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Remote Sensing Research and Applications in Oregon



NASA-CR-133034) FIRST YEAR PROJECTS AND
ACTIVITIES OF THE ENVIRONMENTAL REMOTE
SENSING APPLICATIONS LABORATORY (ERSAL)
Annual Progress Report, 1 Apr. (Oregon
State Univ.) 59 p HC \$5.00 CSCL 08B

N73-25420

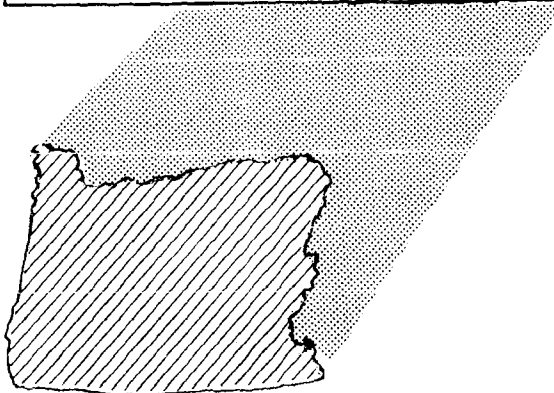
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FIRST-YEAR PROJECTS AND ACTIVITIES
OF THE
ENVIRONMENTAL REMOTE SENSING APPLICATIONS LABORATORY
(ERSAL)

BY

CHARLES E. POULTON AND DAVID P. FAULKNER



OREGON
STATE
UNIVERSITY

COORDINATED BY THE
ENVIRONMENTAL REMOTE
SENSING APPLICATIONS
LABORATORY.

REMOTE SENSING RESEARCH AND APPLICATIONS IN OREGON

Environmental Remote Sensing Applications Laboratory
Oregon State University
Corvallis, Oregon
97331

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Charles E. Poulton and David P. Faulkner

ANNUAL PROGRESS REPORT TO:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF UNIVERSITY AFFAIRS
WASHINGTON, D.C. 20546

**COLOR ILLUSTRATIONS REPRODUCED
IN BLACK AND WHITE**

For the Period
1 April 1972 through 31 March 1973
Under NASA Contract No. 38-002-053

In cooperation with State, County, and Municipal Governments, with
Councils of Government, and with Federal Agencies in the State of Oregon

SUMMARY

The Environmental Remote Sensing Applications Laboratory (ERSAL) was established at Oregon State University on 1 April 1972 with a grant from the Office of University Affairs, National Aeronautics and Space Administration. Its purpose is to engage in activities, pilot projects, and research that will effectively close the gap between state-of-the-art remote sensing technology and the potential users and beneficiaries of this technological and scientific progress. The first year of activity of ERSAL and its collaborators is reported.

The ERSAL staff works in close collaboration with state and county government, municipalities, and federal agencies in Oregon on a broad spectrum of resource and man-environment problems. A strong central thrust of the first-year program has been to support land use planning decisions with information derived from the interpretation of NASA highflight and satellite imagery.

A working relationship has been established with the Cooperative Extension Service in an information-education program that is becoming increasingly effective in stimulating use of remote sensing to solve Oregon problems. The program of extending remote sensing capability is beginning to function in both marine and terrestrial areas as a result of liaison between ERSAL and resource-oriented specialists assigned to these areas.

An effective and growing relationship has been established with the Governor's office and with three of the key, resource-oriented departments of state government. These relationships have stimulated a substantial amount of in-house application of satellite and highflight imagery to help solve problems faced by these agencies.

The collective activity is increasing awareness of all forms of remote sensing capability including standard and specialized commercial imaging capability. This is creating a potential for the future and is progressing toward achievement of ERSAL's purpose. The Laboratory is organized and functioning as a depository of NASA imagery taken over Oregon. During this report period, 105 people visited the Laboratory to consider use and application of the NASA imagery and to consult about feasibility, development of work plans, and image interpretation. These visitors represented 8 major areas of affiliation or business and 32 disciplines. Many of these visits

did result in significant use of space and highlight or other commercial imagery in problem solving.

Following are the more significant accomplishments in the report period:

ERSAL Projects --

1. Crook County Subdivision Inventory -- An inventory of activity on 35 subdivisions was made from NASA highflight. Information not otherwise available to the county was provided with only 20 manhours of actual interpretation time. This significantly influenced the local decision to call a moratorium on all new development activity until impact on the county economy could be more adequately studied. This kind of inventory has been expanded and is now being conducted for the tri-county Council of Governments area in which Crook County lies. One of these counties has so many subdivision developments they literally do not know where all of them are located without individually consulting the permit files relating thereto. This study will relate subdivision activity to impact on other land uses and resources of the area.
2. Benton County Comprehensive Plan -- From NASA highflight photography, ERSAL prepared a 1:24,000 scale uncontrolled mosaic of the county that is being most effectively used in presentation and discussion of the county's comprehensive land use plan. This mosaic serves as a data base and provides a perspective of man-environment-resource problems of the county that was never before possible within available budgets. In addition, ERSAL trained and advised county task force interpreters who made an Existing Land Use map of the county from the NASA highflight photography. In the coming year, collaboration with the Benton County Planning Commission will continue.
3. Monitoring of Field Burning -- Using ERTS-1 color reconstituted imagery, the ERSAL staff conducted a study of the feasibility of monitoring field burning progress by satellites. The inventory of burned fields derived by 3 manhours of interpretation time agreed with the official records of the Department of Environmental Quality within 3 percent.

4. Cost of Interpretation in Resource Inventory -- as an interim project before receipt of NASA imagery, we conducted a vegetational inventory of the Squaw Butte Experiment Station using techniques previously developed to determine some of the cost factors. On the basis of an approximate one township inventory, interpretation cost was 1.2 cents per acre and \$6.12 per stereo model on 1:9,600 scale black and white photography. It was 0.03 cents per acre and \$5.36 per stereo model on 1:63,360 scale black and white photography. Total cost was \$0.056 per acre and \$28.21 per full-frame stereo model for the 1:9,600 scale inventory.

Cooperative Projects --

1. Multidiscipline Land Use Planning Team -- ERSAL is cooperating with a U.S. Forest Service multidiscipline team concerned with coordinated land use and resource planning for four national forests in central Oregon. Both ERTS-1 and NASA highflight photography is being used. This project is now scheduled for completion in 1975. The project leader says availability and use of this imagery has enabled them to reduce project time by one full year and this will save \$100,000.
2. Watershed Protection and Flood Prevention -- As a result of ERSAL collaboration and guidance, the Oregon State Engineer's Office, Water Resources Department, is using NASA highflight imagery on the following projects as an information source and data base:
1) flood control planning of the Ash Creek Drainage which affects the towns of Monmouth and Dallas in Polk County; 2) low flow augmentation from secondary streams for the cranberry producers along the Coquille River in the Bandon, Oregon, area; 3) the use of ground water resources and reserves along the Tualatin River, Washington County, and 4) pollution of the ground water discharge areas of the Metolius River Basin. They are also beginning to use ERTS-1 imagery for a perspective of entire watersheds. They report that "the use of high altitude and satellite photography has decreased planning time and increased the accuracy of landform, natural and cultural area interpretation. . . . your lab appears to be a veritable 'gold mine' of resource material."

3. Timber Access Road Decision -- As a result of one of our County Agent's analyzing and presenting the perspective of timber resources in relation to two towns, the Lake County Planning Commission was able to make a quick and confident decision about a timber access road that they had been holding in limbo for some time. While this is a very minor point, it is illustrative of the value of a perspective from space.

The report also presents maps of available space and highflight imagery in Oregon and briefly explains the program and image acquisition plans for 1973-74.

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INTRODUCTION

This report covers the activities and accomplishments of the Environmental Remote Sensing Applications Laboratory (ERSAL) and its collaborators in the first year of operation. During this period ERSAL was particularly successful, in view of the problems of initial program development and implementation, in stimulating a much expanded use of remote sensing technology in the State of Oregon. Significant gains have been made in "closing the gap between the state-of-the-art technology and the ultimate users and beneficiaries of this technology."

An awareness of the Laboratory and rapport with potential users in municipal, county, and state government and in the federal agencies has been established. This is stimulating leaders in all these groups to look to remote sensing for aid in problem solving where they formerly did not consider this rapidly advancing technology. Members of these groups are now, on their own initiative, coming to the Laboratory for counseling on applications possibilities and to plan applications projects. The Laboratory is now recognized as the depository for the NASA-acquired aircraft and space imagery over the state. A broad spectrum of users examine the imagery in the Laboratory and perform initial work at ERSAL as a routine step in ordering either space or NASA aircraft imagery from the designated outlets.

A working relationship has been established with the Cooperative Extension Service in an information-education program that is becoming increasingly effective in stimulating use of remote sensing to solve Oregon problems. This program is functioning through Extension Specialists in both marine and terrestrial areas, through Land Use and Area Development Extension Specialists assigned to Councils of Government, through Rangeland Resources Extension, through a three-man Land Use Extension Specialist Team working at state level, and through the County Agent staff. These people are particularly effective in setting the stage and creating opportunities for remote sensing applications projects as well as developing local support and participation. In addition, a relationship has been established with the State Rural Development Committee and, through this group, with their local counterparts in areas of active ERSAL projects. This brings the capability of both State and Federal agencies to bear on the ERSAL program and insures a strong land use and resource problem orientation

of the program. All of these groups are extremely valuable in specifying problems and information needs as well as in performing local and state leadership roles as new projects are being conceived and planned for ERSAL participation. These relationships create an optimum situation to insure meaningful use and application of the results from all remote sensing pilot projects and research efforts.

Finally, a very effective and growing relationship has been established with the Governor's Office and his Executive Department heads through the Natural Resources Executive Assistant to the Governor, Kessler Cannon. This relationship with State Government has already resulted in stimulation of significant in-house remote sensing applications by personnel in the Office of the State Engineer on water resources and watershed problems, the State Department of Forestry on forest inventory and evaluation, and the State Highway Department on state highway planning and environmental impact assessment. In addition, ERSAL is interacting with the Coastal Conservation and Development Commission and with the Army National Guard, Mohawk Air Surveillance Unit, on matters of mutual interest.

These relationships are being built toward an effective mechanism for program coordination, interagency cooperation, program support, planning, and implementation that we expect will maximize the benefits derived from the use of remote sensing technology throughout the State of Oregon.

Policy Statements for ERSAL

The guiding policy of the Laboratory will be to achieve its goal of information transfer by stimulating a maximum level of cooperative involvement among potential users of the technology through projects and activities focused on important resource problems in the State of Oregon.

The Director of the Remote Sensing Laboratory is responsible for Laboratory projects and for the coordination of remote sensing activity in the University. The Director has an advisory committee consisting of representatives from those schools, departments, and divisions of the University that are concerned with natural resources and the Governor's Executive Assistant for Natural Resources. The chain of command is through the Oregon Agricultural Experiment Station to the Office of Vice-President for Research and Graduate Studies.

Projects in which the Laboratory is interested may be conducted by the Laboratory staff or by other participating and affiliated departments.

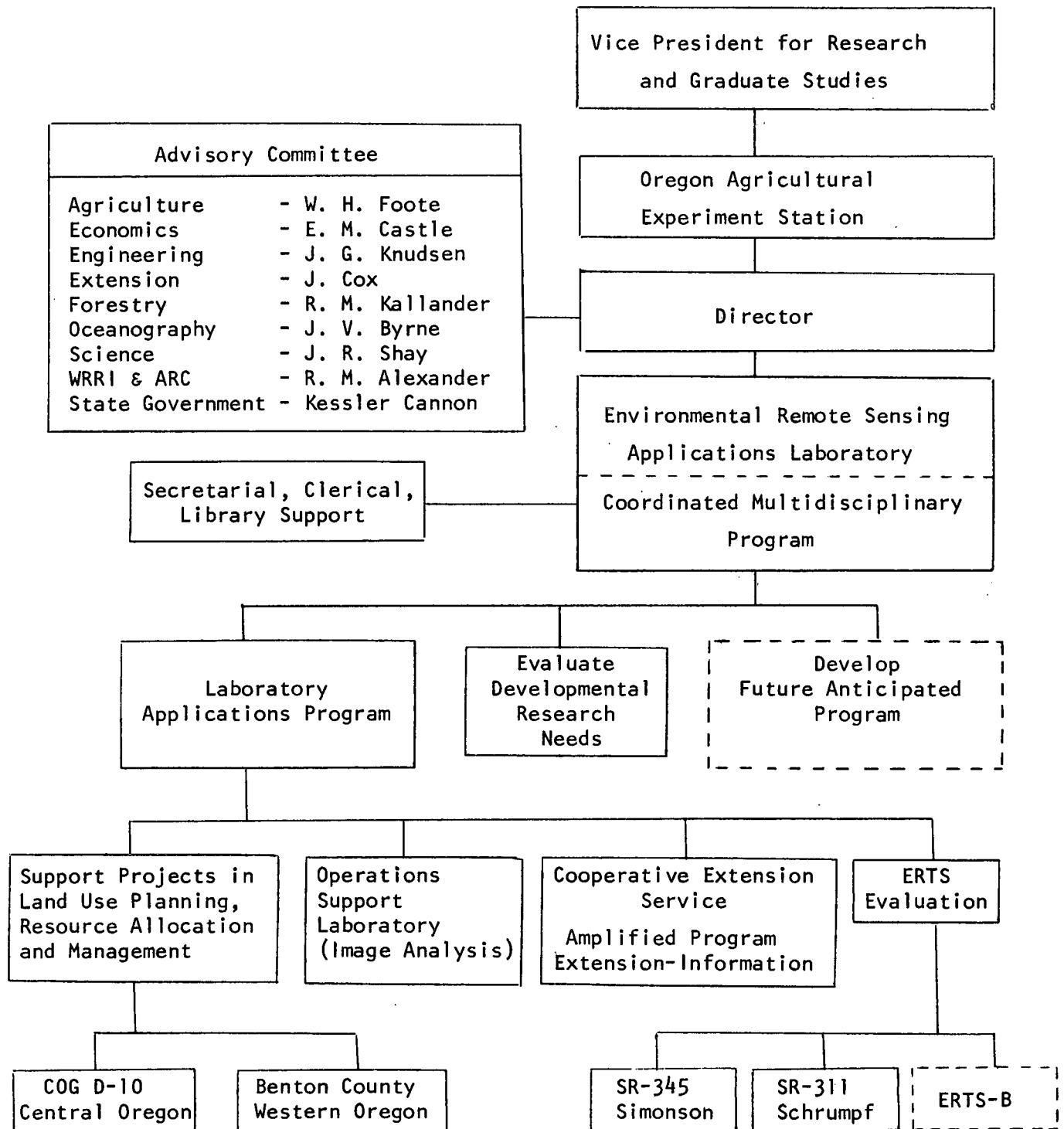
Funding for such projects would be raised directly by the Laboratory, individually by the participating department or school, or jointly by collaborative activity with the Laboratory. Funding may also be accepted from state, federal, or other grant sources. All Laboratory projects will be carefully evaluated for their contribution to the central purpose of "closing the user gap," to research and short courses that effect information transfer, and to stimulation of better use of remote sensing technology to solve natural resources and human problems. The initial organization and program of ERSAL is shown in Figure 1.

Limitations on the distribution of imagery and Laboratory project results are related only to the type of imagery involved. Where release is to government agency groups or to the general public and is consistent with attainment of ERSAL objectives, there are no constraints placed on the Laboratory by the grant from NASA. Where releases involve interpretations from Earth Resources Technology Satellite data, there is a requirement that the results be reported to NASA and released to the public through the NASA Scientific and Technical Information Facility. After public release of such information, it can be made available to all potential users without restrictions. All results of ERTS data interpretation and use will be reported to NASA through our ERTS participation project under Dr. Gerald H. Simonson, Principal Investigator.

The following policies guide the Environmental Remote Sensing Applications Laboratory (ERSAL) as it stimulates involvement of potential users in the application of remote sensing technology and encourages widespread use of data and imagery made available through the NASA Earth Resources Program.

1. With private business and industry users of the raw satellite or aircraft data, the Laboratory will function as an information source to apprise them of the availability of the imagery, of its general quality, and to advise them--to the extent time, funds, and staff availability permits--on feasibility of intended applications. The Laboratory will also assist these people in identifying useful imagery so that it may be efficiently ordered. In all cases, this class of user will be directed to the EROS Data Center, Sioux Falls, South Dakota, with the expectation that they will purchase imagery directly from that facility.

Figure 1. Organizational Plan and Functional Operations Chart for the Environmental Remote Sensing Applications Laboratory at Oregon State University



2. Government agency users (federal, state, county, and municipality) who are cooperators in approved ERSAL projects will be provided with copies of imagery available to the Laboratory--to the extent Laboratory funds and budget allocations permit--without charge and to the extent required for their collaboration.
3. Where the interested government users' intended use is consistent with the objectives of the Laboratory, but not on an established ERSAL project, copies of imagery will be made available--to the extent available funds and budget allocations permit--without cost and providing further that the user will agree in advance to file periodic reports of uses and benefits derived from the imagery for transmittal to NASA by ERSAL. Where such government users prefer not to be constrained by this reporting requirement or where their uses and objectives are divergent from those of the Laboratory, ERSAL will be as helpful to them as possible in identifying useful imagery and will provide information to facilitate ordering. These latter users will be encouraged to order through the designated imagery outlets.
4. Where users wish to pursue feasible ideas on an experimental basis and where their objectives are compatible with the purposes and objectives of ERSAL, copies of imagery will be made available in the Laboratory for the conduct of such experimental interpretations and uses. This is done with the provision that the imagery copies will be used with care and returned with a written summary of the results of the experimental use and an evaluation of the success of the experiment.

5. The Environmental Remote Sensing Applications Laboratory will work generally through a project program approved by the Director on the basis of a specific study plan. The Director may submit project proposals from outside the ERSAL staff to the Advisory Committee (Figure 1) for evaluation and recommendation. Proposals will be evaluated on the basis of their individual merit, cost in relation to available funds, competence and experience of the personnel involved, conformance to constraints dictated by the prime grantor, and contribution to the stated purposes and objectives of ERSAL.

Objectives of ERSAL

The key objective of the Environmental Remote Sensing Applications Laboratory (ERSAL) is to "close the user gap" or to stimulate and aid the application of the full scope of remote sensing technology to the solution of human, environmental, and resource problems in the State of Oregon.

To achieve this goal, the ERSAL staff and its collaborating departments are interacting with state and federal agencies, Councils of Government, Planning Commissions, county government, and urban groups with the following specific objectives in mind:

1. Identify state and local problems which remote sensing can help solve
2. Assist potential users to learn how better to use remote sensing where it is appropriate to the solution of specified problems
3. Conduct remote sensing applications programs to bring remote sensing technology to bear upon the solution of selected, high priority problems
4. Identify additional research needs to which remote sensing technology may be applied and establish priorities for meeting these needs
5. Investigate these problem areas as research funds are made available

6. Stimulate, guide, and aid the faculty and students at Oregon State University and others in the State of Oregon to utilize information from the NASA earth resources satellite and aircraft programs in research and public service activities
7. Provide a center of expertise and an operational Laboratory for short course training, assistance to departments and agencies in utilizing appropriate remote sensing technology in solving their problems, and to make certain specialized equipment available to users.

Facilities and Equipment

The Environmental Remote Sensing Applications Laboratory (ERSAL) is housed in air conditioned facilities in the basement of Withycombe Hall at Oregon State University. It has a teletype intertie with the Computer Center, three rooms and slightly over 2,000 square feet of space. Presently available equipment emphasizes human image interpretation and consists of four good mirror stereoscopes, good quality light tables both for field and laboratory use, a Zoom Transfer Scope for mapping and data transfer, a dark room and excellent photo copy facilities, and a homemade optical combiner housed with our Forestry colleagues.

We are maintaining a file of remote sensing research reports with microfilm reader, ERTS-1 data catalogs, and the complete working file of NASA aircraft and ERTS-1 imagery over Oregon.

ERSAL PROJECTS

Crook County Subdivision Inventory

Almost concurrent with the receipt of our first good metric imagery for the ERSAL project, we had a request from the County Planner in Crook County for assistance in a new subdivision inventory. He and his one-man field staff had been working since August in an attempt to document subdivision development activity (road development and housing starts) by field and ground methods. In frustration they turned to us. Fortunately, we were able to assist them by visiting the county with imagery in-hand, developing with them a list of information needs, determining which of these needs could feasibly be met by interpretation of the metric U-2 imagery and inviting them to the Laboratory to work out their data needs. The County Planner's assistant came to the Laboratory and worked with our staff for a total of 20 manhours including the time spent by our staff in consultation and joint interpretation. At the end of this period, they had obtained all of the basic information desired and had summarized same for each recreational subdivision development on a standard form we help them develop. They were able to determine miles of road constructed and numbers of housing starts or completions in each of the subdivisions and to make selected inferences relating to peripheral problems the subdivision development may have created. This activity is part of an intended ordinance in the county to enable better guidance, direction, and control of this kind of activity.

From this inventory it was determined that 35 subdivisions had been approved for development. Within these developments, over 5,000 lots are proposed. Although less than 1% of the lots show signs of housing construction, over 30% of the subdivisions show development activities mainly in road construction. Over 100 miles of new roads have been constructed within the subdivision boundaries.

It was further determined that over 50% of the subdivisions were within the recharge area for the Prineville Reservoir. Over 75% of the subdivisions are within 20 miles of the city of Prineville, and nearly 20% are within or bordering the prime agricultural lands of the county.

This survey provided the following critical information about the county that was not readily obtainable from the ground:

1. Overall view of the county
2. Up-to-date information
3. Monitoring base
4. Building construction
5. Road Construction
6. Areas not previously reported to have development activities
7. Distance from utilities and services

As a result of the inventory, the county planners have initiated studies to determine future public service requirements, present and future public highway needs, costs to county for public services, and the effects subdivisions will have on the Prineville Reservoir. The latter study has been requested of the Soil Conservation Service.

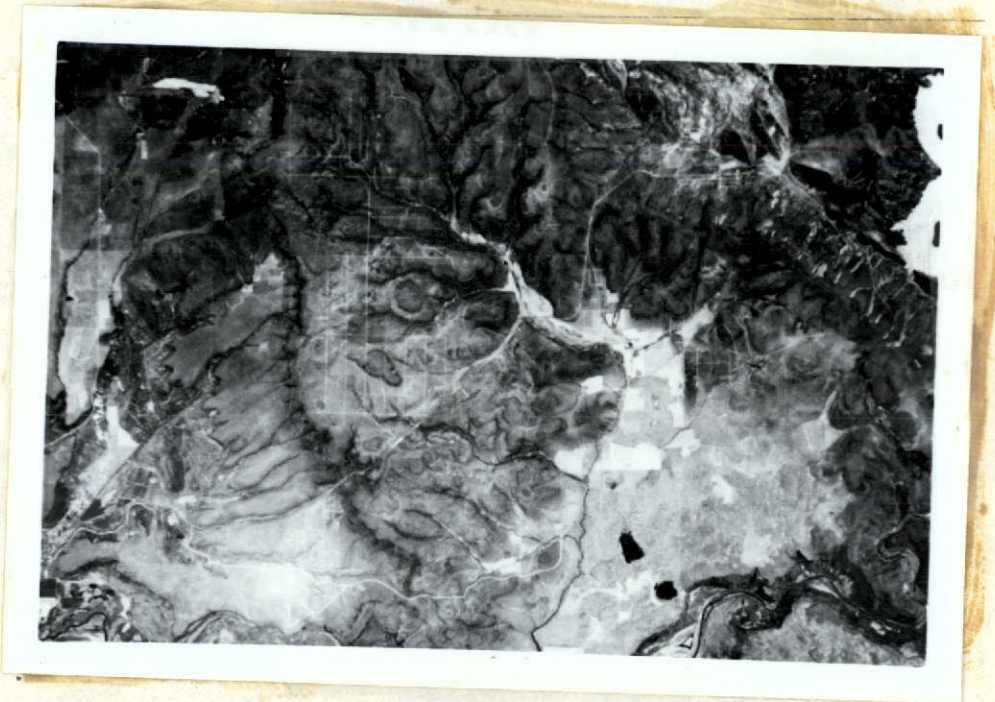
On March 23, a moratorium on new subdivisions was declared by the County Court at the request of the County Planning Commission. This ruling was made in order to give the county planners time to determine the effect subdivisions are and will be having upon the county resources. The court specifically charged the planners to determine what the ground water resources were in the areas of high subdivision activities.

The ERSAL staff is presently working on examples of photo interpretation of natural resources from NASA highflight imagery. Figure 2 is a copy of a portion of one frame from NASA Flight 72-114 taken over the Prineville/Prineville Reservoir area. The overlays in the accompanying envelope show the interpretations made by various members of the OSU multidiscipline remote sensing team. They represent interpretations of present land use, macro-relief, geology, soil landscapes, and natural vegetation. This type of information will help the planners to make their critical decisions of: "How much development does Crook County want to allow?" and, in conjunction, "Where should these subdivisions be allowed to be developed?"

Benton County Comprehensive Plan

Larry Bauer, County Planning Director, Benton County, Oregon, is facing very tight time constraints in finalizing Phase I of his land use planning program. Many task forces throughout the county have essentially completed their assignments or have provided information which the Planning Director's staff has been summarizing on conventional planimetric maps. From this information base, the objective is to develop a comprehensive land use plan

Figure 2. Copy of a portion of Frame 3200, NASA Flight 72-114, over Prineville/Prineville Reservoir area. This illustrates an area of conflict from subdivision development where rangeland and watershed values are high.



The accompanying overlays (see envelope) show the interpretations for vegetation, soils-landscapes, geology, geomorphology, and land use. This material is especially useful to county planners in guiding land use change and in planning for the future.

for the county that will lead to sound zoning regulations. These regulations will guide and control the allocation of resources and the economic development of the county.

The ERSAL staff at Oregon State University, upon receipt of NASA high-flight imagery over Benton County, approached Mr. Bauer with an offer to cooperate in Benton County planning activity. Presentations centered on the following possibilities:

1. Preparation of a county mosaic from NASA highlight to be used as a base for information accumulation throughout all three phases of planning over the next two years, and immediately for graphic display of information and program when the Phase I plan is presented to the citizens and county government for acceptance or modification.
2. The use of photo interpretation from NASA Flight 72-114 to:
 - a. Fill gaps in the present resource information base
 - b. Sharpen the quality of existing information where necessary
 - c. Specifically evaluate recreation and natural area needs, potentialities and limitations within the county. One task force, concerned with recreational potentials and needs within the county, was found to be groping for an approach to their problem.

Because the County Planning Director could see the unique value of this imagery for the graphic summarization of data and presentation in the county, a mosaic was prepared of Benton County for use in this collaborative planning.

Color copies of Flight 72-114 for Benton County were immediately provided to the Recreation Task Force to use in stereo interpretation of resource features relevant to their task. As the Laboratory began to work with this task force, it was apparent that they needed help in:

1. Techniques of photo interpretation
2. A clearer definition of information needs relevant to the recreation planning task

3. The preparation of a meaningful legend enabling them to graphically portray and express the photo-derived information, and
4. To define those components of information need that could be obtained by interpretation from Flight 72-114 photography.

The Laboratory provided the initial training for the two task force interpreters, helped them to more clearly define information needs and determine which of those could be met by image interpretation. Working from this information needs list, the Laboratory then assisted the interpretation team to devise a working interpretation legend. The Recreation Task Force used equipment and facilities of the Laboratory to do their interpretation under the guidance of the Laboratory staff. Their technical guidance on recreation planning came from the Recreation Department of the University, and their guidance in planning aspects from Benton County Planning Director, Larry Bauer. This effort very quickly grew into a better teamwork effort and Planning Director Bauer has given the following appraisal of what involvement with the NASA program and the Laboratory does and means to the success of his program.

Pursuant to our extensive discussions and review of aerial photographic materials furnished by the National Aeronautics and Space Administration, the Benton County Planning Staff has concluded that the NASA photography has a direct application to the needs of Benton County government, specifically in the area of land use planning.

The County Planning Department has established a special research team composed of professional planning staff and post-graduate students in a variety of disciplines. Your input, and the contribution of others involved in the Remote Sensing Center, has proved to be extremely relevant to our objective of developing a Comprehensive Land Use Plan for Benton County. More specifically, the aerial photography is directly applicable and beneficial in our extensive analysis of existing vegetation and land use patterns. We are now capable of identifying on a county-wide basis existing structures, roads, agricultural crop patterns, forest regions, and river channel positions--to name but a few. Prior to the availability of this photographic resource, specific data on existing land use and development patterns was only obtainable through tedious field identification. In addition to analysis of existing features, the photography will be a base for representation of data. The scale we have discussed (1 to 24000) is standard with the planimetric cadastral base series that has been developed in

the past; thus, convenient cross-referencing of data from a photographic base to a planimetric base is facilitated. Further, the mounting of an aerial mosaic of standard scale when depicted in conjunction with other planimetric renderings, presents convenient orientation for the lay citizen.

The availability of support through the application of NASA photography to local governmental needs is conservatively estimated to save the Planning Department of Benton County 2,000 man-hours and a capital outlay cost approaching \$10,000--neither of which is available to us for the completion of our comprehensive plan.

The use of [color] infrared, stereoscopic pairs in advanced analysis is currently being studied. We have identified some basic examples of direct benefit to our county economic analysis to be a part of our Comprehensive Plan - Phase II to begin in the summer of 1973. The use of infrared, stereoscopic pairs to calculate vegetation characteristics is of particular merit to local planning.

Forestry is the number one contributor to the Oregon economy. In Benton County alone, in excess of 25 million dollars a year net contribution is made annually by this natural resource; thusly, effective land use management is imperative to assure long-range community benefit. This relates to our cooperative project, through our ability by use of NASA photography, to not only identify forested regions but determine general forestry characteristics such as tree maturity, harvested areas, reforested regions, slide areas and volume in terms of board feet.

We can relate harvest to resource and determine improved public and private management policies and assist resource preservation through conscientious land use planning at the local level.

In conclusion, the applicability of NASA photographic resources to local planning needs is extensive. We intend to make a subsequent report by August 1, 1973 outlining our successes and discoveries of the relevant nature of these materials to the Association of Oregon Counties and to the Oregon Planning Directors' Association. We feel that this cooperative project is unique in our planning experience, and the benefit derived should be communicated to others.

In April, 1973, the Benton County Comprehensive Plan was formally presented to the public. It was stated by a member of the news media, "This is one of the few county plans I've ever seen greeted with applause." Mr. Bauer and his staff presented the plan on a series of cadastral maps and the mosaic of Benton County (Figures 3 and 4). These maps portrayed

Figure 3. Mosaic of Benton County, Oregon, made from enlarged prints of NASA high altitude photography. This mosaic provides a standard data base and a detailed perspective of land use, human activity, and resources.

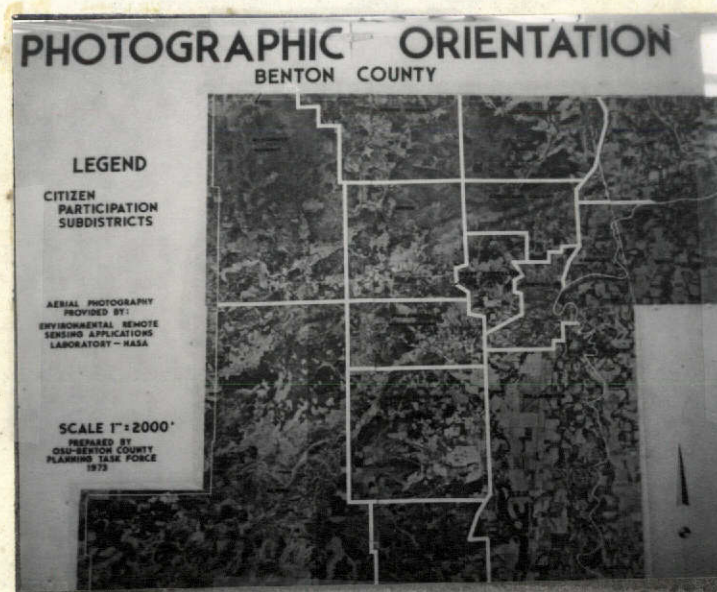


Figure 4. Current land use of Benton County, Oregon, made from interpretation of NASA high altitude, stereo photography.



land ownership, present land use, land capabilities, proposed open space plan, proposed comprehensive plan, and the proposed county zoning plan.

Mr. Bauer at this time acknowledged to the public the assistance given by the ERSAL staff and the use of NASA aircraft imagery. He further stated that the NASA imagery was especially helpful in deriving the present land use map and the open space plan.

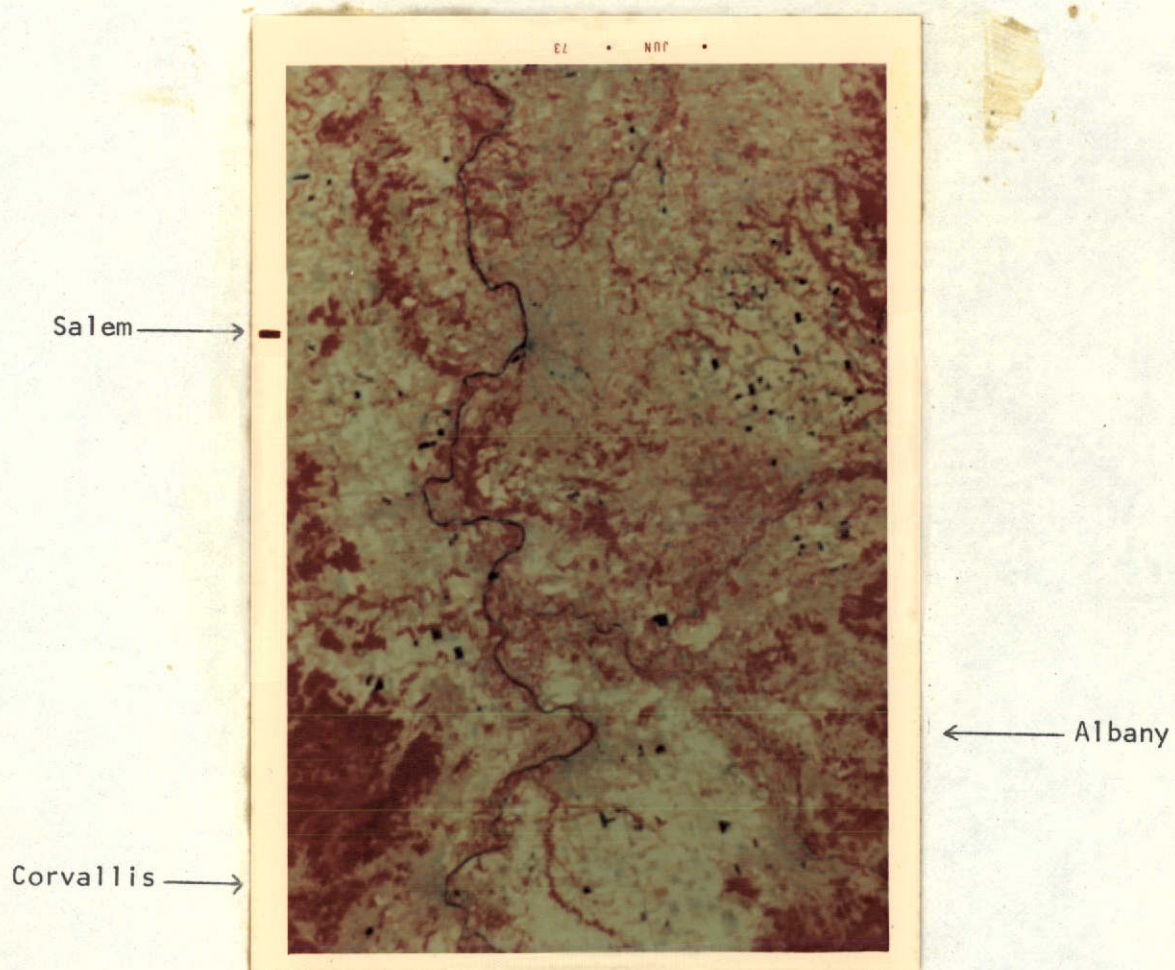
Monitoring of Field Burning from ERTS-1 Imagery

An important problem in Oregon relating to environmental quality and also of critical importance to one of Oregon's major industries, grass seed production, is the monitoring and management of post-harvest field burning as a disease control measure in rye grass seed production. On two color reconstituted frames taken of the Willamette Valley, Oregon, on 29 July 1972, we observed that all burned fields stood out in sharp contrast to other agricultural crop conditions. Since the Oregon Department of Environmental Quality (DEQ) is charged with the responsibility of supervising field burning to minimize air pollution and smog buildup that sometimes is sufficiently serious to interfere with commercial air traffic, we speculated that ERTS imagery may more economically provide information useful in monitoring the effectiveness of control programs (Figure 5).

We contacted DEQ, discussed the idea, and came to the conclusion that monitoring by ERTS would probably not replace the present day-to-day and month-to-month tabulation of burned acreages by Fire Control District. DEQ feels that this kind of short-term record is essential to their control and management of this activity. They are, however, concerned about the effectiveness of their control and burning management program as this is reflected in permit applications and approvals--these being the basis for tabulating progress in field burning. In western Oregon, cloud problems may stand in the way of complete reliance on ERTS imagery for monitoring, but it may have application in the less cloudy areas of eastern Oregon where field burning is also practiced. Thus, a comparison between burned acreage as recorded by DEQ and as measured from the above ERTS imagery was considered a worthwhile exercise as a prelude to more critical evaluation of feasibility.

The above color reconstitutions were not received in time to perform field checks, but the images were sufficiently unique to minimize the possibility of false interpretations. Copies of the burning record compiled by DEQ showed that as of 29 July 1972, 10,620 acres had been burned in the

Figure 5. A portion of ERTS scene over the Willamette Valley, Oregon, July 29, 1972. This scene shows the burned grass fields as dark blue to black in contrast to the white, unburned, harvested, or mature crop fields. Burned field acreage was inventoried within 3% from this ERTS-1 imagery.



Willamette Valley. We counted and measured the burned fields from the two ERTS frames covering the valley. The acreage determined from ERTS was 10,940 acres or 320 acres larger than the DEQ figures (+ 3.01%). Working from the 1:1,000,000 scale color reconstitutions, we were pleasantly surprised at such close agreement. Possible sources of error in such comparisons would include:

1. Acres accidentally burned or burned without approval, and thus not reported
2. Delays in approved burning beyond a designated time
3. Reservoirs and ponds of 20 acres or less that might be confused, because of their near black color, with a burned field image
4. Fence rows and field borders not measurable on the ERTS imagery and, thus, lumped into burned acreage whereas DEQ records would reflect more nearly the true field acreage.

We feel that the errors from misidentification of small ponds were eliminated in this instance by examining color IR aircraft imagery at a scale of 1:120,000 to verify questionable signatures.

The above ERTS data were tabulated in 3 manhours. The tabulation from DEQ records was not specifically determined, but it was estimated to have required 100 manhours to produce the same record. With more practice and experience, plus real-time ground checking of questionable signatures, both the speed of interpretation and accuracy of the determinations could be significantly increased.

It thus appears that for regions of minimum cloud interference, monitoring of field burning activities from ERTS could be a feasible application of the ERTS system. To be feasible in management of burning activities, however, the lag time between image acquisition and delivery would have to be cut under 18 days. As a double check on program effectiveness, on the other hand, the periodic determination of burned acreages from ERTS imagery should serve as a worthwhile cross-check against the day-to-day tabulations maintained by the Department of Environmental Quality. This would indicate areas requiring closer supervision as well as to increase the agency and

and public confidence in compliance with the air quality control program as it is demonstrated that the permitted burn acreage and the monitored acreage are, in fact, in close agreement.

Squaw Butte Resource Inventory

To take advantage of the time lag between the founding of the Remote Sensing Laboratory and the receipt of NASA imagery for our primary project area, we initiated a substitute project. This was a highly intensive photo interpretation resource analysis of the Squaw Butte Experiment Station area in southeastern Oregon. Imagery at varying scales and in both black and white and color were already available for the area. Using a multistage inventory concept, working with small scale (1:63,360) conventional photography and large scale (1:9,600) photography, we did a photo interpretation job of the vegetational and landform characteristics of the area.

The primary purpose of this exercise was to determine time and cost statistics from photo interpretation activities. Through these statistics we can better explain the benefits and savings generated through remote sensing technology.

This project was also presented at the Society for Range Management's 26th Annual Convention held in Boise, Idaho, February 4-9, 1973. This paper is included to serve as a summary of the project.

Paper Presented at SRM Convention

PROCEDURE FOR INTENSIVE ECOLOGICAL RESOURCE ANALYSIS THROUGH REMOTE SENSING

INTRODUCTION

Those concerned with managing rangeland resource areas continually face the problem of obtaining or updating information about the natural resources for which they are responsible. Demands on the resource change as human values and uses and the intensity of management change. Because of this, it will be necessary to periodically reanalyze, update, and monitor rangeland resource areas to keep the resource allocation and management decision process in step with the changing times. These activities can become very expensive in both professional manpower and dollars. It is to our advantage to seek ways of minimizing these costs.

Since about 1965, various persons in the Rangeland Resources Program at Oregon State University have been working to develop better ways of solving

these problems through remote sensing. Remote sensing is a sophisticated expression for an operations idea that dates back to the 1930's when the use of aerial photography in range surveys began. But, remote sensing implies much more than was involved in those early days when aerial photography was mainly used as a new and better "map" for the recording of information. Remote sensing implies gaining information about a subject without direct physical contact with that subject. Thus, it requires interpretation to identify subjects and conditions as well as to locate and delineate the areas in which the specified conditions exist. Our research in recent years has developed improved techniques for extracting this interpreted information.

In the past decade, many new devices and improvements in remote sensing technology have been developed, but the system that has the greatest operational utility in the natural resources setting is still vertical aerial photography viewed in stereo. Even this method has many new features--each with its special purpose or application enabling the user to learn more from the vantage point of the analyst's desk. The wide variety of choices now include high resolution panchromatic black and white photography, black and white infrared photography, color and color infrared photography, and multispectral photography. To further increase the alternatives, any of these may be used in appropriate repetitive coverage (multidate) or in multiple scales (multistage) each with its special advantages and applications.

Even though this wide variety of remote sensor systems and products is available to you, the techniques for analysis and interpretation of the imagery by human means remains fairly constant for all photographic systems. Certain of the sophisticated optical and electronic aids to interpretation are especially useful and may enable extraction of even more information. In the final analysis, however, the terminal decision on the meaning and significance of an image is made by a human being. The basic techniques of resource analysis by photo interpretation are, therefore, likely to be useful for many years to come.

The purposes of this paper are (1) to summarize some of the proven techniques and guidelines for photo interpretation as they relate to range-land resource analysis, and (2) to present some useful figures on the components of cost where one strives to maximize reliance on photo interpretation in preference to ground work. Hopefully, this will give you a better idea of where full use of remote sensing fits as a time and cost saver and as a

means of increasing the efficiency of rangeland resources inventory and monitoring.

Specifically, we are summarizing resource analysis guidelines developed primarily in research funded by the Oregon State Land Board and the Bureau of Land Management and amplified or improved on various NASA projects. We are presenting some preliminary cost figures subsequently developed as part of an applications study funded by the National Aeronautics and Space Administration and conducted by the Environmental Remote Sensing Applications Laboratory at Oregon State University. Through these projects we have been able to test and document procedures and guidelines, make some determinations of interpretation accuracy and compile preliminary statistics on unique time and cost items for intensive ecological resource analysis. We are presenting figures for two scales and intensities of resource analysis, 1:63,360 and 1:9,600. The figures on time and costs were developed from new low- and high-intensity inventories of the Squaw Butte Experiment Station in the sagebrush steppe and western juniper country of southeastern Oregon.

Because this is a relatively small area (16,000 acres), the figures are not entirely representative of a large project operation but we believe the costs associated with photo handling, delineation and interpretation are realistic and can be used as a guide in costing out these operations where done by an experienced crew.

PROCEDURES

Two scales of recent black and white photography were available for the Squaw Butte Experimental Range. The larger scale, 1:9,600, was particularly appropriate to a high intensity inventory for research planning purposes. The smaller scale, 1:63,360, was more fitting for a generalized operational survey in more extensively managed rangelands. The inventory techniques were applied using each of these scales of photography and careful records were kept of time and costs for each separate step in the operation.

The only missing ingredient, in terms of an average operational inventory, was an extended period of training such as would usually be necessary with crews assembled for a large project. Both interpreters in this instance had had previous experience with the methods used and in similar vegetations. Each knew the vegetational communities in the project area and had had some prior ground experience in the area as well.

PLANNING

As in any resource analysis program, thorough and complete planning determines the efficiency with which it is conducted and quality of the information in the final product. Planning considerations begin with the final products in mind. The first of the planning considerations are the inventory objectives and applications. Our inventory was conducted to give the Research Staff at the Squaw Butte Station an updated, high-intensity ecological resource inventory based on the closed legend principles we had developed. The principal application of this inventory will be as a research planning data base.

The next considerations concern the personnel involved. Staffing, training, and supervision should all be provided for. Questions concerning a single or multiple discipline team, experience levels desired, field and photo interpretation training, and standardizing and mapping, should be answered.

Once the staff has been selected, they should, as a team, agree on the mapping intensity and delineation standards. Since our objectives were research oriented, our mapping intensities were more detailed than those normally required for management. Some considerations are size of delineations, complexing guidelines, and definitions of inclusions.

Closely aligned with planned mapping intensity is the selection of the photography needed. The photographic scale must match the objectives and, if properly selected, will essentially determine the mapping intensity. In some cases, more than one scale may be desirable. The planning group should also determine the film and filter types desired. Here, costs and contractor capabilities may be an important factor. If color or color infrared is desired, it is important to plan on working with the photo lab to obtain the best color balance for your purposes. Even with black and white, quality standards should be specified for contrast and tone. You may find also that recent photography of acceptable scale and quality has been flown, as was our case, eliminating the need to contract a new flight.

The inventory legend requirements should also be considered at this time. An ecological approach is a multidiscipline applications approach. It is possible to describe each unique vegetation/soil system of an area that will have management implications. This should be done in developing the mapping legend.

Finally, the details of the project can be planned. Such things as equipment and space needs should be considered. It is usually possible to set up a working layout that is well-lit, free from disturbance, has reference materials and photo interpretation aids readily accessible, and is otherwise conducive to effective work. It should also be decided if photo interpretation aids are needed. They are often very helpful on larger projects, especially during training or standardization.

Scheduling work in proper sequence should also be considered.

PRELIMINARY TASKS

Prior to the actual interpretation job, there are several preparatory tasks. First, the photos must be prepared by marking principal points, conjugate points, and flight line segments for ease in stereo alignment. The photos should also be blocked to improve coordination of mapping between photos and to facilitate transferring cartographic detail to base map or mosaic.

A legend is needed for identifying units and conveying resource information. Once the legend is developed during the initial inventory, it should require only expansion and adjustment on successive inventories within the same ecological province as detail of information needs change or new types are encountered. The legend used in this resource analysis, which we strongly recommend, is a universal, hierarchically arranged closed legend describing vegetational systems on a plant sociological basis.

STANDARDIZATION

Prior to the actual mapping job, the photo interpreters must be able to standardize first their interpretation, second, application of guidelines for intensity of mapping, and, finally, criteria for delineating units to a predetermined scale and standard. This may be done by the individuals pre-typing a number of stereo pairs and then discussing and comparing the mapping jobs. Ideally, though, this standardizing should be done using a dual stereo setup so the individuals are observing the same image characteristics at the time they are discussing them. This also serves as additional training for new photo interpreters.

During the process of standardization, there should be agreement on mapping guidelines. The guidelines used are: Delineate pure types wherever possible; where complexing is necessary, each mapping unit should be limited to no more than two components; recognize that variations do occur within

both pure types and complexes; and treat units that are too small to be mapped separately and which comprise less than 10% of the mapped delineations as inclusions.

The mapping job begins by delineating the photos. This means actually placing a line at the boundary of each vegetation-soil unit at the intensity standards predetermined during the planning and standardizing phase.

At the same time as the delineations are being made, the units should be identified. This may be done by placing the appropriate legend symbol within the delineation. This procedure eliminates handling the photos twice. Identifications of delineations requires the use of all available information such as photo interpretation aids, ground truth records, past surveys, personal knowledge of the area, and research studies.

These interpretations can be placed in two categories: those in which the interpreters have a high degree of confidence and those of a low degree of confidence and for which additional field information is required. This field information is needed before the map can be finalized.

The final steps in mapping are the adjustment of the mapped units to insure continuity between photos and adjacent flight lines and the checking of mapping standards. The map is finalized when an accuracy check compares a selection of mapped units with ground truth information and interpretations are adjusted accordingly. The information on this map can next be cartographically transferred to the final base map.

FINAL PRODUCT

The final product of the inventory is preferably a photo mosaic presenting the basic information. Vegetational and interpretive overlays may be derived from this basic map. Some interpretive overlays will integrate support information such as soils, geomorphology, geology, wildlife, land use, ownership patterns, recreation, and climate. These furnish the information basic in making management decisions.

TIME/COST STATISTICS

Our main reason for keeping detailed cost records on aerial photo interpretation is to enable easier and more accurate estimates of direct cost in new project estimating, budgeting, and staffing. It is desirable to present the costs in a manner that compensates for the impact of varying scales and mapping intensity.

In this project, manhour time records were kept according to task as shown in Table 1.

For this 16,000 acre test area, planning sessions totaled 19 hours, 20 minutes. Time necessary for planning will vary with size of project, complexity of the inventory team, similarity of this project to previous inventories, and objectives of the inventory. Preparation time, which included ordering photos, setting up photo interpretation stations and blocking photos, was 17 hours, 19 minutes. The preparation time is nearly constant for all projects and depends mainly on the number of photos used.

The next task, preparation for interpretation, required 45 hours and 18 minutes. Of this time, 19½ hours was spent in legend development and 25 hours, 48 minutes in standardizations between the interpretation team members. The legend development time is highly variable depending upon the complexity and variations of the area being inventoried and degree of inventory intensity in comparison to previous inventories. Time required for standardization is also highly variable depending upon the size of the project and crew, experience, complexity of the landscape and intensity of the inventory.

The final task is mapping which required 105 hours, 53 minutes. Forty-eight hours and thirty-eight minutes of this time was used in delineation and identification. This time is variable from photo to photo depending upon complexity and intensity, but on the whole the average time spent per frame is fairly uniform regardless of scale because the mapping intensity is adjusted accordingly. The adjustment of types required 15 hours, 15 minutes and varies with the number of mapped photos and with the complexity of the mapping. Ground truth accuracy checks, 12 hours, will vary with the size of the project, crew experience, sample selection, and ground accessibility. The cartographic time, 30 hours, will vary directly with the size of the project and complexity of the mapping as well as the scale differences between the photos and base.

The total manhours required for this project was 187 hours, 50 minutes, or in mandays, 23 days, 3 hours, 50 minutes. Although this particular project was a more intense inventory and at larger scale than may be required by most, we feel the times involved are fairly typical.

Table 1. Manhour Time Records

PREPARATION FOR INTERPRETATION:

LEGEND DEVELOPMENT	19 HRS	30 MIN	
STANDARDIZATION	25 HRS	48 MIN	
SUB-TOTAL	45 HRS	18 MIN	

MAPPING:

DELINEATION & IDENTIFICATION	48 HRS	38 MIN	
ADJUSTMENT OF TYPES	15 HRS	15 MIN	
GROUND TRUTH ACCURACY CHECKS	12 HRS	00 MIN	
CARTOGRAPHIC	30 HRS	00 MIN	
SUB-TOTAL	105 HRS	53 MIN	

ORGANIZATION:

PLANNING	19 HRS	20 MIN	
PREPARATION	17 HRS	19 MIN	
SUB-TOTAL	36 HRS	39 MIN	
TOTAL	187 HRS	50 MIN	

TOTAL MAN/DAYS: 23 DAYS, 3 HRS, 50 MIN

The cost of this project based on supply and materials costs and typical estimated salaries commensurate with the task, totaled \$902.79 (See Table 2).

In summary (Table 3), the total costs are expressed in cost per acre and cost per stereo model. If one assumes that project planning includes the selection of scales of photography that match the inventory intensity as required by project objective, then expressing costs on a stereo model basis may be the best way to summarize the information.

Comparing the costs of inventory using the two scales of photography, only the interpretation time and cost were used. Due to the size of the inventory, only one stereo model was required for the 1:63,360 scale, therefore, the organization and preparation times were not realistic. The comparison in Table 4 of the cost per stereo model is the more realistic, as the cost per acre is a function of information content.

The cost of interpretive overlays for management information needs are not a part of basic resource inventory cost. Also, cost of integrating related support information for more detailed interpretations are not charged to basic resource inventory.

SUMMARY

Until just a few years ago, range men accepted photography that others had left over as their working material. Largely for this reason, the range man has not always been able to fully exploit photo interpretation technology. Since these days are rapidly passing and the range man can now specify a photographic system to meet his needs, two important questions are: "How do you go at it?" and "What does it cost?" This paper has attempted to answer some of these questions and to provide guidelines for estimating some of the direct costs of photo interpretation.

The approaches to learning photo interpretation vary as to detail, depending on the size of the inventory project, but the basic steps are the same for all systems.

- (1) Make sure that the remote sensing system is matched to the task at hand and that only the highest quality imagery is used.

- (2) There is no substitute in photo interpretation for knowing what to expect. Local ground familiarity is essential, but it can be restricted

Table 2. Costs

MATERIALS & SUPPLIES	\$ 74.50
ESTIMATED SALARIES	\$ 828.29
TOTAL	\$ 902.79

Table 3. Cost Summary

\$.056 PER ACRE
\$28.21 PER STEREO MODEL

Table 4. Interpretation Time and Cost

<u>SCALE AND INTENSITY</u>	<u>PER ACRE</u>	<u>PER STEREO MODEL</u>
1:9,600	1.2 CENTS	\$ 6.12
1:63,360	.03 CENTS	\$ 5.36

to well-chosen and representative ground locations typical of each kind of image encountered in the project area.

(3) Develop an understanding of subject-image relationships and of the differentiating image characteristics by studying sample image areas on the ground and from a low-flying aircraft with imagery in-hand.

(4) Always use stereo viewing when doing image interpretation and be especially aware of associated evidences that aid the identification decision--such things as relief relationships, indications of stoniness, geographic or geometric relationships within and among image areas.

(5) As this knowledge is developed, it is worthwhile, especially on large projects, to develop a set of stereograms illustrative of the subjects of interest. These should be accompanied by narrative pointing out the discriminating characteristics and associated or convergent evidence contributing to a right decision as well as to list subjects with which each illustrated image is most likely to be confused.

With experience gained in these areas, the operational inventory should strive to extract the highest possible amount of information by interpretive techniques--leaving only the intricate detail, the doubtful interpretations, and the non-imaged subject features for determination by ground examination in a sub-sampling mode.

Given the ability to apply these techniques, the next question is, "What does it cost?" Based on one small operational survey conducted with two scales of photography and at a high mapping intensity, manhour and dollar cost figures are presented. They are broken down by operational functions as cost per acre, 5.6¢, and cost per stereo model, \$28.21. It is hoped that these figures will be useful in planning and budgeting other resource inventory projects.

In application, one should be able to count the number of stereo models to be analyzed in a project area, consider the relative complexity of the landscapes, and select a projected cost level based on our results to estimate and budget for the photo preparation, and image interpretation functions.

When you have a resource inventory, analysis, or monitoring task to perform, it is our hope that we will have encouraged you to obtain the specific kind of photography that will do your job best, insist on

top-quality working material, and then proceed always to obtain a maximum of information by interpretation. This will reduce the very high cost of ground work, increase the quality and timeliness of the information upon which your resource management decisions are based, and give you more time for the really important job of decision making and management.

COOPERATIVE PROJECTS

The primary purpose of the Laboratory is to engage in activities that will close the "user gap" between the scientific research community and potential users of remote sensing technology. Specifically, this has been stated in the Laboratory proposal in four objectives:

1. Identify state and local problems which remote sensing can help solve.
2. Assist potential users to learn how better to use remote sensing where it is appropriate to the solution of specified problems.
6. Stimulate, guide, and aid the faculty and students at O.S.U. and others in the State of Oregon to utilize information from the NASA earth resources satellite and aircraft programs in research and public service activities.
7. Provide a center of expertise and an operational laboratory for short course training, assistance to departments and agencies in utilizing appropriate remote sensing technology in solving their problems, and to make certain specialized equipment available to users.

During the past year we have had the opportunity to interact with many interested individuals and organizations. Some came merely out of curiosity as to what remote sensing is all about. Others had problems that could not directly be solved with the aid of remote sensing techniques. Still others came seeking information, sources of imagery, or explanations of remote sensing applications. All of these groups we were able to assist by communicating with them about their problems, analyzing their needs, providing desired references or explanations, and encouraging them in their search for information or problem solutions.

There were, however, other visitors to the Laboratory that more appropriately fit the criteria of "potential user." With many of these visitors we were able to identify areas in which the Laboratory, its staff, NASA imagery (both ERTS and highflight), and remote sensing techniques could be of direct, immediate assistance in the solution of their problems. The

purpose of this section is to report some of these cooperative projects, the problems, their solution, and value of ERSAL/NASA involvement.

Multidiscipline Land Use Planning Team

Through the ERSAL facilities, the Multidiscipline Planning Team of the Ochoco National Forest was able to obtain imagery, both ERTS imagery and support high altitude aircraft photography, over their planning area. James W. Pierce, the Planning Team Coordinator, summarized the uses of the imagery and its value in the following:

The Ochoco National Forest Planning Team is utilizing the 1:1,000,000 imagery to produce 1:250,000 composites in both black and white and [color] infrared. This imagery plus the U-2 1:125,000 will provide us with a three level planning base upon which to predict capability and suitability for forest resource allocation.

Our land use planning is based on land type delineations. Specifically, we are using aerial photographs at varying scales as a series of filters to see land characteristics for identification of these units of land. The following is an example of this process.

- A. Using 1:1,000,000 black/white and infrared ERTS imagery, we were able to view land characteristics of the Blue Mountain, High Cascade and Harney Lava Provinces. The Ochoco National Forest lands were viewed in relation to these provinces to delineate land types we could see at the 1:1,000,000 scale. The Crooked River Planning Unit was one land type delineated because of its distinct dendritic drainages. We were able to see this drainage pattern due to the high vegetation density in the draws contrasted by low vegetation on the ridges and benches. The planning unit is a dominant south aspect found in transition between the Harney Lava and Blue Mountain Provinces. It is basically the Columbia River Basalt flow within the Ochoco Mountains.
- B. 1:250,000 black/white and infrared 30" x 30" blowups of the ERTS imagery were used to clarify the relationships described earlier and to further break down the planning units into smaller land types. We delineated 6 land types based on the following descriptions:
 1. Alluvium deposit in a high plateau basin
 2. Scattered dendritic dissections (20-40% of the area) on a predominant south slope with gentle topography (0-20% slope). Scab flats, few deep draws with widely spaced narrow stringers of timber.

3. Moderately dense dendritic dissections (40-70% of the area) throughout this moderately steep (20-35% slope) south slope. Many deep draws, narrow scabflats, and tree stringers.
 4. High elevation plateau crest with rough, broken topography in high relief. Subalpine openings are common.
 5. Very dense dendritic dissections (70%+ of the area) with well developed deep draws and narrow to rounded ridges. Many scattered small scabflats. Stringer pattern of vegetation is not common.
 6. Looks like unit #1 but is found lower in elevation. It is a meadow land mixed with gently sloping remnant basalt plateaus.
- C. The land type delineations are verified using 1:125,000 [color] infrared imagery obtained from NASA flight 72-114. The delineations are first approximations ONLY, which will be modified or verified through our field work. These land types serve as our basic analysis units for computerized simulation of lands response to management alternatives.

We hope to have our project completed in F.Y. 1975, about a year ahead of the original target date, because of the availability of this imagery. This is an approximate \$100,000 savings.

Watershed Protection and Flood Prevention

Personnel from the Oregon State Engineer's Office, Water Resources Department, were able to utilize NASA imagery on several of their projects. The projects were: 1) flood control planning of the Ash Creek Drainage which affects the towns of Monmouth and Dallas in Polk County; 2) low flow augmentation from secondary streams for the cranberry producers along the Coquille River in the Bandon area; 3) the use of the ground water resources and reserves along the Tualatin River, Washington County; and 4) pollution of the ground water discharge areas of the Metolius River Basin. Samuel R. Allison, Engineer-Geologist, sent us the following report on their use of satellite and high altitude photography:

Public Law 566 - 83rd Congress, known as the Watershed Protection and Flood Prevention Act, authorizes the Secretary of Agriculture to cooperate with state and local agencies in the planning and carrying out of works of improvement for flood protection and agricultural uses of surface water.

Since 1965, the State Engineer has engaged in watershed planning work in order to reduce the number of unattended P.L. 566 applications and to provide help for urban and rural groups interested in conserving their land and water resources.

Aerial photographs, in conjunction with U.S.G.S. Quadrangle maps, provide invaluable aid in developing watershed protection and utilization plans. Both high altitude and low altitude photographs are used in the planning process. Low altitude photographs are used to delineate and plot the topography of individual damsites, existing works of man, diversion and distribution systems, and other items of limited areal extent.

An accurate view of an entire watershed is possible only through use of [NASA] high altitude photography. The Watershed Planning Division of the Oregon State Engineer's Office, in cooperation with the Environmental Remote Sensing Applications Laboratory, Oregon State University, has been utilizing high altitude U-2 photography and E.R.T.S.-1 satellite imagery to derive a wide range of data necessary for an overall watershed investigation.

Several items and watersheds for which high altitude photography and satellite imagery have been used are as follows:

1. Regional Overview - An entire small watershed such as Ash Creek in Polk County, can be delineated on a single 9" x 9" U-2 frame. An enlargement of a frame enables us to establish drainage patterns, drainage areas of tributaries, and possible reservoir sites. Regional geologic patterns not discernible on photographs and maps of smaller areal extent can be distinguished. As a result, much time and money usually spent in field work can be saved.
2. Distortion Reduced - An enlargement of a single high altitude photograph can be made with less distortion [relief displacement] than is possible with a photo-mosaic from low-level flights. A single high altitude print is much less expensive and time consuming than a specially-flown low-level photo mosaic.
3. Land Use - Land use patterns and areas of native vegetation can readily be distinguished on an aerial photograph. Crops and cropping patterns, reservoirs, roads, rural and urban developments can easily be identified and tabulated. As the population of Oregon continues to increase, proper land use and zoning are becoming increasingly important. High altitude photography allows rapid and accurate delineation of patterns that otherwise would require several field personnel and considerable time. (This was the case for both the Ash Creek Watershed, Polk County, and the Bandon area, Coos County.)

4. Public Presentations - Enlargements from both U-2 photographs and E.R.T.S.-1 imagery have been used in public meetings with favorable results. Participants at the meetings seem much more able to distinguish natural and man-made patterns on the photographs than on maps. As a result, they participate more freely in the meeting discussions (Tualatin River Basin Public Hearing, Washington County).
5. Map Scale Flexibility - E.R.T.S.-1 imagery has been enlarged to 1:250,000 to match Army Map Service topographic maps. U-2 photographs have been enlarged to match scales on existing 30, 15, and 7½ minute topographic maps, and geologic maps. The enlargements were made by the Oregon State Highway Division's photo lab for the State Engineer's Office.

In short, the use of high altitude and satellite photography has decreased planning time and increased the accuracy of land form, natural and cultural area interpretation.

H. R. Sweet, Hydrologist, summarized the value of high altitude photography in analyzing the Metolius River Basin in the following letter:

We have completed our report to the Department of Environmental Quality and the State Health Division. I would like to thank you for your assistance.

With the aid of your E.R.S.A.L. input, we were able to add supportive evidence to our contention that selected areas within the upper Metolius River Basin receive relatively greater volumes of ground water discharge. These areas include not only the ubiquitous springs in the area but also the buried remanent stream channels of the glacial outwash plain. I must say that I was amazed at the high quality of the NASA infrared photos.

I am looking forward to working with you and your most cooperative staff in the future. Your lab appears to be a veritable "gold mine" of resource material.

On reporting on their use of a single enlargement of a U-2 frame over the Tualatin River-Beaverton-Hillsboro area, James W. Carver, Jr., the Deputy State Engineer stated:

This area is an area in which the groundwater table is declining. Public meetings and hearings are presently underway to determine whether this should be declared a critically short groundwater area.

With this print we are now able to determine urbanization, land use patterns, directions of present urban growth and probable expansion, and stream channels, both present and abandoned.

This map will also be very useful at the public hearings. It will give the citizens in attendance a frame of reference, and will allow them to pinpoint the trouble spots.

Timber Access Road Decision

In Lake County, Oregon, there are two widely separated communities, the economy of which is prominently tied to forest production that supports one major sawmill in each community. The range livestock industry is second in importance. These communities are Bly, in the south, and Paisley, in the north. Bly has the larger sawmill.

For a number of years, the U.S. Forest Service has intended to build a new timber access and market road to move logs from the north end of the county to the Bly sawmill. There has been considerable pressure to do this, but it could not be done without concurrence of the County Commissioners. While statistics on timber supplies were available and each National Forest had good planimetric maps of timber resources, no map was available to show the resources of this large county in perspective. Timber type and supply maps were at large scale required for management. From no available source was a clear perspective of timber supply and location in respect to these two communities' mill capacity and product flow to retail outlets available. The County Commissioners felt themselves unable to see the problem in a perspective that would permit a confident decision. Assessment of impact of the proposed road on the Paisley community was not possible.

When ERTS-1 imagery of Lake and Klamath Counties became available (all on a single frame), the County Agricultural Agent, a well-qualified and experienced photo interpreter, requested prints of red-band imagery. They were immediately supplied by the Remote Sensing Lab (ERSAL) at Oregon State University.

With this image in hand, the County Agent discussed the problem with key County Commissioners. He made some broad interpretations of forest types and rangelands in relation to these two communities, marked the locations of the towns, indicated the existing major road systems, and sketched the approximate proposed road location on the space photo (Figure 6). They then briefly discussed some of the available statistics and the economies of the two towns in this perspective. It was immediately apparent that the ERTS-1 imagery had given them the best overview of the problem they had yet

obtained and they were able, quickly, to reach a decision that all now feel is best for the total county economy.

The decision was not to build the road. It became obvious that the new road would drain an unacceptable amount of timber from the Paisley community. This relationship became clear because the ERTS:

1. Provided the necessary synoptic view of the resources, milling, and market centers and made the allocation of timber resources visually evident
2. Gave a photographic image of the situation to which the Commissioners could more effectively relate, and
3. Provided a base on which to organize available data in relation to the specific decision.

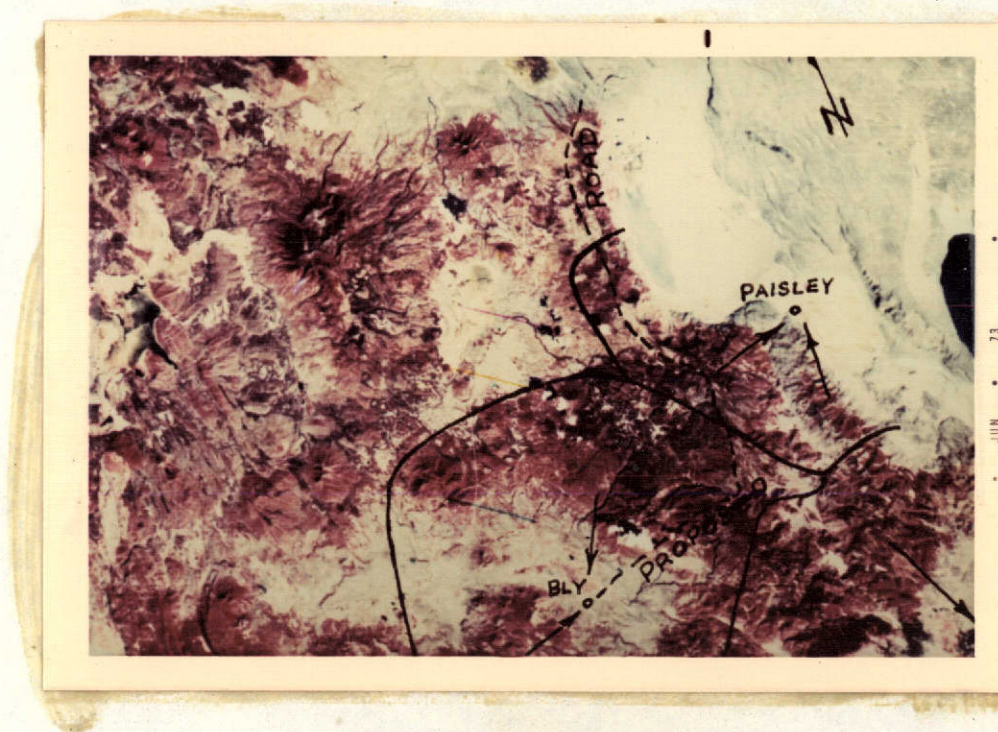
The County Agent's retrospective evaluation is that the decision could have gone the wrong way in the absence of ERTS and that the decision was easily and confidently made as soon as perspective from ERTS was explained and related to the problem.

Small as this contribution may seem, County Agent Isley says this is only the beginning of the substantial ways interpretations of ERTS and related highflight data will help county-level decisions in the future.

In follow-on conversations with the County Agent, he anticipates another beneficial use of ERTS imagery in connection with an environmental impact statement about range improvement in his county. Doing this one satisfactorily will be dependent upon receiving green season ERTS imagery in color reconstitution for the county. Through a cooperative county program, they are planning to develop 100,000 acres of seeded rangeland for winter range by domestic livestock. This new approach to animal management in this area will greatly reduce wintering costs and help significantly to widen the profit margin for the livestock industry. Livestock is the prime industry in Lake County. One of the initial questions is where should segments of this range development program be located in relation to ranching headquarters, snow cover, critical wildlife ranges, and other considerations. From the work he has done on the above problem, County Agent Isley is firmly convinced that he can answer these questions better from spring season ERTS imagery than in any other way. In addition, when these proposed developments are plotted on 1:1,000,000 or 1:250,000 ERTS enlargements, he feels that he

will have one of the best possible ways to answer the environmental extremists who become alarmed about changing natural vegetation. This perspective will clearly show the insignificant county-wide impact of 100-200,000 acres of improved rangeland scattered judiciously through the 5,800,000 acre area of the county. Isley contemplates making candidate area selections for this improvement program from the ERTS imagery and then making detailed site evaluations and final selection by the use of conventional aerial photography.

Figure 6. Timber access road construction.



This photograph shows the way in which ERTS-1 imagery brought about a major road construction decision in Lake County, Oregon. The red areas in this frame are largely forest vegetation, predominantly in the ponderosa pine zone of south central Oregon. The blue-gray areas are sagebrush steppe, and the near white to creamy areas are playas and generally somewhat saline shrubby vegetation types with little ground cover. The two towns in question, Paisley and Bly, are labelled on the north and south, respectively. The heavy black lines define the portion of the forest resource that supply sawmills at three major locations. The arrows indicate raw timber movement from these forest compartments respectively to the sawmills in Paisley, Bly, and Lakeview, Oregon. The heavy dashed line shows the approximate location of a proposed timber access road that has been under consideration for a long time. Its purpose would be to funnel a larger timber supply into the Bly sawmill.

It is quite obvious from consideration of the factors portrayed on this illustration, that construction of the road would draw substantial amounts of timber away from the Paisley mill. After viewing this relationship as graphically portrayed here, the County Commissioners decided that construction of this new road was not in the best total interest of the county economy and that it would have very strong adverse effect on the economy of Paisley.

GENERAL SERVICES ACTIVITIES

In keeping with the purposes of the Laboratory, two objectives were stated to help guide us in setting up general services and information activities. These objectives are:

1. Assist potential users to learn how better to use remote sensing where it is appropriate to the solution of specified problems.
2. Provide a center of expertise and an operational laboratory for short course training, assistance to departments and agencies in utilizing appropriate remote sensing technology in solving their problems, and to make certain specialized equipment available to users.

The reaction and appreciation of most of the visitors to our facilities has shown that these were very timely objectives. Table 5 shows the kinds of visitations we did receive between 1 September 1972 and 1 April 1973.

The educational institutions represented were Oregon State University, University of Oregon, Portland State University, Treasure Valley Community College, and Crescent Valley High School. State agencies included the State Engineer's Office, State Department of Forestry, Highway Department, House of Representatives, Army National Guard, the Division of State Lands, and the Oregon Coastal Conservation and Development Commission. Visitors from federal agencies came from the U.S. Forest Service, Environmental Protection Agency, Bureau of Indian Affairs, U.S. Bureau of Mines, and the Agricultural Stabilization and Conservation Service. Private industry sent representatives from a lumber company, an architectural firm, a consulting firm, and private citizens.

The majority of the visitors were seeking information concerning satellite and high altitude coverage over specific geographical areas. Our policy is to show them the imagery available, assist and advise in the determination of feasible applications, and then refer them to either the USGS EROS Data Center or the ASCS Western Aerial Photographic Laboratory.

Some of the visitors had problems that were in keeping with the main objectives of the Laboratory. We have attempted to cooperate with them through providing imagery, serving as advisors, training their personnel,

Table 5. Analysis of Visitors to the Environmental Remote Sensing Applications Laboratory

AFFILIATION DISCIPLINE	EDUCATIONAL INSTITUTIONS	EXTENSION SERVICE	STATE AGENCY	FEDERAL AGENCY	CITY OR COUNTY AGENCY	PRIVATE INDUSTRY	UNCLASSIFIED	NON-U.S.	TOTALS
Range	4			3					7
Forestry	2	2	6	2		2			14
Agriculture		2							2
Geology	5		1	1			1		8
Geography	8								8
Oceanography	2	1							3
Soils	3		1	1					5
Wildlife	2								2
Entomology		1		1					2
Hydrology			1	3					4
Engineering	3		2	3		1			9
Snow Survey	2								2
County Planning		1	1		10				12
City Planning					2				2
Highway Planning			2						2
Coastal Planning					1				1
Land Use Planning	1			2		1	1	2	7
Pollution				3					3
Politics			1						1
Military	1		1						2
County Extension		6							6
Law Enforcement					2				2
Teaching	1								1
TOTALS	34	13	16	19	15	4	2	2	105

providing working facilities and materials, and providing some remote sensing expertise. Some of these projects are summarized in Section 4 of this report.

With the first receipt of NASA imagery, we found it desirable to devise a filing system that would enable Laboratory staff, cooperative investigators, and visitors to readily find the desired scenes. We further found it necessary to have separate filing systems for ERTS data, support highflight aircraft data, and other satellite imagery. Both of these accessioning and filing systems are now working effectively.

With the ERTS data we started by plotting the centers of each of the initial scenes received. We then assigned each scene a place name suggested by a geographic location at the scene center. Next, each of the orbit paths were assigned an alpha symbol starting with the westernmost path over Oregon. Figure 7 shows these paths with their alpha symbol and the scene place names for Oregon. Scene repeatability is close enough to permit designation by place name.

Within the files, the imagery was filed first by orbit path; secondly by location (north to south) along that path and designated by scene name; thirdly by spectral band; and, finally, by date. We found it also helpful to separate the types of products--70 mm, 9x9 transparencies, prints, negatives, and color reconstitutions.

We further developed a reference index that shows the dates, numbers, types and quality of imagery received. These are in both map and tabular form. Examples of each of these are found in Figures 8 and 9.

The support aircraft imagery has also been indexed and filed for easy access. The enclosed map (Figure 10) shows the coverage of all NASA high-flight over Oregon that has been received and indexed at ERSAL. Since the majority of this film is in transparencies, we have established an open-shelf file for the canisters. Each canister and enclosed reel of film is labeled with flight number, accession number, date of flight, and geographical location of coverage. Where more than one spectral band, accession number, or flight occurs on a reel, they are arranged in chronological order by accession number.

Transparency frames receiving high frequency use are reproduced as paper positive contact prints in multiple copies as needed. Some transparency frames are individually mounted in special transparent protective covers for easier viewing and use.

Figure 7. KEY TO ERTS COVERAGE FOR THE STATE OF OREGON

Showing ground traces and their designators, photocenter symbolization, and frame names.

43

ILLWACO LONGVIEW

A

17 Aug. 72

HOOD RIVER ARLINGTON

PENDLETON

LEWISTON

GRANGEVILLE

CORVALLIS

MT. JEFFERSON

OCHOCO

JOHN DAY

BAKER

ONTARIO

COOS BAY

CRATER LAKE

FT. ROCK

WAGONTIRE

JUNTURA

JORDAN VALLEY

B

CRESCENT CITY

16 Aug. 72

C

15 Aug. 72

D

14 Aug. 72

MODOC MODOC

13 Aug. 72

E

12 Aug. 72

F

ALVORD L.

HUMBOLDT

11 Aug. 72

G

OROVADA

10 Aug. 72

H

HUMBOLT R.

MT. HOME

TWIN FALLS

CASSIA

MINIDOKA

GOODING

ELMORE

BLAINE

BOISE

IDAHO CITY

PAIDETTE

WASHINGTON

WENNER

HUNTINGTON

BOYER

NEW MEADOWS

ADAMS

MC CALL

STANLEY

LEMO

SEBASTIAN

WAGONTIRE

JOHN DAY

BAKER

PENDLETON

LEWISTON

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ARLINGTON

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GRANGEVILLE

ARLINGTON

HOOD RIVER

LONGVIEW

ILLWACO

COOS BAY

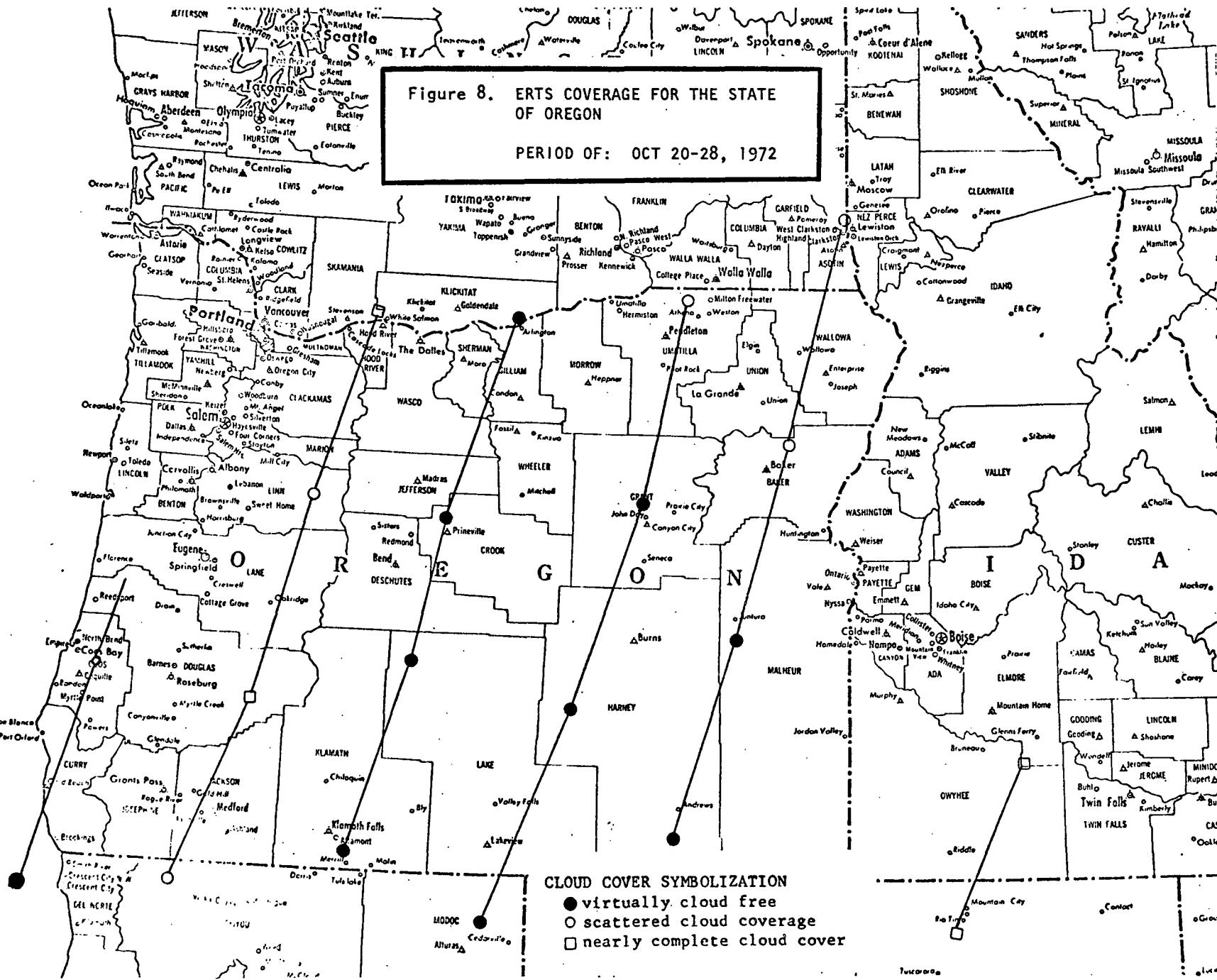
CRATER LAKE

Figure 8. ERTS COVERAGE FOR THE STATE OF OREGON

PERIOD OF: OCT 20-28, 1972

CLOUD COVER SYMBOLIZATION

- virtually cloud free
- scattered cloud coverage
- nearly complete cloud cover



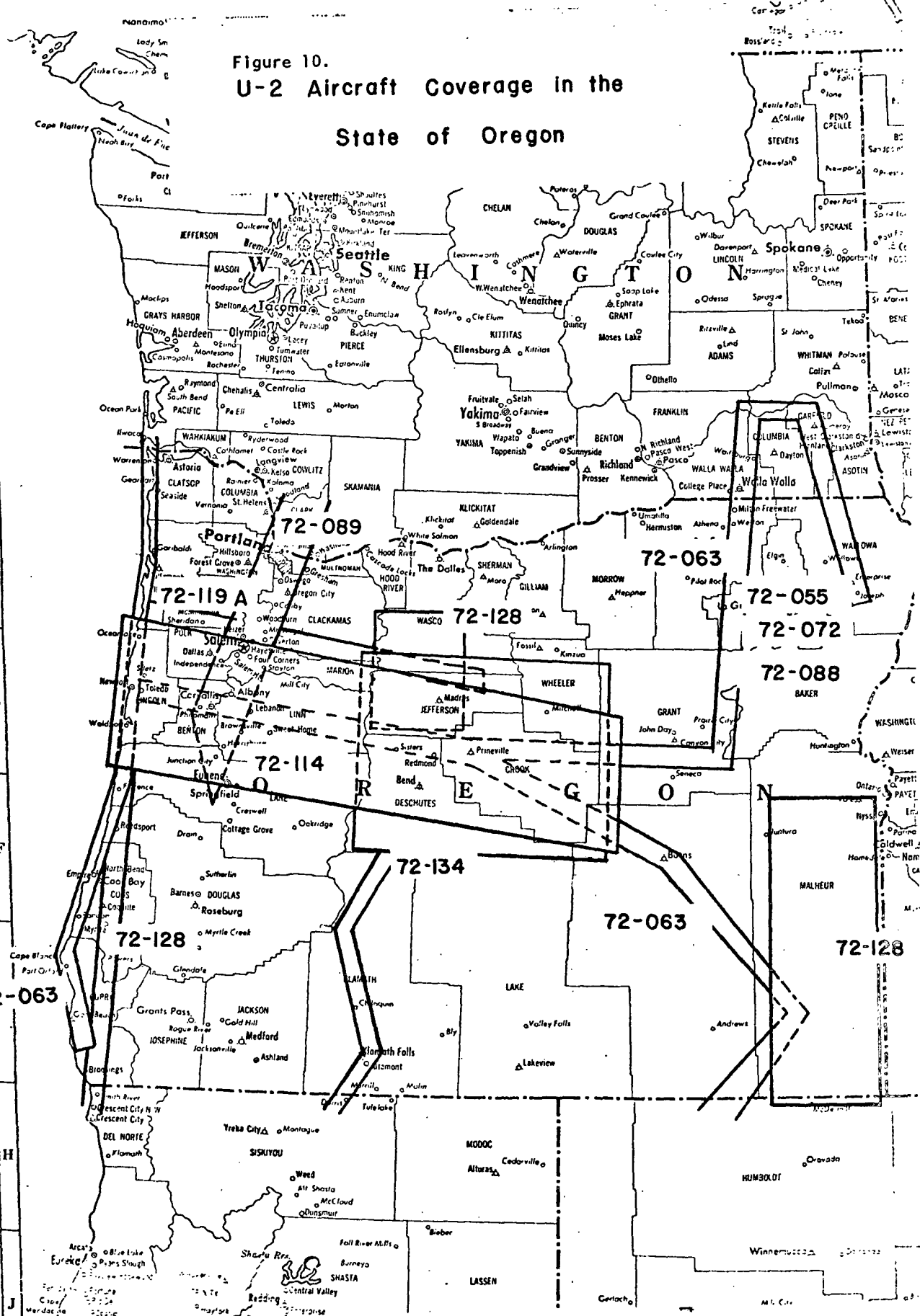
ERTS 1 CATALOGUE OF IMAGERY RECEIVED

AREA NAME OR NUMBER

GROUND TRACE D

45

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z
72



PROPOSED AND ONGOING PROJECTS

The program of the Laboratory was reviewed with Dr. Joseph A. Vitale, NASA Headquarters, University Affairs Office, in February 1973. New guidelines for the ERSAL program were provided and a series of local conferences were held to identify high priority projects in conformity with these guidelines. Conferences with local government groups in Central Oregon have identified the following two project areas on which the ERSAL program will initially concentrate effort in 1973-74:

1. "Subdivision Land Development in Oregon COG District 10 (Central Oregon)," and
2. "Impact of Residential Land Conversion on Agriculture in the Prineville, Oregon, Area."

These projects will be carried out in priority order as listed above. It is anticipated that neither project will require the full year for completion. The objective, approach, and need for each project is summarized as follows:

TITLE: Subdivision Land Development in Oregon COG District 10 (Central Oregon)

OBJECTIVE:

Define the location, amount, and rate of land subdivision activity in relation to resource characteristics and competing land uses.

APPROACH:

From NASA highlight CIR photography, locate and inventory subdivision activity, compare same with existing county records of approved subdivisions, assess the ecological characteristics of the resource in each subdivision area, and cartographically depict relationship to other land uses.

NEED:

New recreational subdivision development is sufficiently impacting the economy of COG District 10 that two of the three counties have declared a moratorium on all developmental activity until the problems can be assessed and a suitable process for management of this activity determined. In two of the counties, developmental activity is moving so fast that the local staff can hardly stay ahead of routine paperwork. They do not have time to compile records and thoroughly evaluate impacts to permit informed, rational

decisions by the County Planning Commission. Exploratory work shows that this is a natural for interpretation from NASA highflight imagery that is available for the subject area.

TITLE: Impact of Residential Land Conversion on Agriculture in the
Prineville, Oregon, Area

OBJECTIVE:

Evaluate land use capability and potential residential conversion on the capability for agricultural production.

APPROACH:

Assemble in cartographic form on NASA highflight enlargements, all available resource information relevant to land use capability in the subject area, fill gaps where possible from highflight photo interpretation and assess the impact of alternative conversions on environmental quality and resource productivity. Present results to the County Planning Commission and County Court for their consideration and use in guiding land use and development in the Prineville, Oregon, area.

NEED:

In the region represented by Prineville, Oregon, agricultural land is particularly limited in extent. The economy of the area is primarily range livestock production, agricultural crop production, and lumbering, with various forms of outdoor recreation being particularly important. The pressure for open space living together with the opportunity for short-term economic gain, produces pressures to change land use from agriculture to urban and suburban residence. Facts relevant to this problem need to be organized, displayed, and interpreted so they may be used to guide decisions of the County Planning Commission and County Court.

As these projects near completion, new high-priority projects will be planned for implementation. ERSAL is continually alert to newly emerging needs and opportunities for high-priority contributions to the solution of Oregon problems through remote sensing applications. In addition, the ERSAL staff is maintaining a close working liaison with the Office of the Governor through his Natural Resources Executive Assistant, Kessler Cannon, and with the individual departments of state government previously named. Most of these are rapidly increasing their individual use of NASA imagery and commercial aerial photography in their operational programs.

NEW HIGHFLIGHT PHOTOGRAPHY PLANS

Three areas of critical importance to the land use planning effort and the economy of Oregon have been included in new data requests for the 1973 aircraft imaging season. These are the Coastal Strip, the Willamette River Drainage, and Central Oregon Intergovernmental Council District 10. All of these missions have been scheduled for flying by the NASA-Ames facility with a 6-inch metric and 24-inch high resolution camera system. The 6-inch focal length camera will provide stereo coverage of the respective target areas. The 24-inch focal length camera will provide stereo coverage and will be used to sample critical areas down the center of each flight line. A multidiscipline team determined these priority sampling sites. They include specific kinds of natural resources problems, practically all of the moderate size and major metropolitan areas and the entire coastal strip except for portions where the high, stable rock bluffs come immediately to the ocean with virtually no beach. The areas to be flown are shown in the composite map of Figure 11.

The Laboratory worked out a compromise flight schedule for the above support with the U.S. Geological Survey to coordinate almost identical requests from the two groups. Our coordinated flight plan should result in significantly more efficient servicing of the needs of both groups by NASA.

