environment.

A number of workers have developed procedures for the evaluation of environmental impact based upon matrix analysis techniques. Leopold, et al.,^{4/} developed an information matrix which serves as a reference check list through which probable impacts of proposed technical or engineering plans of action can be analyzed, numerically weighted and assessed. Their approach involves consideration of 100 possible actions against 88 environmental characteristics which might be impacted, estimating the "magnitude" of the effect on environmental characteristics as well as an evaluation of the "importance" of each of these effects. Their matrix allows the weights assigned to the two dimension to be combined in a summary evaluation.

More recently, Schneider, et al.,^{5/} have published a report on a technique which employs a water-resource evaluation matrix as a means for determining the relative importance of water-related problems and for identifying the data needed to evaluate those problems for the purpose of urban planning and management. Their

^{4/} Leopold, Luna B., Clarke, Frank E.; Hanshaw, Bruce B.; and Balsley, James R.; A Procedure for Evaluating Environmental Impact, Geological Survey Circular 645, Washington, D.C., 1971.

^{5/} Schneider, William J.; Rickert, David A.; and Spieker, Andrew M.; Role of Water in Urban Planning and Management, Geological Survey Circular 601-H, Washington, D.C., 1973.

matrix lists 9 subject categories in which water-related urban problems may occur as well as 51 possible data inputs for the evaluation of the problem areas. In addition, they include interfacing factors of climate, land, and culture. The method also involves the weighting or ranking of elements in the matrix.

A matrix analysis of environmental impacts of residential, commercial, industrial, agricultural, recreational, transportation, and extractive industry activities was developed in 1970 by Jes C. Sorensen to assist in the production of California's Comprehensive Ocean Area Plan.^{6/} His matrix analysis sought to show environment, and included a consideration of initial, secondary, and tertiary impacts of the same specific action. The matrix was particularly designed to trace the chain of consequences resulting from various land uses and further to provide a means for the computer analysis of those chains.

Finally, Ian McHarg has also demonstrated a matrix approach to the identification and evaluation of environmental impact in which he assesses the "intercompatibility" of 24 types of land use as well as the identification of the resources necessary for the support of those land uses.^{7/} These resources (called "natural determinants") are climate water supply dependability, aquifer recharge areas, soils, vehicular accessibility, and slope. In addition, the matrix assesses the consequences of carrying out the specific land uses vis-a-vis soil erosion, flood and drought control, stream sedimentation, water pollution and air pollution.

Land Use Association and Impact Analysis

Building upon the matrix methodology developed by Leopold and others, a preliminary matrix analysis was conducted in the Geographic Applications Program of the U.S. Geological Survey for Level II land uses in the Norfolk-Portsmouth SMSA in order to assess the areal importance of land use associations in an area as well as to evaluate the negative environmental impact of those land use associations. The importance of association in that early study was defined as the frequency with which 31 categories of land use were found continuous with the same 31 categories in the Norfolk test area. Land use pairs in the test area were examined and rated on a scale of 1 through 5 insofar as they were never, rarely, occasionally, frequently, or very commonly associated. In the same way, the 31 categories of land use were examined and rated according to their probable environmental impact on a scale of 1 through 5: no impact, low impact, medium impact, moderate impact, and high impact. Each of the 961 cells of the 31 by 31 matrix was divided by a diagonal so that the completed ratings present a fractional rating.

Through that analysis, it became evident that associativity of land use must be considered--in the analysis of environmental impact--from at least two aspects. In some land use pairs, the areal proximity of two different land uses is economically desirable: the location of a sand and gravel borrow-pit is economically critical for highway construction, for example. In the same manner, heavy industry is dependent upon the areal association of a rail network. These pairs of land

^{6/} Sorensen, J. S. A Framework for Identification and Control of Resources Degradation and Conflict in the Multiple Uses of the Coastal Zone, University of California, Berkeley, Department of Landscape Architecture, M.S. Thesis, 1971.

^{7/} McHarg, Ian L.; Design with Nature, Doubleday & Company, Garden City, New York, 1971

use can be said to be "compatible". This aspect of associativity, of course, has long been a consideration in locational analysis (particularly industrial location) in geography. Other traditional considerations in locational impact are environmental factors--soils, climate, vegetation, water supply, geologic characteristics, etc.--as an aid in determining the potential of a location. These are called "natural determinants" by McHarg.

The second aspect of associativity between land uses is the "incompatibility" of land uses. In this instance the activities related to a given land use will have a derogatory or adverse affect upon the areally associated land use or upon the environmental factors related to that use. The areal association of these land uses can be expected to result in the degradation of one or both of the uses, but usually more seriously on the dependent one. Moreover, the impact has an adverse effect upon the natural environment upon which the land uses are based and results in problems such as soil erosion, flooding, sedimentation, water pollution, slumping and sliding, etc. Thus, it is important in an analysis of environmental impact to identify and measure the areal associativity of land uses and to relate that associativity to the compatibility or incompatibility of associated land uses.

Environmental Factors and Land Use

The analysis of environmental factors relating to land use has been a part of the CARETS program since its inception. In addition to serving as a necessary and important data base for planners and decision-makers in the region, the environmental data base is also being incorporated into the CARETS environmental impact analysis.

For the Norfolk SMSA test area, work completed on the survey and evaluation of the earth materials of the area are being used to assess the resource potential for "compatible" land uses as well as to weigh the environmental consequences of "incompatible" uses. The analysis in the Norfolk test area provides a description of 16 types of earth materials as well as an identification of 6 features affecting agriculture and engineering work. The descriptions include a physical characterization of each unit, together with its topographic expression and origin, and its present use and vegetation type. The features analyzed include drainage characteristics, soil types, and agricultural adaptability, adaptability to earth work in wet periods, feasibility for use as top soil, feasibility as a source for construction materials, and feasibility for foundations. A second analysis of the characteristics of dominant earth materials has been completed and mapped for the Norfolk area. This approach does not address specific engineering problems or design criteria, but will be used to weight the environmental impact of associated land uses. For six different material types, this study characterizes them as to slope, local relief, landform, materials, drainage, bearing capacity, slope stability, ease of excavation, maximum dry density, optimum moisture, liquid limit, plasticity index, permeability, and equivalent geological formations. Eventually the entire CARETS area will be analyzed and mapped according to this plan.

Another study completed for the CARETS Project will be incorporated into the environmental impact analysis of the Norfolk area. This study, conducted through

a contract with the Department of Environmental Sciences at the University of Virginia,^{8/} attempted the identification and quantification of the environmental impact of the various activities associated with land use: food production and processing, transportation and communication, raw material production and processing, manufacturing and commerce, and habitation and recreation. Identified environmental effects of these activities are principally from the following: 1) fossil; 2) fertilizer and pesticide application; 3) animal and human wastes; 4) accelerated erosion from construction, land use change, and drainage basin alteration; 5) industrial and manufacturing effluents; 6) solid waste generation and disposal; and 7) altered patterns of surface runoff and diminished ground water reserves. Goodell's study collected several data sets for a portion of southern Virginia (including the Norfolk area) and concluded that the size of the data sets require their analysis in a computerized framework.

Land Use and Environmental Impact Analysis

The preceding sections have described the analysis conducted in identifying heirarchical levels of land use in the Norfolk-Portsmouth SMSA test site, monitoring those land use changes on a repetitive basis, assessing the impact of associated and competing land uses, and identifying areas of potential environmental deterioration. Figure 6 shows the activity flow for research in the CARETS project for land use planning analysis which is planned for fiscal year 1974. As suggested previously, continued attention will be paid to the complementary aspects of land use and the environment. As shown on the left hand side of the flow diagram, studies of slope (topographic mapping), water supply and quality, and geology are being carried out in order to determine the resource and hazard potentials of the environmental factors of the test area. That determination is required for an assessment of the capability of the environment to support various land uses. In other words, "land capability" provides an indication of the "capability" of land uses and the associated resources of the land. The center of the diagram indicates the environmental factors which are being considered in the assessment or calibration of the environmental impact. In the case of "incompatible" land uses, the analysis is attempting to calibrate the consequences of those land uses upon the various factors. A major objective of the study will continue to be the development of a methodology for environmental impact analysis which also takes into consideration the effect of the environment on land use.

Basic to the analysis, of course, is the monitoring of changing land use and the effects of the association of compatible and incompatible land uses. Recently developed techniques of computer analysis permit the measurement of the interface boundary between uses, and the areal extent of land uses within the environmental regions. Future applications of this analysis to regional development models (including socio-economic and political data) should assist in the planning and decision-making in the regional context.

^{8/} Goodell, H.G., Woolheater, C.M., and Echternacht, K.L., Environmental Application of Remote Sensing Methods to Coastal Zone Land Use and Marine Resource Management, Final Report: Interagency Report USGS-243; NASA Contract No. 14-08-001-12540, with the University of Virginia, 1972.

ACTIVITY FLOW FOR LAND-USE PLANNING ANALYSIS

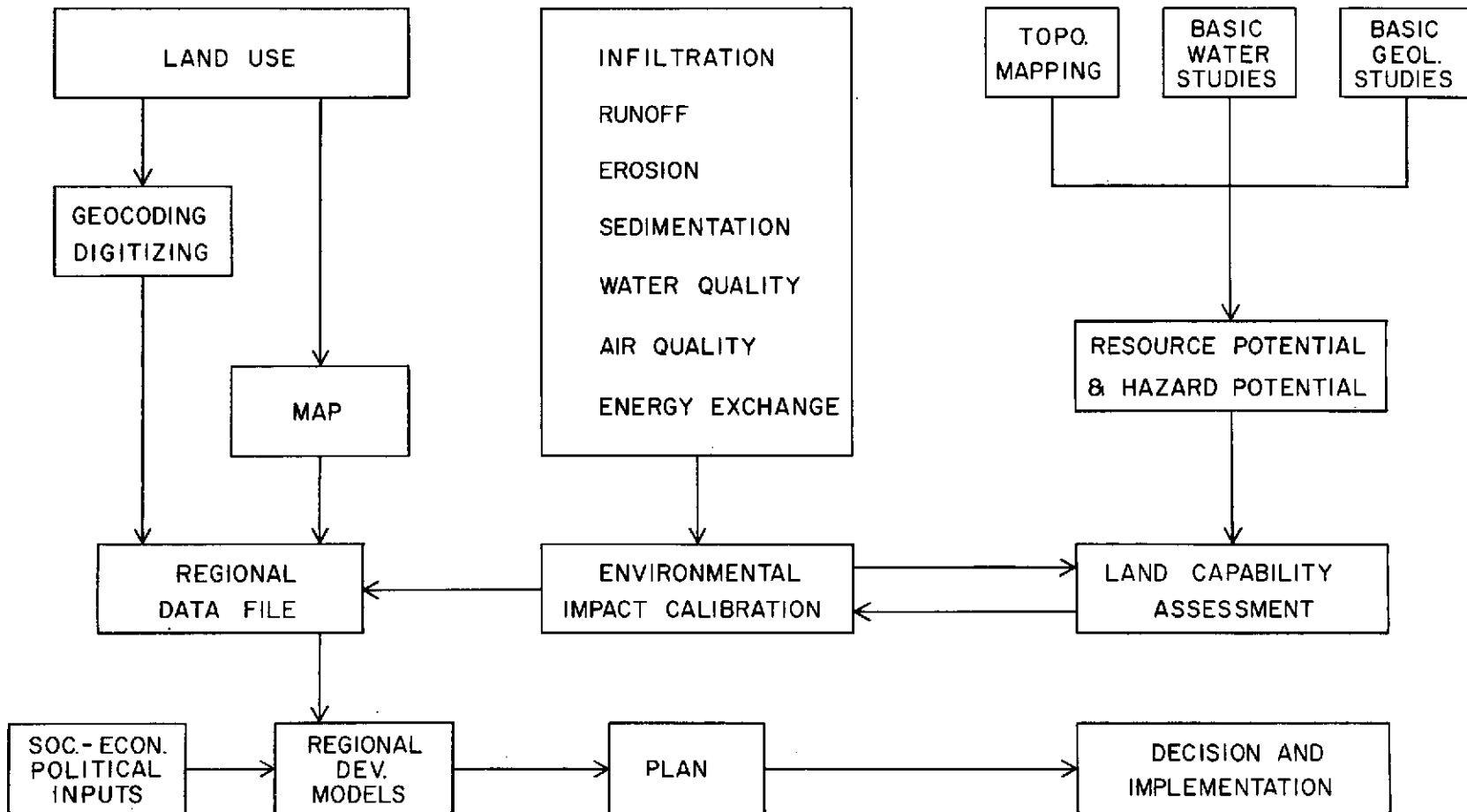


Figure 6. Activity Flow for land use planning analysis. 35.

REVIEW OF OPERATIONAL APPLICATIONS OF INFRARED AND MULTISPECTRAL SCANNERS

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Daedalus Enterprises, Inc.
Ann Arbor, Michigan

Thomas Ory was employed by HRB Singer Inc. from 1964 to 1972, advancing from the position of staff geologist to Director of Decision Sciences Laboratory. Mr. Ory is an expert in the field of data interpretation and has been actively engaged in developing new civil and military applications for remote sensors with emphasis on infrared technology. Mr. Ory's background includes a close working relationship with natural resources agencies and civil engineers and has authored numerous publications on these studies.

Daedalus Enterprises Inc. is a publicly-help Delaware Corporation formed in 1968. The incorporators and other principals of the company were formerly members of the Special Applications Group of the Infrared Laboratory of the University of Michigan's Willow Run Laboratories.

SUMMARY

Mr. Ory did not submit a paper. His presentation has been summarized by Ken Keifenheim.

This presentation is a review of the infrared and multispectral scanners available through Daedalus Enterprises and some practical applications that can be made through the use of this equipment.

The line scanner in general is an electro-optical device which has an instantaneous field of view. The sensitivity of what spectral region one is operating in is purely a function of the detector placed in the device. The focal field of view of most present day scanners is 75° - 120° and is usually smaller in calibrated scanners.

The airborne hardware normally includes the scan head, control console, and power distribution box. The new scanners are designed for operation in small aircraft and the trend is now toward building smaller scanners. The scanning head weighs 38 pounds and the optics mirror scans through 360 degrees although the ground scene is electronically gated to be 77 degrees 20 minutes. The energy emitted from objects on the earth bounces from the scanner mirror into a parabolic collecting mirror and then into a beam splitter for more than one channel of information.

Important aspects of the quantitative system are the Internal Reference Sources. The Black Body Reference Source is important in data playback and gives all the information needed to totally calibrate the signal and this of course gives the ability to produce quantitative data.

The Multispectral Scanner is basically the same as the thermal scanner, but here a small spectrometer is added (in place of one of the detectors) and the spectrum can then be dispersed into ten channels. It has the same detector or ray (solid state silicon ray) as the ERTS satellite which is a simple series of lenses with a prism in between to disperse the spectrum. The optics are virtually the same;

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the dichroic mirror takes wavelength from 2.2 micrometers and longer and reflects them into the thermal channel and everything down to .38 micrometers is reflected into the spectrometer and this then gives the unit an 11 channel capability.

One limiting factor of the hardware is the tape recorder. Most present scanning systems use a magnetic tape recorder which is one of the biggest drawers of power in the entire system. The problem lies in the fact that the small aircraft to which the new scanners are geared are power limited. This problem is now often solved by using small battery operated magnetic tape recorders.

Another problem is that while in the air the scanner operator has little control over the quality of imagery generated. When designing a multispectral mission it is important to try and translate target characteristics into something which the operator can understand. For example, if a mission is geared to concentrate on water detail this should be communicated to the operator so he can gear his controls on this object. Frequently this is not gotten across to the operator and should be.

The scanner can also be used in a helicopter and an illustration was presented showing how a scanner, mounted in a helicopter flying 100 feet above power transmission lines, was used to locate hot spots in the power lines.

A night time infrared image was compared to an aerial photo and it was pointed out how much greater contrast difference there is between the infrared imagery and the conventional photo. At night the dynamic thermal range is very great, 20-30° centigrade, and if the detector can detect temperature difference of 1/10 of a degree we would expect to get a very large dynamic range.

Resolution of Multispectral Scanners is almost the same as infrared scanners but it looks better. This is because it looks much more familiar to us since we are looking at energy that we are used to looking at on photographs.

There are distortions in every scan because the scanner scans slower in the center than at the edges of the view. This is because there is much more area to cover at the edges of the scan. This has been a problem in the past but most present day scanning systems can eliminate this problem by varying the speed at which a cathode ray tube is swept across the film when the image is produced. By scanning the beam slower in the middle than at the edge it is possible to correct much of the problem but it still does not give the geometric fidelity that a camera system gives.

When procuring this imagery it is very important to keep the aircraft at a constant speed. If the speed of the aircraft varies it is almost impossible to correct for distortion in the playback. Constant speed and constant heading are very important for procuring imagery with the least possible distortion. Because of distortion problems with line scanners mosaics are often difficult to construct.

One of the simplest ways of playing back the data and obtaining a quantitative output is to divide the entire dynamic range of signals into six equal increments which in turn can be divided once more. In order to enhance the identification of calibrated levels, color film is frequently used (with a standard range of colors ranging from magenta through red) so that the colors can be divided up whereby each color represents a certain temperature range.

Another technique is to perform some simple functions on the signal in order to

use the multi-channel data more effectively. One method is to take two channels of infrared imagery simultaneously at 3 to 5 micrometers and 8 to 14 micrometers and ratio these. They are then set up for lake temperatures to be equal in both channels. In theory a null signal should be obtained when they are ratioed unless the emissivity is different in the two spectral regions. Examples where emissivity is different include vegetation along the edges of water and the bulldozing of tundra vegetation. Another method is to multiply the signals together to decrease the dynamic range recorded on the film which would more effectively utilize the dynamic range. If two positive signals are multiplied together a positive signal is obtained and if two negative signals are multiplied together a positive signal is also obtained. Therefore almost all the signals are on the positive side which can then be expanded to more effectively utilize the total dynamic range on the film. Here, however, calibration reference is lost and the actual temperature is not known but finer, more detailed temperature differences can be seen.

When considering costs, a simple single channel or dual channel infrared scanner with tape recorder, detectors, and all control consoles would cost approximately \$90,000 to \$100,000. Ground playback equipment varies from \$25,000 (for equipment to simply produce a piece of film) to \$150,000 to \$200,000 for equipment to produce calibrated playback and other enhancements. The color recording system runs from \$30,000 to \$40,000.

Examples of Operational Applications of Multispectral and Thermal Scanners include:

- 1) Animal Census-Thermal Scanners were used for the enumeration of moose and white-tailed deer. It was found that the white-tailed deer could be detected in the summertime. It was thought that the winter-term imagery would detect the deer even better because of the good cold background. However this was not the case but rather it was found that the deer have a good insulating coat to keep their body heat in during the winter and allow them to lose it during the summer. Therefore it was found there is less thermal difference between the deer and the winter background than there is between the deer and the summer background.
- 2) Irrigated Areas-Thermal Scanning was also used here to try and determine when to re-irrigate areas. Infrared imagery taken at irrigation time shows where the irrigated area is and what part of the area was most recently irrigated. The imagery showed a gradation type pattern which represented the path of the irrigation sprinkler across the field. The image was broken up into six scales with each scale representing 3°C. Since the temperature can now be calibrated it may be possible to correlate surface moisture content with surface soil temperature.
- 3) Field Tile-Thermal Scanning was used in Southern Illinois to determine the number and functioning ability of field tile. It was found that only some hint of tiling was shown on the day-time imagery, but the night-time imagery gave a clear image of the tile which is evidence of how the field tile produces a differential effect on near surface temperatures in most areas.
- 4) Discharge of Fresh Water-One major problem in Lebanon was the loss of fresh water as it drained through cracks in limestone that dips towards the Mediterranean Sea. It was decided to use thermal imagery to try to find discharge areas in the Sea. It was found that the colder fresh water gave a darker image on the film and from this evidence field workers were able to find the source of the leak and capture much of the fresh water before it was lost to the sea.

- 5) Volcanic and Geothermal Areas-Thermal Scanning can also be used to detect geothermal heat flow from volcanic areas. Previously it was found that this is not easily done with infrared scanners because the temperature differential caused by sun and shade effects during the day are really greater than the temperature differential of the geothermal heat flow. Geothermal heat flow is most easily detected at the crater edge of a volcano, in recent lava flows, and in rift zones near the volcanos.

Multispectral Scanners are now not used much in operational applications but are used in many experimental studies in various areas. Illustrations of spectral images were shown from flights over the Detroit area. These were images obtained by using the same four channels as used in the ERTS satellite and illustrated the differences in the spectral regions covered by the multispectral scanner.

One practical application of multispectral scanning is the detection of certain chemical contaminants in water bodies. By using thermal scanning only temperature differences can be detected, but hopefully multispectral scanning can isolate the effects of some kinds of chemical contaminants. It is hoped that the channels can be ratioed in order to determine the relative amount of energy there is across the channel and correlate this with certain types of chemicals.

APPLICATION OF REMOTE SENSING TO FORESTRY

Donald T. Lauer
Forestry Remote Sensing Laboratory
University of California
Berkeley, California

Donald T. Lauer is leader of the Image Interpretation and Enhancement Unit of the Forestry Remote Sensing Laboratory, University of California, Berkeley. His responsibilities include developing methodology for extracting useful resource information from remote sensing imagery--using manual image interpretation techniques. He received a B.S. degree in Forestry from the University of California, Berkeley in 1963 and a M.S. degree in Forestry in 1965. He is a member of the American Society of Photogrammetry and the Society of American Foresters.

SUMMARY

Mr. Lauer did not submit a separate paper for this presentation, since most of his material was presented in detail for the Forestry Workshop. Ken Keifenheim has summarized this presentation.

The first use of air photos in forestry was made by a young German forester who, in the 1880's, took photographs of a forested area from a balloon. The use and importance of air photos in forestry grew quickly and by the pre-WW II days and certainly after World War II, courses in forestry air photo interpretation or photogrammetry became core courses in the Forestry curriculum of many Universities in the country.

Applications of Remote Sensing in forestry can be divided into four general areas. These are: 1) Inventory, 2) Monitoring, 3) Detection, and 4) Management. For the last 30 to 40 years conventional black and white photographs have been primarily used for classification of forest lands. Inventory is taken by trying to stratify out homogeneous appearing forest classes. The classification data is used for generating type maps and for follow-on timber volume estimates. The classes are then ground checked and an estimate of timber volume is made. Direct forest inventory estimation is carried out by stratification of timber volume estimates as perceived by the photo interpreter as he looks at tree heights, and average crown and closure spacing. This gives a rough, cheap, and easy estimate of timber volume.

Research projects are presently going on to try and quantitatively prove what type of remote sensing is best to use in forestry studies. It has been found that the infrared imagery appears to be the best imagery to use, although this has yet to be quantitatively established. There was not much difference between the quality of the maps made from the black and white photos than from the color photographs, although it was found that the interpreters worked twice as fast from the color photos than they did from the black and white photos. The greater interpreting speed for the color photos was attributed to the fact that the human eye is very receptive to color and therefore the interpreters did not have to ponder their decisions as long as they did when interpreting the black and white photos. Mexico is presently using color photos for a complete land inventory of the country.

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An important use of large scale photos is the fact that tree species can be picked out from these larger scale photos. This is important to the forester because of the different monetary value given to different types of lumber taken from the trees. Another important aspect of air photo interpretation that applies to forestry is the detection of insect damage and disease. The example of the Western Pine Beetle was presented, which is an insect infamous for being able to wipe out Ponderosa Pine trees. A similar bark beetle destroyed 80% of the Honduras Pine forests five years ago. Early detection of insects and early implementation of management practices is therefore obviously important. An infrared color photo of an area affected by the Western Pine Beetle was shown. It was pointed out that trees on the photo with blue crowns had been dead several years, trees with bright orange or red crowns had been dead for a year or two and that trees with chartreuse colored crowns were those where the insect had left the tree and it was well on its way to becoming dead. It is possible with sequentiary photos over time to monitor the insect dynamics as they operate in a forested area.

In a recent study, sequential thermal infrared line scan imagery was used to determine the best time of day for the imagery to be taken so that one can tell all things apart on the photo. As was shown by the imagery presented it was determined that mid-day was the best time for the imagery to be taken, however, if one is looking for specific information such as shadowing affects or differences in water, other times of the day may be better.

Experiments in Arizona with Side Looking Airborne Radar showed that it is difficult to assess vegetation conditions in a rugged area because of the very gross impact of the terrain.

For coverage of very large areas high flight photography (RB-57 or ERTS Imagery) may be best to use. In a study of one 50,000 acre area it was found that 78 conventional black and white photos were needed to cover the area, while only one stereopair of high flight color infrared imagery was needed to cover the area. Inspection of the maps of the area made from the conventional photos and the high altitude imagery showed little difference in the effectiveness of the two classification maps. However, it took much less time to do the interpreting job with the NASA high flight photos and the cost was only 1/2 of that incurred by using conventional photos. It was pointed out that large areas of the U.S. are now covered by high flight photography including 60% of California and 40% of Michigan.

ERTS Satellite Imagery may be used effectively for regional mapping. The state of California mapped a 2 1/2 million acre area (Feather River Basin) using a vegetation terrain classification. They compiled a map from files, library material, forest service files, and other similar material at a cost of hundreds of thousands of dollars over a two year period. With part of one ERTS photo it took one trained interpreter four hours to delineate land use areas for 2/3 of the study area.

A photographic process of triple exposing 3 multispectral bands of the ERTS Imagery is now being done. There is much interest in experimenting for water quality to discover which color combinations are best for water quality delineations.

APPLICATIONS OF REMOTE SENSING TO AGRICULTURE

Claire M. Hay
Forestry Remote Sensing Laboratory
University of California
Berkeley, California

Claire Hay attended the University of California receiving her B.A. in Geography in 1967, and has completed several terms of graduate work in geology.

She has worked with the Forestry Remote Sensing Laboratory for six years, participating in geologic and agricultural research for such projects as the Apollo IX spaceflight. Her current projects include agricultural analysis with Earth Resource Technology Satellite Imagery.

SUMMARY

Ms. Hay did not submit a separate paper for this presentation, since the material discussed in the presentation was used and expanded on in the Agriculture workshop. Ken Keifenheim has summarized this presentation.

Remote sensing applications to agriculture lie in three main areas. These are; 1) General land use mapping and stratification, 2) Identification, and inventory of distinct crops, and 3) Detection of stress conditions and other factors affecting crop yields.

The purpose of stratification in an agricultural sampling program such as the one used by the USDA Statistical Reporting Service is to increase the efficiency of the sampling program. Presently the Statistical Reporting Service uses conventional aerial photography for the purpose of stratification but often the photography can be up to eight years out of date.

Satellite Imagery such as is provided by the ERTS-1 multispectral scanner offers an efficient and timely solution to the problem of out-of-date stratifications. Land use stratifications performed on the ERTS-1 imagery of the Central Valley at California have proven to be meaningful and statistically significant. Land Use categories which can consistently be differentiated include: Urban areas, Range areas and Wildland areas.

Automatic classification of specific crop types found in San Joaquin County, California has achieved accuracies of better than 85% correct on a single date from ERTS-1 tape data. This can be expected to improve if more than one date of data is used.

By using imagery of more than one date, timed to coincide with certain key phenological stages in a crop's development, specific crop types can be successfully identified and inventoried with accuracies comparable to those obtained by the Statistical Reporting Service with their present ground system. An inventory of the 1970 cotton crop of Maricopa County, Arizona, using sequential (May and July) high altitude aircraft color photography had sampling errors of 9.4% on 1:120,000 scale photography and 15.67% on 1:450,000 scale photography. These sampling errors are comparable to sampling errors that the SRS feels it is achieving at the county level, namely between 10% and 20%.

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Studies conducted by the USDA Agricultural Research Service at Weslaco, Texas have shown that color infrared photography can be used to detect insect infestations and other pathogenic conditions in agricultural fields which might reduce expected yields such as areas of imperfect irrigation due to improper leveling or variances in soil types, or areas of salt accumulation, plant lodging, and others.

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DINNER ADDRESS

Joseph Vitale, Chief
Engineering Systems Design Branch
Office of University Affairs
National Aeronautics and Space Administration

Mr. Vitale is the NASA Technical Monitor for the research grants awarded to Michigan State University and for the Environmental Research Institute of Michigan. He brought home to the 75 conference participants and distinguished dinner guests the hopes NASA has for research grants such as these. The role of continued research into promising applications of remote sensing technology, and the needs of state and local policy and program makers were sketched and discussed. The climate of federal funding in the areas of space research, technology applications, public service and national defense was explained. Mr. Vitale's insights into the changing Washington scene were warmly received.

Those attending the dinner session as honored guests of the MSU and ERIM Project Staff included the following:

The Honorable William Copeland, Chairman, House Appropriations Committee, Michigan House of Representatives, State of Michigan

Allison Green, State Treasurer, Department of Treasury, State of Michigan

David H. Jenkins, Deputy Director, Department of Natural Resources, State of Michigan

Charles Carroll, Head, Route Location Section, Michigan Department of State Highways, State of Michigan

Robert Boatman, Head, Transportation Planning Division, Michigan Department of State Highways

Dan Demlow, Deputy Director, Michigan Department of Commerce

Terry Yonkers, Department of Commerce

John Beck, Office of Intergovernmental Relations, Department of Management, Budget

Dorn Diehl, Director, Agricultural Stabilization & Conservation Service, USDA

John Putman, Economic Research Service, Department of Agriculture

Milton H. Muelder, Vice President for Research Development, MSU

Jacob Hoefer, Assistant Director, Agricultural Experiment Station

Axel Andersen, Coordinator for Remote Sensing, MSU

William Brown, Director, Environmental Research Institute of Michigan

PART II

WORKSHOPS

May 16, 1973

URBAN WORKSHOP

Mr. William Smollen and Professor William A. Howard
Summarized by Ken Keifenheim

Mr. Smollen began the workshop with a word of advice. His most earnest plea to the members was to not go out and fly a mission you have to do without first consulting the person or agency for whom you are doing the work.

Professor Howard then began his presentation to the workshop. His talk centered around his study of Dutch Elm Disease in Denver, Colorado. He characterized it as a do-it-yourself remote sensing project since he had very little financial aid. Initially Dutch Elm Disease invaded the area in 1948 but the spreading of the disease was stopped by taking out the infected trees. In 1969 the disease again broke out in the Denver area. A forester came on local T.V. and asked if anyone had a current tree survey of Denver so the forest people could do some type of tree inventory. Dr. Howard became interested and he and a graduate student got a hold of some color infrared film from the Houston Space Center and the use of an airplane from the USGS. They had flights flown over two test areas: one was an old residential area where there was a very high concentration of elm trees, and the other was over the University of Denver where there were no known cases of Dutch Elm Disease. From the test flight the most appropriate scale was determined for picking out the individual tree crowns. Additionally, from the test flight the possibility of doing the study for the Denver Metropolitan Area looked promising. The major drawback was that very little financing was available. Dr. Howard with much help from others got the color infrared film for the whole study from Kodak Co., the flights were flown by a U.S. Air Force Reconnaissance plane and the processing of the film was done by NASA at the Houston Space Center.

The prime reason for using infrared imagery was to attempt to detect for pre-visual stress effects on the elms. From the first flight it was found that most elm trees were planted on boulevards and they were too close together. There were more than 1,200,000 trees in Denver Metropolitan Area and of this total 400,000 were elm trees. The major problem then was to determine if it was possible to use color infrared photography for detecting previsual Dutch Elm Disease symptoms so that the trees can be taken out and disposed of as soon as possible to keep the disease from spreading. The elm trees are very important for attracting tourists and for use as shade trees. Because of this importance of the elm trees there was much support of the project.

The Denver Metropolitan Area covers about 350 square miles and there were three critical stages in the development of the area that were important in helping interpret the photographs. The elm trees are culturally dependent. They were brought in primarily to the northeastern part of the city by Anglos, while Italians and Chicanos brought other tree species with them to the northwestern part of Denver. The year 1905 was also important in the development of the elm trees for this is the year Mayor Spear started his tree planting program.

The great bulk of the elm plantings were done mainly in the period from 1905 to 1930. From 1930 to 1950 most of the elm trees that were planted were Siberian elms. Since 1948 there have been no elms planted in Denver except for the Siberian variety which were planted on the edge of the city and are usually the last elms to be affected by the disease.

At this time Dr. Howard quoted various figures connected with the Dutch Elm Disease outbreak. Forty percent of the 1,200,000 trees are elms and there are about 60

square miles in the area were 25% or more of the trees are elms. The cost of removing one tree is \$50 to \$200 depending on the size with \$125 being average. These figures do not include the transportation and disposal of the remains of the cut elm trees. The Rocky Mountain Shade Tree Association values each elm tree at about \$1500 to \$2000. Therefore all the elms in the area are valued at about \$500 million and this of course does not include aesthetic value. It would cost another \$15 million to transplant 1/4 to 1/2 of the lost elms with other trees 2 to 3 inches in diameter.

The agent that actually kills the tree is a fungus, which is spread by two main methods. In about 75% of the cases the disease is spread through root grubs and the other 25% of the time it is spread by the European or Native Bark Beetle which diffuses the fungus quickly.

It was found that the disease first affects the area high up in the crown of the tree and eventually spreads from there. Slides were shown illustrating this and other points connected with the Dutch Elm Disease in Denver. If the tree definitely has the disease a dark ring is noticeable on the outer layer of the stump where the fungus literally strangles the tree to death. One can usually tell if a tree has Dutch Elm Disease because normally the tree is a very deep magenta color and high up in the crown appears a discoloration area which is the stress area. When ground checks were made the stress situation could not be detected. However, due to the ground rules in terms of exercising the police powers, before any tree could be removed a sample from the tree had to be taken to determine if the tree actually did have Dutch Elm Disease. The processing of the sample took about two weeks and usually by this time the symptoms of the disease were visible. Also, the city officials were reluctant to use color infrared photography as a basis for ordering trees cut down. They felt this way because it was found that amateur interpreters or interpreters who were not used to looking for the early symptoms of the disease on the photography had trouble distinguishing early Dutch Elm Disease symptoms from other stress factors. Dr. Howard pointed out that other stress factors look very similar to the diseased symptoms and that one must be very careful when designating trees that appear to have early symptoms of Dutch Elm Disease.

In summary it was found that this study was useful in that it was possible to detect Dutch Elm diseased trees before any visual symptoms were noticeable. Also this is an example of a very expensive study that was done at actually very little expense on the part of the people involved.

Following this a question and answer period ensued. Some of the more important questions are given below:

Q: How would you suggest a county planning agency could convince its' county board as to the necessity for a complete set of remote sensing maps to up date its existing land use maps?

A: It was noted that it might be difficult to convince a county board to obtain remote sensing data because these people really don't get inherently excited about spending the amount of money needed to finance an undertaking such as was suggested.

Q: How useful is RB-57 high flight photography?

A: It was pointed out that RB-57 photography is useful for delineations of land use at Levels I and II in the land use classification system devised by the Department of Interior.

Q: What would you tell a planning commission for a community of 150,000 that is fairly geographically isolated that they could get from ERTS-1 photography?

A: A frank answer was given noting that not too much information can be obtained from ERTS imagery in this situation. If you want information past the one and two levels of classification you can forget about this scale photography.

Q: One land use planner asked what he could use ERTS satellite imagery for in helping him do his planning.

A: You can tell where roads that you already know are being developed are; you can tell where subdivisions are going up and where real estate investors are putting their money. You can tell where swamps are being drained or lakes are being made. But on such a gross scale it takes hours of looking and eye strain to do it. Until we get a better version of ERTS, something with more resolution and covering a narrower area we won't be able to tell much more than the gross things that we already know. The main thing you can get out of ERTS, as a planner, is an idea of where the changes are taking place in your geographic regions.

Q: What is the long range selling point of small scale color infrared photography?

A: It was mentioned that the false color imagery of the infrared photos has an awe producing affect on planners and others not acquainted with infrared photography and this is what gives infrared photography its uniqueness or class and is what often sells it to planners. An example of its advantages was presented by noting that one can easily tell sick from healthy vegetation from color infrared photography.

AGRICULTURAL WORKSHOP

Claire M. Hay

Two Practical exercises were given to familiarize participants with the types and scales of imagery.

I. Stratification and Change Detection Using Satellite Imagery

The purpose of this exercise is to illustrate the utility of satellite imagery in the monitoring of changes in land use.

1. Three strata are to be delineated on the Apollo 9, March 1969, color infrared photo of Maricopa County, Arizona (scale 1:650,000). The strata are: (1) Urban-Surburban Areas, (2) Agricultural Areas and (3) Wildland-Range Areas.
2. A similar stratification is to be made on the ERTS-1 color composite taken in August 1972 of the same area (scale 1:670,000).
3. Calculate the amount of area that has shifted from agricultural use to urban use by means of the dot area grid.

II. Crop Identification and Inventory

The purpose of this exercise is to illustrate the application of the sequential technique in the identification of wheat, barley, cotton and alfalfa for the test cells illustrated in the handout.

Using the high altitude aircraft color photography of the three cells shown, determine the photo characteristics of wheat, barley, cotton and alfalfa by studying the training cell. For the two testing cells, identify which fields are occupied by the four crops listed above.

SMALL GRAIN INVENTORY; MARICOPA COUNTY, ARIZONA

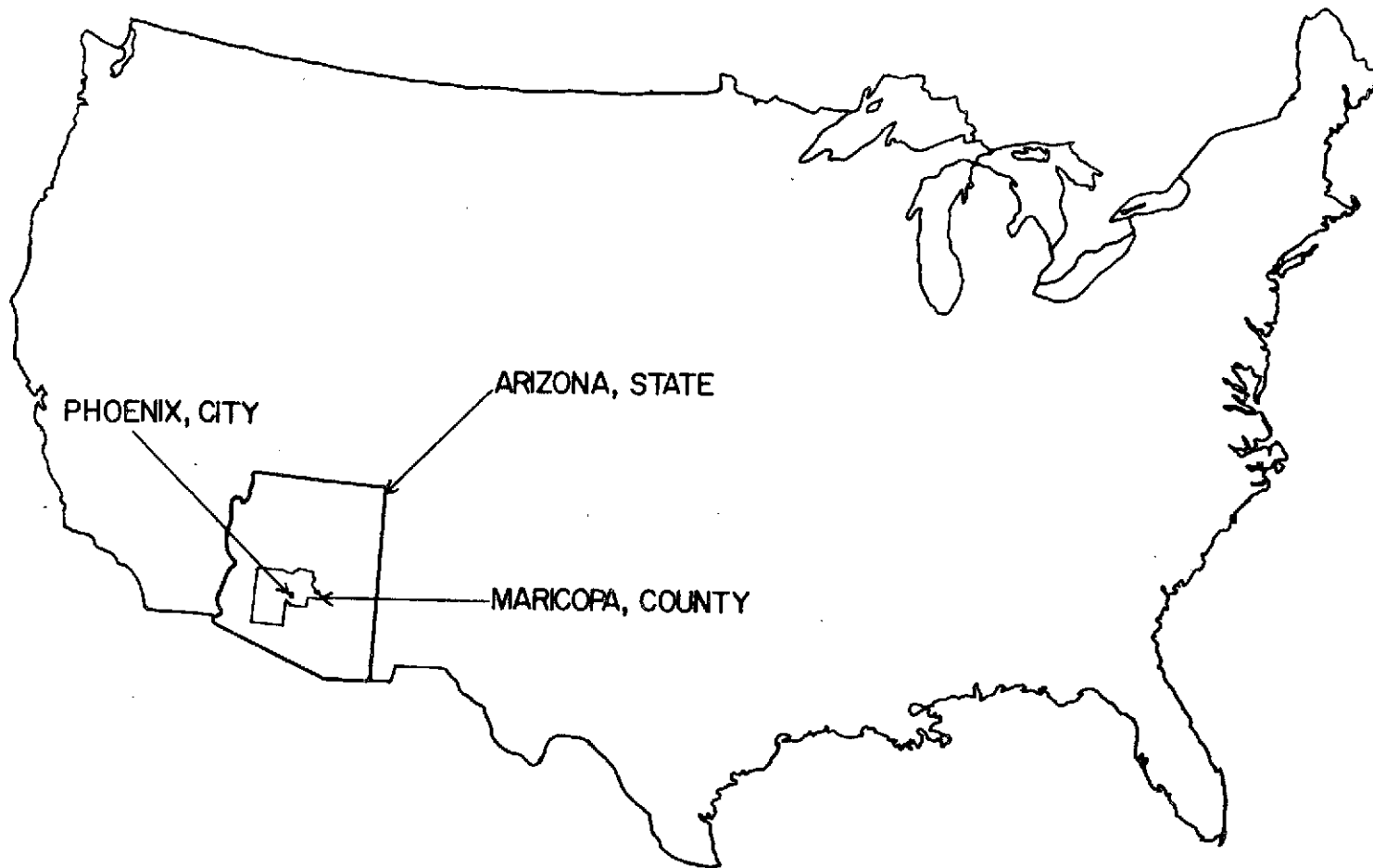
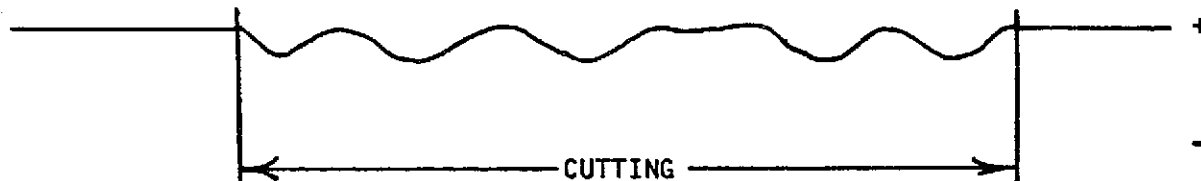


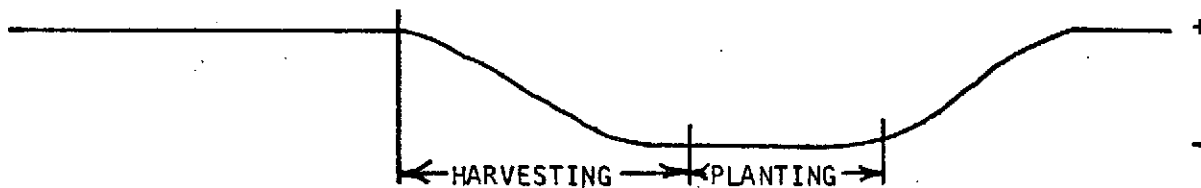
PHOTO CROP CALENDER FOR MARICOPA COUNTY, ARIZONA

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

ALFALFA



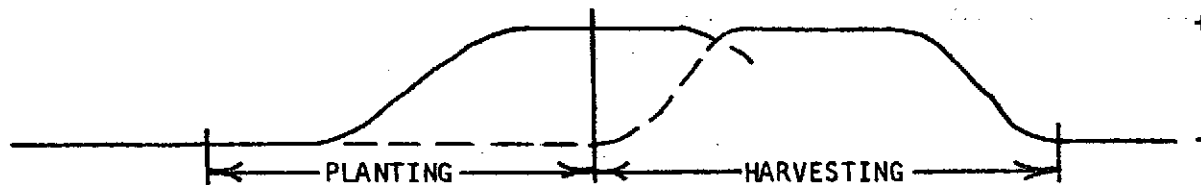
SUGAR BEETS



COTTON



SORGHUM



SAFFLOWER



SMALL GRAINS



FALLOW





Apollo 9 Photo, March, 1969



ERTS-I PHOTO, August, 1972

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APOLLO 9 SPACE PHOTOGRAPH



SALT RIVER

PHOENIX

TESTING CELL

TRAINING CELL

GILA RIVER

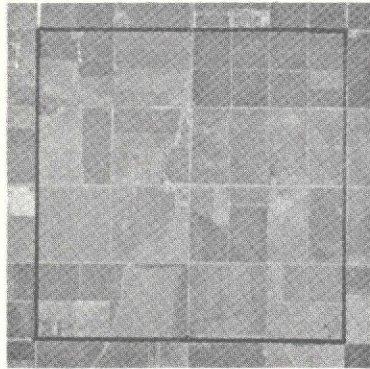
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TRAINING CELL; SCALE 1:84,480

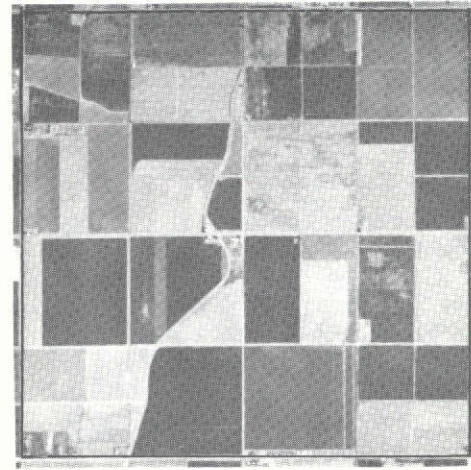
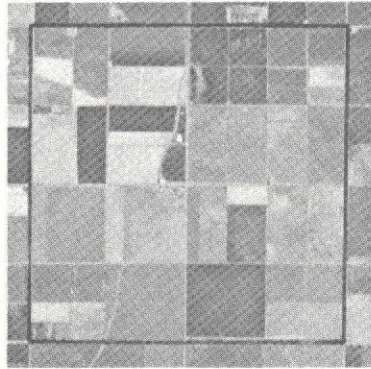
JULY 20, 1970

COLOR PHOTOGRAPHY

MAY 21, 1970



JUNE 16, 1970



GROUND TRUTH

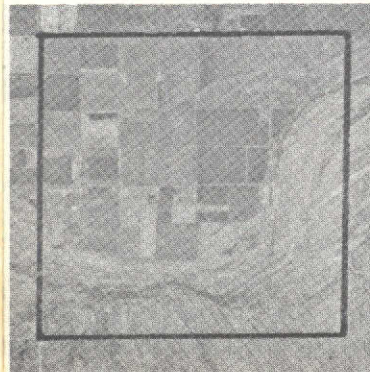
A	A	A	A	A	W	W
B	B	B	A	A	W	W
C		A			C	C
B	A	B	A	B	B	C
					W	
C	B	C		C	SB	C
		B				B
W	W					C
B		C				C
						B

TESTING CELL; SCALE 1:84,480

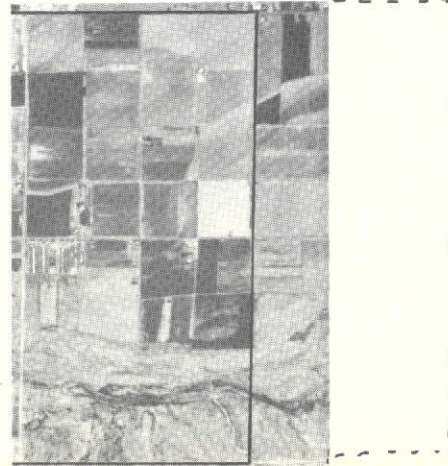
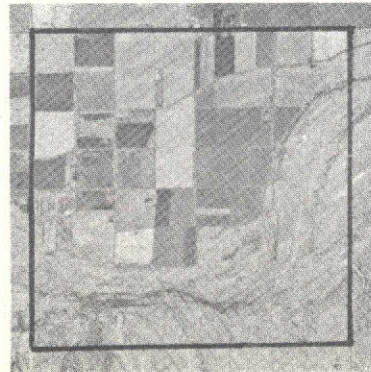
JULY 20, 1970 PHOTO

COLOR PHOTOGRAPHY

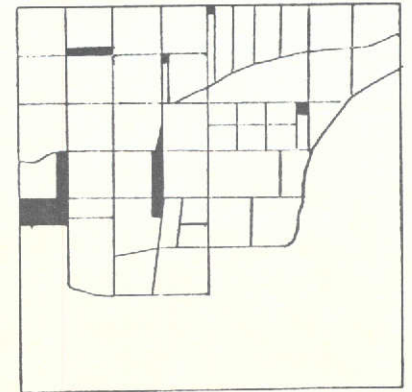
MAY 21, 1970



JUNE 16, 1970



INTERPRETATION RESULTS

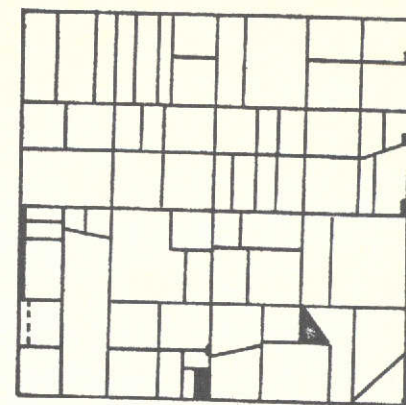
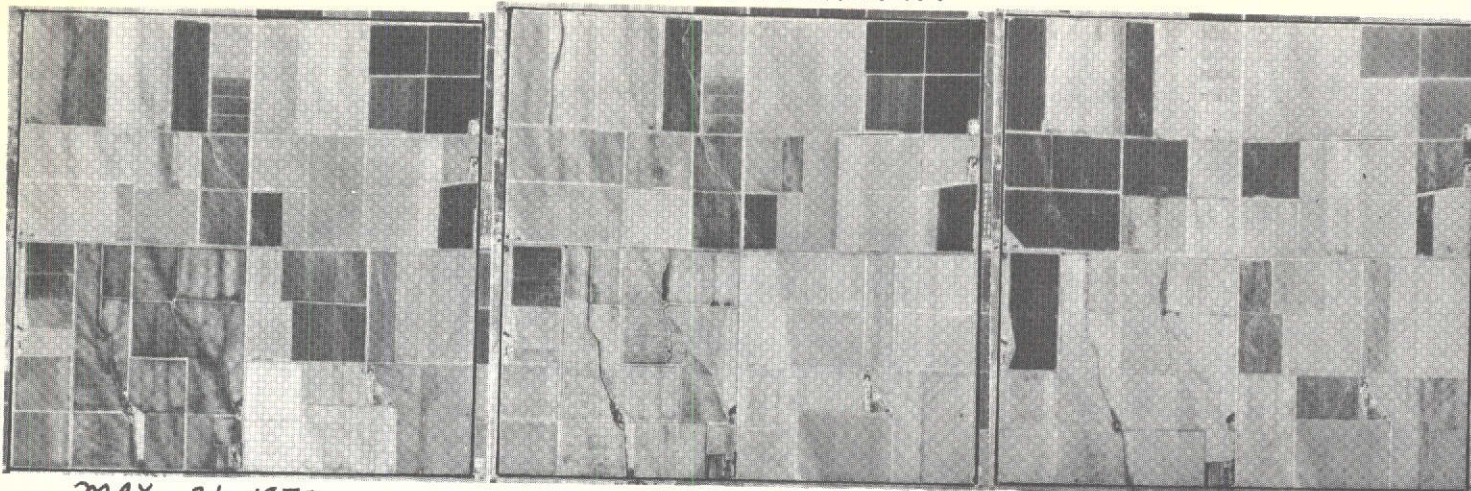


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TESTING CELL 7-1; SCALE 1:84,480

COLOR PHOTOGRAPHY

GROUND DATA



MAY 21, 1970

JUNE 16, 1970

JULY 20, 1970

INTERPRETATION KEY

PHOTO CHARACTERISTICS

CROP TYPE

MAY

JUNE

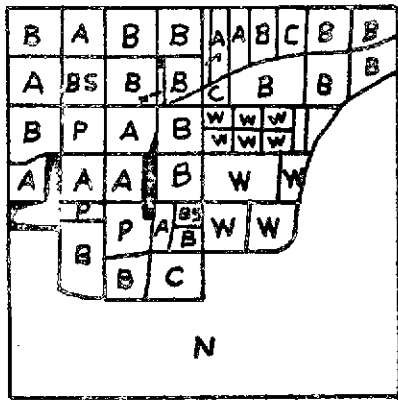
JULY

	MAY	JUNE	JULY
BARLEY			
WHEAT			
COTTON			
ALFALFA			

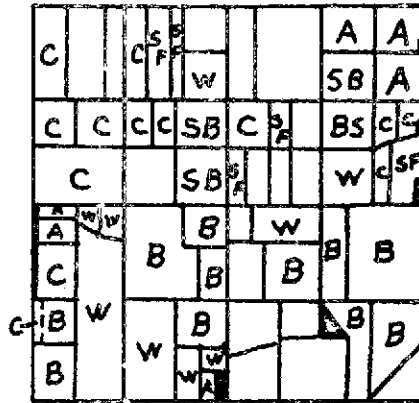
55.

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GROUND DATA FOR TESTING CELLS



CELL 4-5



CELL 7-1

LEGEND

- A ALFALFA
- B BARLEY
- BS BARE SOIL
- C COTTON
- N NATIVE
- P PASTURE
- SB SUGAR BEETS
- SF SAFFLOWER
- W WHEAT

ANALYSIS OF INTERPRETATION RESULTS

CROP	TOTAL NUMBER FIELDS	FIELDS		
		CORRECTLY IDENTIFIED	FIELDS OMITTED	FIELDS COMMITTED
BARLEY	28	_____	_____	_____
WHEAT	22	_____	_____	_____
COTTON	16	_____	_____	_____
ALFALFA	16	_____	_____	_____
TOTAL	82	_____	_____	_____

WETLANDS WORKSHOP

Buzz Sellman, Environmental Research Institute of Michigan

This workshop session was canceled and merged with the environmental impacts session.

ENVIRONMENTAL IMPACTS APPLICATIONS WORKSHOP

Dr. G. Lennis Berlin
Dr. Wm. B. Mitchell
Thomas Ory

Summarized by Ken Keifenheim

The workshop was begun by Dr. Berlin who laid out an index map of the CARETS Project. The areas were mapped with a land use classification at levels one and two.

Examples of ERTS Imagery were also displayed to show how this type of imagery can be used. It was noted that the ERTS Imagery was blown up to scales of 1:250,000 and 1:100,000 for interpretation tests. A map compiled from U-2 and ERTS Imagery of land use changes that occurred from 1970 to 1972 to show how ERTS imagery was used at the level II classification was presented to the participants.

A map of topographic expression and land uses, vegetation types and soil and agricultural suitability were also shown to the group. A large test area was mapped according to this classification. A computer analysis was run by storing in the land use and relating that map against the characteristics of the area for suitability of that land use for that particular area.

A sample map of the Norfolk area was presented to show how an attempt is being made to use remote sensing data for land use classification at Level III. It was noted that land use past Level II probably is interpretable off remote sensing data.

The group was then informed of the Environmental Impact Matrix study. This study is concerned with the impact of one land use on another, especially proximal areas. Each cell shows a frequency association and environmental impacts and then are grouped into land uses in negative environmental compatibilities.

Also shown was a series of four matrixes where the authors have gone through and considered types of environmental activities and the kinds of actions on the environment that would result and their impact on the environment.

Additionally the value of digitizing information was discussed. One can ask the computer to tell how many land uses interface on a certain type of land use and what is the length of the interface. Essentially the interface idea is to continue to do a detailed analysis of how land uses relate to one another and then relate back to environmental factors. They look at how land use is affected by land use, how land use is affected by environmental factors and how environmental factors are affected by land use.

The workshop participants were advised that a land use mapping of a 1911 square kilometer area would take three man weeks at Level II and it can be quickly collapsed to Level I. A Level I and II mapping from ERTS Imagery would take about 33 man hours. Little can be said about the cost although it is fairly expensive since this is in the initial stages.

Mr. Tom Ory from Daedalus Enterprises then gave a short talk and slide presentation on two examples of the use of infrared thermal scanners as a tool in environmental impact studies.

The first example pertains to techniques used for extracting semi-automatically certain kinds of terrain features in doing large site studies. A night time infrared image of a rural scene in Indiana that was to be the proposed site for a highway corridor was shown. In preparation for preliminary corridor studies one of the objectives is to isolate several categories of land features very quickly in order to make some routine decisions on alignment. There were several specific objects that were looked for. These included: existing surface water (farm ponds), woodlots, (since woodlots in this area of Indiana are slowly becoming extinct it was important not to cut any part of these down) and wet soil areas which were to be avoided for obvious reasons. It was possible to isolate certain segments of the signal in terms of temperature and pull them off singly. High temperatures were evidence of surface water. It was also possible to isolate temperatures most representative of trees, or the woodlots. Additionally it was found that wet soil areas could also be singled out and these generally followed stream courses. There is also the possibility of displaying the images in a different manner. For instance, it was found that by superimposing one of the extracted signals on the subdued analogue background signal that this is much easier to map than by just having the signal singled out without the subdued background.

Another technique that can be used with thermal scanners is that of thermal mapping. A spike in the image is generated when there is a significant change in the surface temperature. An image was shown of a sizable reservoir that was contoured with thermal mapping. This was a color coded example that was laid out for observation to the workshop participants.

This marked the end of the formal part of the workshop and the participants then began to inspect the displays provided by the workshop instructors.

FORESTRY APPLICATIONS WORKSHOP

Donald T. Lauer

WILDLAND VEGETATION/TERRAIN ANALYSIS

OBJECTIVE

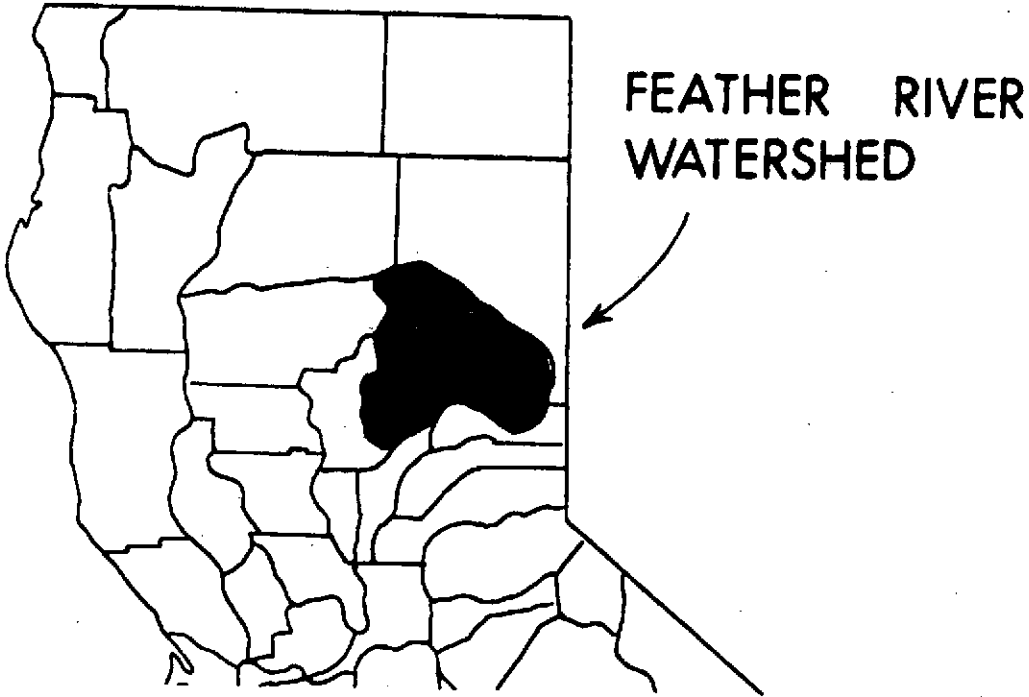
The purpose of this exercise on wildland vegetation/terrain analysis using remote sensing techniques is to familiarize the student with the use of ultra-small scale, synoptic view, false-color infrared imagery. The student will be asked to employ the components of the entire image interpretation process which have been presented to him as he seeks to delineate and identify pertinent resource features on representative images. Emphasis will be placed on his doing this particular exercise by himself, the better to appreciate the task of the resource inventory expert. At the conclusion of this exercise he will be provided with the correct solution, as verified by "ground truth" for the area.

PROCEDURE

During the exercise considerable time will be spend reviewing the components of the entire image interpretation process. Thus, we will proceed in a step wise fashion and study each of the following topics: (1) familiarizing personnel with the important resources of an area, (2) acquiring and preparing imagery for that area, (3) selecting image interpreters, (4) training image interpreters, (5) performing image interpretation tasks, (6) compiling image interpretation results, (7) collecting ground data information, (8) correlating ground data and interpretation data, and (9) evaluating interpretation results.

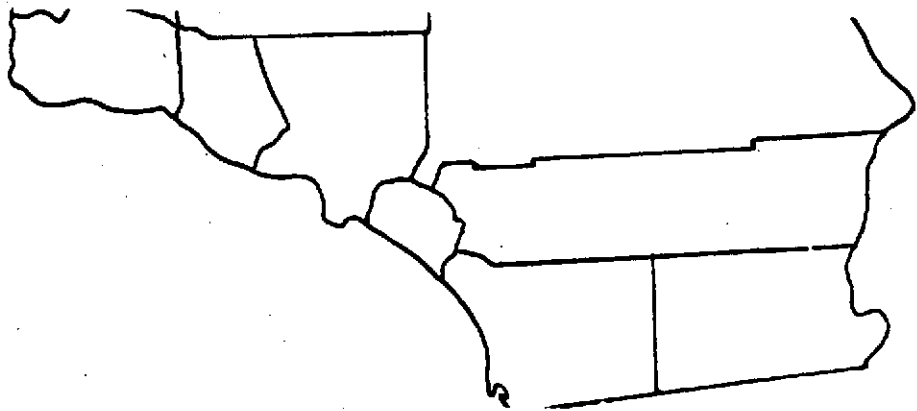
DISCUSSION

Emphasis in this exercise is being placed on understanding the methodologies for effectively utilizing--by means of manual image interpretation--small scale, synoptic view imagery, similar to that which might be obtainable from ERTS and Skylab vehicles. We will discuss the various wildland resource classification schemes and image analysis techniques currently being employed by land resource managers. Each student will have the opportunity to (1) directly compare conventional black-and-white aerial photography with high-flight, false color infrared photography and (2) freely discuss the advantages and limitations associated with using each type of imagery. In addition, a considerable amount of time will be spent discussing the practical aspects associated with using synoptic view imagery. Thus, as each student evaluates his interpretation results for a remote wildland area, he will be given the opportunity to decide for himself the level of accuracy, time needed for interpretation, and cost of interpretation associated with using imagery procured from high flying aircraft and/or earth orbiting spacecraft.



UPPER FEATHER RIVER WATERSHED
(2-1/2 MILLION ACRES)

<u>Type of Data</u>	<u>Scale</u>	<u>Format</u>	<u>No. of Photos</u>
Conventional B/W Photography (stereo)	1/15,840	9" x 9"	2,600
High-flight CIR Photography (stereo)	1/120,000	9" x 9"	58
ERTS-A RBV Imagery (non-stereo)	1/1,000,000	9" x 9"	1



This map of California shows the geographic location of the Feather River Watershed -- a large remote area in the northern Sierra Nevada Mountains -- possessing extensive timber, forage, water, wildlife and recreation resources.

IMAGE CHARACTERISTICS FOR NINE VEGETATION/TERRAIN TYPES
 FOUND TO OCCUR IN THE FEATHER RIVER WATERSHED AREA

Based on High-altitude, Small Scale, False-color Infrared Imagery

FEATURE	TONE OR COLOR	TEXTURE	TOPOGRAPHY	LOCATION/ASSOCIATION
CONIFERS	Variable: purple-red to red-blue	Variable: rough, spiked	Mountainous slopes, ridges, gullies, all topographic types	Understory of brush and grass sometimes is visible
HARDWOODS, DRY SITE	Bright pink	Variable: medium texture, billowy	Mountainous slopes, and gullies	Usually associated with drier slopes
HARDWOODS, RIPARIAN	Bright red	Medium texture, billowy	Flat areas and gully stringers	Red fir forest; meadow areas
MEADOW, DRY	Light pink to pink	Smooth	Flats, Depressions	Sometimes with streams and/or riparian hardwoods
MEADOW, WET	Bright red	Smooth	Flats, depressions	Sometimes with streams and/or riparian hardwoods; with alpine forest
LOW HERBACEOUS AND GRASS	Grey, grey-pink, grey-blue	Smooth	All topographic types	Burned areas; serpentine soils; under forest canopy
BRUSH	Medium Pink	Smooth	Mountainous slopes	May be scattered trees; usually associated with drier slopes
WATER	Blue or black	Smooth		--
NON-VEGETATED	White to light white-pink	Variable: medium to rough	Any topographic types, especially steep granite	Granitic outcroppings; mining operations; cleared areas

FACTORS GOVERNING THE
INTERPRETABILITY OF REMOTE SENSING IMAGERY

I. Factors affecting image characteristics

FACTORS	USFS B/W stereo pair	NASA RB57 stereo pair
film	Plus X Aerographic	Aerochrome Infrared
filter	Minus blue	Minus blue
image scale	1/15,840 (4" = 1 mi)	1/125,000 (4" = 1 mi)
season of year	early summer, 1966	mid-summer, 1969
time of day	10:00 am	2:00 pm
atmospheric effects	little or none	little or none
film resolution	50 line pairs/mm	32 line pairs/mm
image motion	0.73 ft @ 1/250 sec (.0005 in)	1.35 ft @ 1/500 sec (.0001 in)
parallax	B/H = .40	B/H = .51
film exposure	optimum	optimum
film processing	optimum	optimum

II. Factors affecting image

FACTORS	USFS B/W stereo pair	NASA RB57 stereo pair
visual acuity of interpreter	stereo perception?	color blind?
mental acuity of interpreter	?	?
interpretation equipment	2x stereoscope	3x photo enlargement
training aids	--	interpretation key

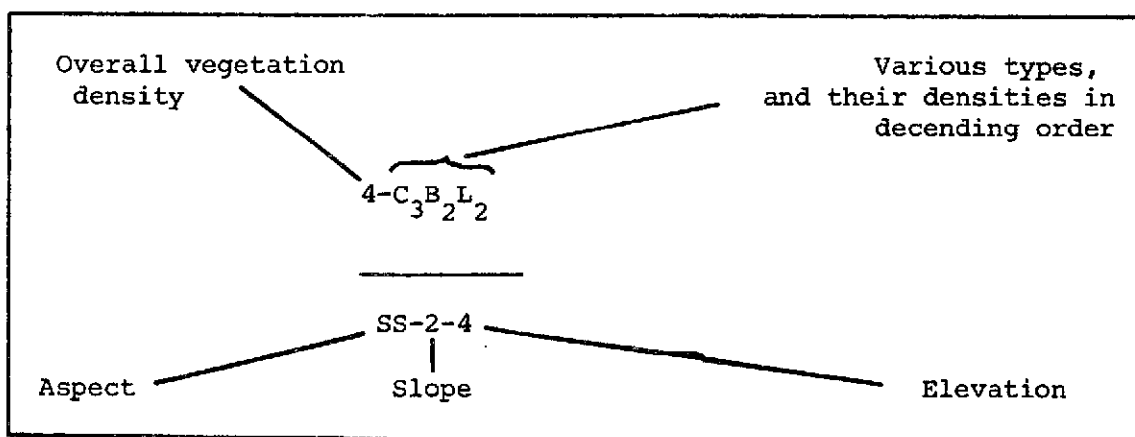
A WILDLAND VEGETATION/TERRAIN CLASSIFICATION SCHEME

Vegetation Density

- 1 - 0-5%
- 2 - 5-20%
- 3 - 20-50%
- 4 - 50-80%
- 5 - 80-100%

Vegetation Type

- C - Conifers
- H - Hardwoods, dry site
- R - Hardwoods, riparian
- Md - Meadow, dry
- Mw - Meadow, wet
- L - Low herbaceous & grass (not M)
- B - Brush
- W - Water
- N - Non-vegetated, bare soil or rock



Aspect

- NN - North
- NE - Northeast
- EE - East
- SE - Southeast
- SS - South
- SW - Southwest
- WW - West
- NW - Northwest
- LL - Level

Slope

- 1 - Level; 0-3%
- 2 - Gentle; 3-10%
- 3 - Moderate; 10-50%
- 4 - Steep; 50%

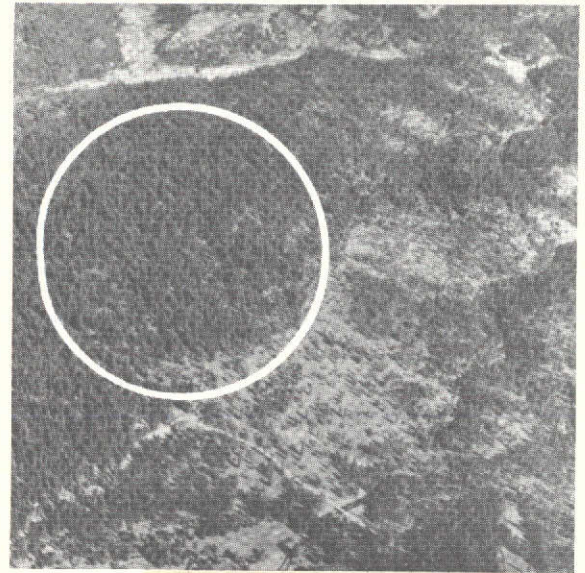
Elevation

- 2 - 2000-3000 feet
- 3 - 3000-4000 feet
- 4 - 4000-5000 feet
- 5 - 5000-6000 feet
- 6 - 6000-7000 feet

AN EXAMPLE OF AN IMAGE INTERPRETATION KEY
FOR MOUNTAIN CONIFEROUS FOREST

Description:

The Mountain Coniferous Forest comprises the main timber region of the western slope of the Sierra Nevada. It extends from approximately 4000 feet (Ponderosa pine belt) through an upper zone characterized by Red fir and Lodgepole pine (greater than 7000-8000 feet). This type occupies an area that is dry in summer and snow covered in winter with podzolic soils characterized by deep and permeable clay loams, loams and sandy loams. Within the coniferous stands, there is generally a sparse cover of grasses or low shrubs beneath.



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Principal Species:

Sugar pine	<u>Pinus lambertiana</u>
Ponderosa pine	<u>Pinus ponderosa</u>
Jeffrey pine	<u>Pinus jeffreyi</u>
Lodgepole pine	<u>Pinus murrayana</u>
Douglas fir	<u>Pseudotsuga menziesii</u>
White fir	<u>Abies concolor</u>
Red fir	<u>Abies magnifica</u>
Sequoia	<u>Sequoia gigantea</u>
Incense cedar	<u>Libocedrus decurrens</u>
Madrone	<u>Arbutus menziesii</u>
Currants and gooseberries	<u>Ribes</u>
Mountain misery	<u>Chamaebatia foliolosa</u>
Ceanothus	<u>Ceanothus</u>
Manzanita	<u>Arctostaphylos</u>

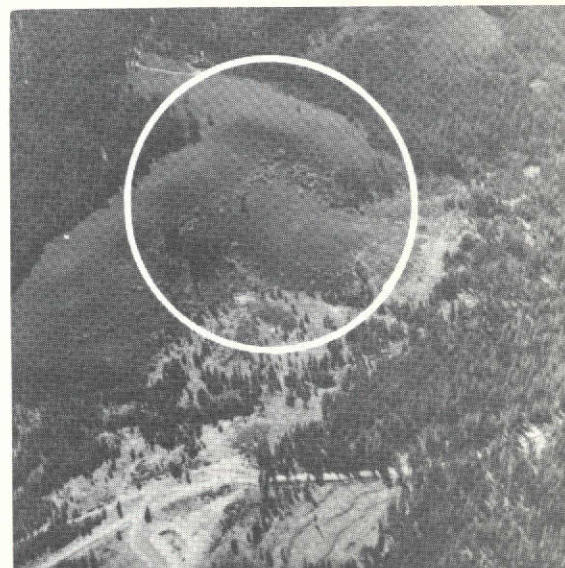
Image Characteristics (small scale, false-color infrared):

Mountain coniferous forest type is found on all aspects of slopes and ridge tops. It appears rough in texture with variable crown closure caused by timber density differences. Coniferous trees can be seen rising above the terrain features and other vegetation types. Although often close in height to hardwoods, the conifers offer a more spiked appearance. Mountain coniferous is the main vegetation type of the area and varies in color from purple-red to red-blue. The color changes are associated with differences in aspect, soil types, stand density, stand associations and logging operations.

AN EXAMPLE OF AN IMAGE INTERPRETATION KEY
FOR MOUNTAIN CHAPARRAL

Description:

The chaparral vegetation type is composed of multi-stemmed, woody, perennial shrubs ranging in height from 2 to 12 feet. The shrubs are often closely spaced and frequently found in large stands relatively free of other vegetation types. Mountain chaparral occupies both aspects of the western Sierra, ranging in elevation from approximately 4000 feet (Ponderosa pine belt) up to 9000 feet (Subalpine belt). It occupies both poorer soil sites unsuitable for timber production as well as disturbed timber areas. The primary use of mountain chaparral is to protect the watershed and secondly as forage for deer and livestock.



Principal Species:

Deer brush	<u>Ceanothus integerrimus</u>
Mountain whitethorn	<u>Ceanothus cordulatus</u>
Snowbrush ceanothus	<u>Ceanothus velutinus</u>
Littleleaf ceanothus	<u>Ceanothus parvifolius</u>
Fresno mat	<u>Ceanothus fresnensis</u>
Green manzanita	<u>Arctostaphylos patula</u>
Pinemat manzanita	<u>Arctostaphylos nevadensis</u>
Huckleberry oak	<u>Quercus vaccinifolia</u>
Bush chinquapin	<u>Castanopsis sempervirens</u>
Bitter cherry	<u>Prunus emarginata</u>
Service berry	<u>Amelanchier alnifolia</u>
Mountain misery	<u>Chamaebatia foliolosa</u>

Image Characteristics (small scale, false-color infrared):

Mountain chaparral type as seen on high-altitude false-color infrared imagery appears medium pink with a smooth texture. The chaparral is conspicuously lower in height than coniferous and hardwood types. It is generally found in fairly large, continuous areas, though scattered trees easily may be seen rising above the brush. Chaparral can be found on all aspects and should not be confused with the generally flat meadow areas.

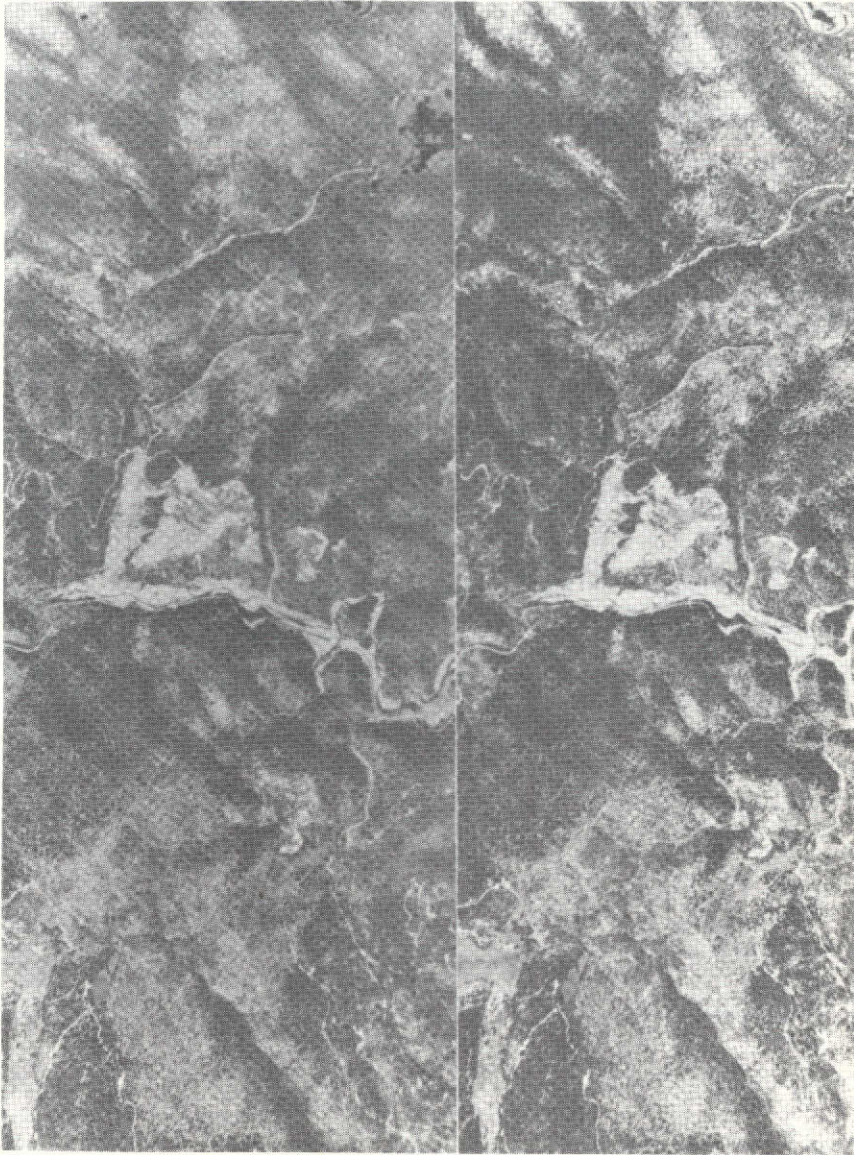
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DICHOTOMOUS IMAGE INTERPRETATION KEY FOR
 NINE VEGETATION/TERRAIN TYPES FOUND TO OCCUR
 IN THE FEATHER RIVER WATERSHED AREA

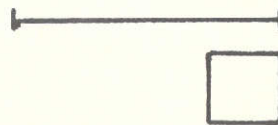
Based on High-Altitude, Small Scale, False-color infrared Imagery

- | | | |
|----|--------------------------------------|-----------------------------------|
| 1. | Texture, smooth | 2. |
| 1. | Texture, medium to rough | 6. |
| 2. | Topography, flat | 3. |
| 2. | Topography, mountainous | 5. |
| 3. | Color, blue or black | <u>Water</u> |
| 3. | Color, not blue or black | 4. |
| 4. | Color, bright red | <u>Meadow, wet</u> |
| 4. | Color, light pink to pink | <u>Meadow, dry</u> |
| 5. | Color, pink | <u>Brush</u> |
| 5. | Color, grey or grey-pink | <u>Low herbaceous & grass</u> |
| 6. | Texture, very rough | <u>Conifers</u> |
| 6. | Texture, medium | 7. |
| 7. | Color, white or light pink | <u>Non-vegetated</u> |
| 7. | Color, bright pink or red | 8. |
| 8. | Association, dry sites | <u>Hardwoods, dry site</u> |
| 8. | Association, wet sites | <u>Hardwoods, riparian</u> |

INTERPRETATION EXERCISE



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1 mile

40 acres

Vehicle: NASA RB57F
Flying Altitude: 65,000 feet
Sensor: Wild RC8 camera; 6" focal length
Film: Kodak Aerochrome Infrared, Type 2443
Scale: 1/120,000 (original)
1/47,000 (reproduced)

INTERPRETATION EXERCISE -- FIELD DATA

(Example of ground truth data collected in the field)

(front of card)	
SURVEY: <u>A</u>	PLOT #: <u>10</u>
DATE: <u>19 July 1971</u> CREW: <u>JPM & RMC</u>	
Veg.-Terrain Type: <u>Mountain Chaparral</u>	Geology: <u>Volcanic</u>
Veg. Cover %, All Veg.: <u>95%</u>	Soil Depth: <u>1 1/2'</u>
Veg. Cover %, Trees: <u>25%</u>	Soil Color: <u>10YR 4/3</u>
Veg. Cover %, Shrubs: <u>90%</u>	Aspect: <u>flat</u>
Veg. Cover %, Herbaceous & Grass: <u>5%</u>	Slope: <u>flat</u>
Avg. Canopy Ht., All Cover: <u>10'</u>	Elevation: <u>4500'</u>
Avg. Canopy Ht., Trees: <u>40'</u>	Location
	Survey: <u>T2BN RBE Sec. 15</u>
	UTM: <u>Chester Quad</u>

(back of card)

SPECIES PRESENT

TREES: Pinus ponderosa, Abies concolor

SHRUBS: Arctostaphylos patula, Ceanothus cordulatus, Ceanothus prostratus

HERBACEOUS: Grasses, flowers (Compositae)

REMARKS: Brush field with scattered pine and fir coming in. Very few old trees. Some disease in the pines. Site seems pretty good based on yearly growth on young trees.

AERIAL PHOTO #: 2 195

GROUND PHOTOS: 1-6-11 thru 13

INTERPRETATION EXERCISE -- FIELD DATA

Stratification:

Classification (Points):



1. $\frac{4-H_3C_3}{SW-4-4.2}$
2. $\frac{4-C_3B_3}{S-3-4.2}$
3. $\frac{4-C_4L_1H_1}{SE-2-4.0}$
4. $\frac{4-C_4B_2H_1}{SE-3-3.6}$
5. $\frac{2-C_2B_1L_1}{S-2-3.6}$
6. $\frac{4-H_3C_3B_2}{SW-4-4.0}$
7. $\frac{5-C_5H_2L_1}{SE-3-3.8}$
8. $\frac{4-B_4L_3C_2}{S-2-3.7}$
9. $\frac{5-Md_5}{LL-1-3.7}$
10. $\frac{5-C_5L_2}{NW-2-3.7}$

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WRAP UP SESSION

Donald Lowe

Environmental Research Institute of Michigan

I would like to take this time to be a little bit serious, and to summarize what all the other speakers have said. I think we all agree that remote sensing is a technology; it is a solution looking for a problem; we've heard that there is a users gap; we've heard that it has potential of collecting fantastic amounts of information; and we have heard that the solution to one problem just creates another problem. I think there is a lot of truth in all of these statements.

I'd like to show you three slides. If you analyze the world's history and you look at the big picture, man has made a lot of mistakes. And inevitably, all of these mistakes were made by men who really thought they were doing something good-"I'm going to create fertility or I'm going to do more to increase yield"-and each of these have resulted in some fairly disastrous things. I think everybody knows of the problem of salinity in the desert in Texas, where each time we do something, we are inevitably creating problems, such as the DDT or strontium ninety. But all our actions haven't been problems. We can look at them as being some successes maybe, and we put the maybe behind it, because we really don't know, living in this short space of time; but there have been remarkable things that man has been able to do to cope with his problems and adjust to expanding population needs. These have been quite successful.

One of the reasons NASA is pursuing the earth observations program is to recognize that we have changed the environment many times in the past and have had some disastrous results. We are going to continue to change the environment, and more important, we are probably going to increase these changes and the speed with which we can do this; in fact, we can take a mountain down in two seconds flat. It would seem that these changes are going to be progressing faster and faster and I think there is definitely a need to be able to monitor and assess our environment on a rather rapid course or else we can all exceed the recovery mechanism.

When we do something, nature has a remarkable affinity to correct our mistakes but if you do it too fast, you can't always correct for it. So then what we feed it is a big problem, we've got some small problems here and now. These small problems might be big too, such as problems of state or local land use.

I think what I would like to get across is that, today and yesterday we have purposely brought in some very good lecturers, people that can use this. Many of them are from out of state, so you perhaps might say "this doesn't apply to me, it's a little different than my problem, because of the geographical location. This fellow was working in forestry and my real interest isn't forestry, it's in rangeland management". But what we hope to accomplish with this work session is that we will at least have stimulated your thinking as to "Hey, maybe there is something in Remote Sensing, some way I can use this technology in my particular problem." That's where ERIM and MSU are hoping that we can stimulate you and assist you. Indeed, as Joe Vitale said last night, we are commissioned and funded to help people understand remote sensing and to use remote sensing. Like everything else, there's limited funds, but we do encourage you, and certainly welcome any of you who have any areas where you think remote sensing might help

you. We would like to assist you in making this a discussion, in making you actually participating in some limited manner at a particular exercise to see that you report and follow through on a successful application of remote sensing. We do have the technology, we are looking for users, there is no question about it, and if there's any way that we can help you, we'd like to.

In part of the handout we gave you is a very good description of all the RB-57 imagery that's available here in Michigan. We've had limited success with the ERTS, but believe you me, the weather has got to be better than it was last winter and we're expecting alot of ERTS data and we will be able to tap in on this, both as pictures and as computer compatible types. We will try to work with you in any way that we can to help you.

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SUMMARY

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Guests	<u>25</u>
TOTAL	83