THE APPLICATION OF REMOTE SENSING TO RESOURCE MANAGEMENT AND ENVIRONMENTAL QUALITY PROGRAMS IN KANSAS

By

B. G. Barr, Director
Space Technology Center
The University of Kansas

July, 1975

An Annual Report of Work
Performed Under NASA Grant
No. NGL 17-004-024

(April 1, 1974 - March 31, 1975)

THE UNIVERSITY OF KANSAS CENTER FOR RESEARCH, INC.
Space Technology Center—Nichols Hall
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KU/NASA Applications Program

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ABSTRACT

The staff of the University of Kansas Satellite Applications Laboratory is engaged in a program designed to introduce remote sensing techniques to decision makers at local, state and regional levels of government in Kansas. This report outlines the means employed to acquaint officials with the potential of remote sensing data and summarizes results obtained in projects with which the Applications Laboratory has been associated. Emphasis is placed on the period April 1, 1974 through March 31, 1975.

Specific assistance on over 15 remote sensing projects concerned with (1) urban and regional analysis, (2) rural development, and (3) habitat management and environmental analysis was provided for several different state agencies and public bodies during the reporting period. Projects were designed both to deal with specific problems of officials and to provide a basis for communication by demonstration. Remote Sensing data products based on interpretations and analysis by Applications Laboratory personnel were provided in support of several agency decisions and projects which are currently approaching completion or final action. Two major projects were completed during the term: Applications Laboratory personnel provided data bearing upon (1) the decision to cancel the construction of the Pattonsburg Reservoir and to proceed with completion of Interstate 35 (northwest Missouri), and (2) development around Clinton Reservoir (northeast Kansas) designed to preserve the natural environment. In addition to data products in support of specific agency projects; consultation and training in use of satellite and aircraft imagery was provided to personnel from several state, regional and county agencies. Effective communication and confidence has been established through these efforts and users now routinely call on KU personnel for information and advice about the application of remote sensing technology to solution of their agency problems.

I. THE KU/NASA APPLICATIONS PROGRAM

INTRODUCTION

Changes presently occurring in Kansas, such as the rapid growth of irrigation, increasing urbanization of the population, instabilities in the agricultural market and uncertainties as to future availabilities of fuel, have necessitated re-evaluation of types of data and methods of data acquisition upon which decisions are based. The growing requirements for specific environmental, social and economic information about the dynamic milieu in which they operate have begun to force city commissions, county commissions, state agencies and regional planning and development commissions to initiate a search for alternative methods of data gathering.

Officials at all levels of government are daily faced with requirements for objective data to be employed in the decision making process. At lower levels of government acquisition of data by traditional methods is often beyond the physical and economic resources of the governing body. Consequently, decisions are frequently based upon incomplete or potentially biased data sets.

Since 1972 the staff of the University of Kansas Applications Laboratory has, with support from a grant from the NASA Office of University Affairs, engaged in a program of activities designed to acquaint state and local officials of Kansas with the potential of remote sensing as an alternative data collection system. This report outlines the procedures employed in acquainting Kansas officials with the potential of employing remote sensing data within their own context and summarizes results obtained in projects with which the Applications Laboratory has been associated. Emphasis is placed on the period April 1, 1974, through March 31, 1975. These projects have been designed both to answer specific questions of officials and to provide a basis for communication by demonstration.

ORGANIZATION OF APPLICATIONS PROJECTS

Six phases of application activity may be identified in projects undertaken by the Applications Laboratory (Figure 1). The Contact Phase is intended to establish rapport between experts in the use of remote sensing technology and the government official in need of data. Activities in this phase have taken the form of two Kansas Governor's Conferences on Remote Sensing, short courses on the interpretation of LANDSAT and high and low altitude aircraft imagery for state and local government officials, articles

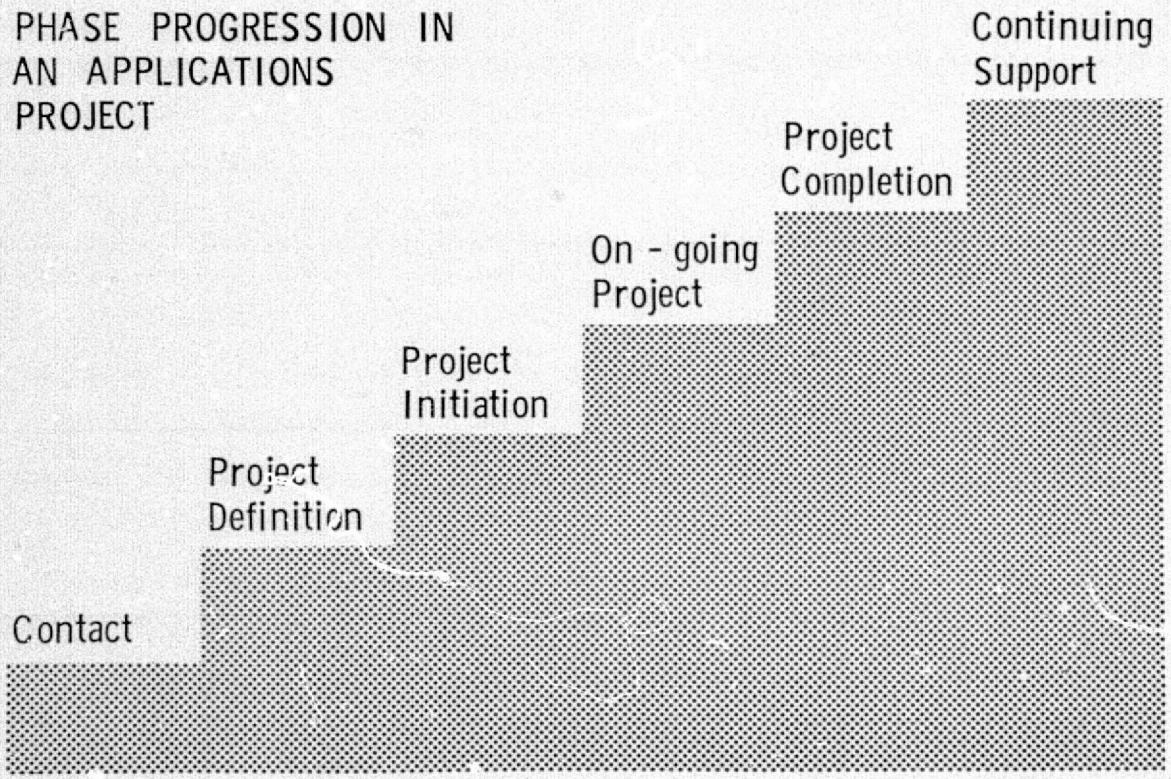


Figure 1. Each project undertaken by the KU Applications Laboratory progresses through six phases of project development.

in such magazines as the Kansas Government Journal, and individual contact between government officials and Laboratory personnel trained in specialties paralleling those of the government official, i.e., urban and regional planning or natural resources.

This Contact Phase may lead to agency personnel and/or Laboratory staff identifying a data requirement which can be solely or partially met from imagery sources. At this point an attempt is made to specify a project and the agency/Laboratory relationship is extended to the Project Definition Phase. During this phase, questions about the scope of the project, the intended use of data interpreted from the imagery, and how costs will be shared are answered. Upon mutually satsifactory assessment of the project, a task group is organized among personnel within the Laboratory. This task group may include agency personnel working in the University's Space Technology Center and/or Laboratory personnel working within the agency.

Actual utilization of remotely sensed data begins with the Project Initiation Phase. During this period critical operations are conducted which may be focal to the success or failure of agency use of remotely sensed data. These include sensor selection and mission planning. After sensor selection, image acquisition is undertaken from existing sources (EROS Data Center, NASA-Houston, etc.), if the imagery is not already available in the Laboratory's film library. Alternatively, imagery may be acquired by the University's aircraft or by a private contractor. Parallel to image acquisition is interpretion development. This activity relies on the experience of the Laboratory's image interpreters and literature review to determine if the interpretation has been undertaken before. If it has, the method and accuracy of the effort are elicited from the literature. If not, suitable interpretations to successfully accomplish the project are developed and documented.

After imagery has been acquired and effective interpretations developed, the actual interpretation and preparation of final products for use by agency personnel occur during the On-Going Project Phase.

When the products required for the project have been developed they are delivered to the user agency and Laboratory personnel prepare documentation for further reference and to support the agency in using the products in the Project Completion Phase. Efforts are also made to document the use of the remote sensing products in the agency environment.

This leads to the Continuing Support Phase of the Application effort, in which support to state and local agencies is provided in the form of personnel training, product improvement, fulfillment of new product requirements, and consultation services in data utilization. The continuing support phase can be seen as the culmination of the Laboratory's effort. Agency/Laboratory projects which reach this phase explicity indicate agency acceptance and continuing utilization of remotely sensed data.

Nature of Projects

Table 1 indicates the range of projects totally or partially completed during FY 74-75. Note in Figure 2 that projects have been distributed widely over Kansas. Additionally, some have been undertaken in Missouri which has no comparable program.

General Activities

An integral part of the service provided by the Applications program is the ability to respond to new ventures as they arise, either from agencies with which activities have already established a cooperative base or with new potential cooperators. Agencies with which contacts have been established are listed in Table 2. Contacts are maintained with all of these agencies and additional contacts fostered. Such contacts test uses which are being made of past products of the KU/NASA Applications Program and reveal other potential applications of remote sensing.

Contacts with Agencies

While many projects have developed through individual contacts between agency and Laboratory personnel, these communications have often been fostered by more general information dissemination efforts aimed at promoting widespread interest in remote sensing applications. These activities have included (1) conferences, workshops and short courses, (2) journal articles, (3) maps and mosaics of general interest, and (4) a newsletter.

To date three workshops have been held at which fifty different agencies were represented by over 125 people. The first workshop was planned for county and area personnel (Douglas County and Kansas City), and held in the KU Space Technology Center in June, 1972. The second was designed to appeal to a

Table 1

PROJECTS IN COMPLETION PHASE
OR CONTINUING SUPPORT PHASE
AS OF MARCH 31, 1975

1. PROJECT: Decision on Completion of I-35 and Pattonsburg Reservoir
   COOPERATING AGENCY: Governor's Office, State of Missouri

2. PROJECT: Developmental Planning on Clinton Reservoir
   COOPERATING AGENCY: Douglas County, Kansas Planning Department

3. PROJECT: Kansas Land Use Patterns Map
   COOPERATING AGENCY: Kansas Department of Economic Development

4. PROJECT: Regional Land Use Map for the Four Rivers Resource Conservation and Development Project
   COOPERATING AGENCIES: Four Rivers RC&D, U.S. Soil Conservation Service

5. PROJECT: Land Use Map of Cherokee County
   COOPERATING AGENCIES: Cherokee County Commission, Kansas Geological Survey

6. PROJECT: Test of Automatic Land Use Updating Procedure
   COOPERATING AGENCY: Kansas Department of Economic Development

7. PROJECT: Remote Sensing Applications in Lawrence-Douglas County, Kansas
   COOPERATING AGENCIES: Various local agencies

8. PROJECT: Sanitation Route Allocation in Kansas City, Kansas
   COOPERATING AGENCY: Department of Planning and Development, Kansas City Kansas

9. PROJECT. Evaluating Environmental Impact of Road Construction
   COOPERATING AGENCY: Department of Planning and Development, Kansas City, Kansas

10. PROJECT: Kansas Geographic Information System Pilot Project
    COOPERATING AGENCY: Wyandotte County, Kansas

11. PROJECT: Census Tract Division
    COOPERATING AGENCY: Mid-America Regional Council

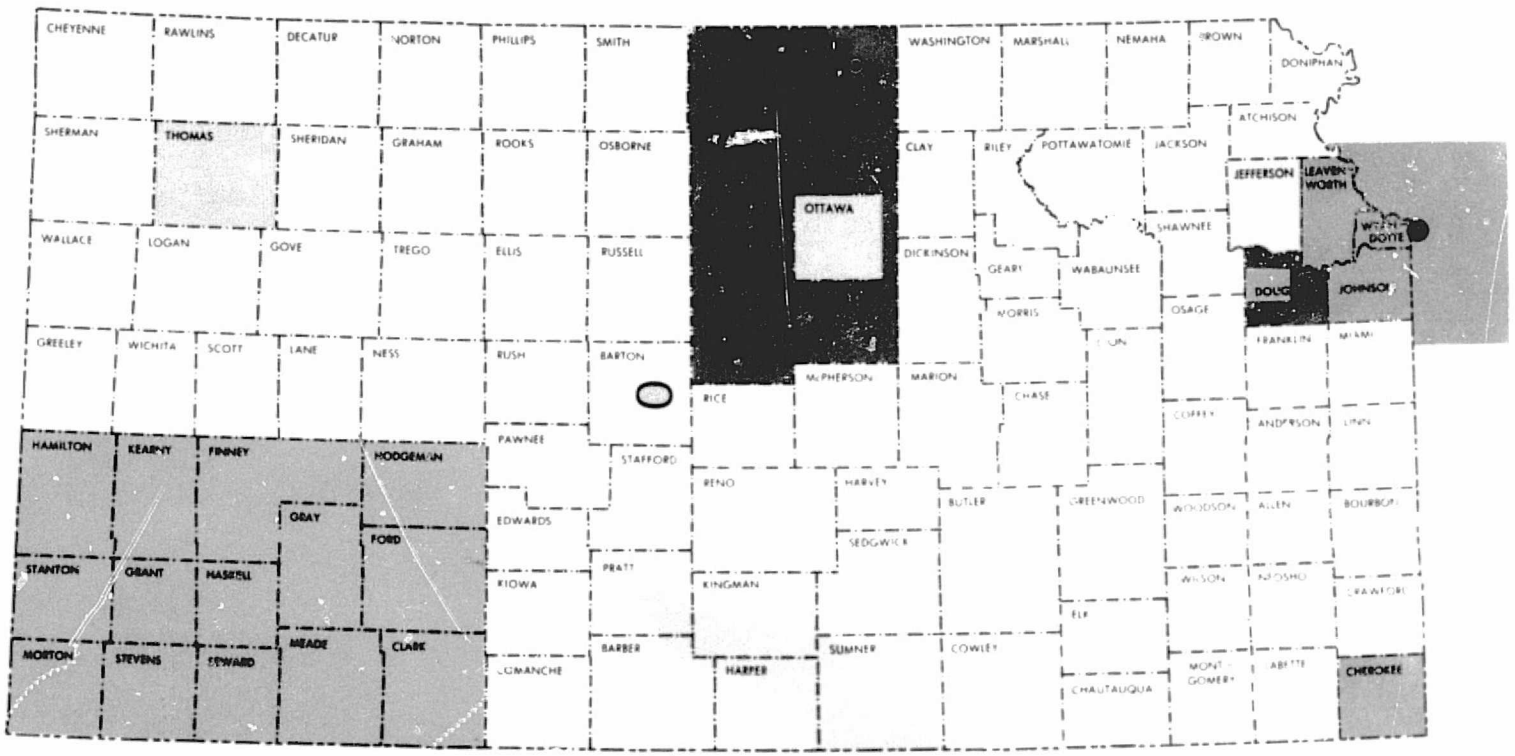
12. PROJECT: Mapping Center Pivot Irrigation in Southwest Kansas
    COOPERATING AGENCIES: Kansas Forestry, Fish and Game Commission, Kansas Water Resources Board, Kansas Geological Survey

13. PROJECT: Using Remote Sensing for Wildlife Habitat Inventory in Kansas
    COOPERATING AGENCY: Kansas Forestry, Fish and Game Commission

14. PROJECT: Habitat and Stream Order Mapping of the Chikaskia River Basin
    COOPERATING AGENCIES: Kansas Forestry, Fish and Game Commission, U.S. Fish and Wildlife Service, Sunflower RC&D Project

15. PROJECT: Mapping and Monitoring of Vegetation in Cheyenne Bottoms Waterfowl Management Area
    COOPERATING AGENCY: Kansas Forestry, Fish and Game Commission

REMOTE SENSING APPLICATIONS PROJECTS
April, 1974 - March, 1975



- Clinton Reservoir Project
- Four Rivers RC&D Project
- Lawrence - Douglas County Project
- Mid-America Regional Council (MARC) Projects
- Kansas City, Kansas Projects
- Center Pivot Irrigation Project
- Wildlife Habitat Inventory Project
- Cheyenne Bottoms WMA Project
- Chikaskia River Watershed Project
- Cherokee County Project

Figure 2. Applications projects have been distributed widely over Kansas

Table 2

AGENCIES WITH WHICH CONTACTS HAVE BEEN ESTABLISHED
BY THE KU/NASA APPLICATIONS PROGRAM

Municipal:

- Kansas City, Kansas Department of Planning and Development
- Kansas City, Kansas, City Commission
- Lawrence, Kansas, Planning Department
- Kansas City, Kansas, Mayor's Office
- Lawrence, Kansas, City Engineer
- Lawrence, Kansas, City Commission

County:

- Douglas, Kansas, Planning Department
- Cherokee, Kansas Board of Commissioners
- Douglas, Kansas, County Extension Agent

State:

- Kansas Forestry, Fish and Game Commission
- Kansas Water Resources Board
- Kansas Department of Economic Development
- Missouri Clean Water Commission
- Kansas Governor's Office
- Kansas Department of Agriculture
- Kansas Geological Survey
- Kansas Department of State Planning
- Kansas Department of Revenue
- Kansas Department of Environmental Health
- Kansas Highway Department
- Kansas Agricultural Extension Service
- Missouri Governor's Office
- Missouri Geological Survey

Regional:

- Mid America Regional Council
- Chikaskia-Indian Hills Regional Planning Commission (Sumner, Harper, Kingman)
- Northwest Kansas Planning and Development Commission (Cheyenne, Sherman, Wallace, Rawlins, Thomas, Logan, Decatur, Sheridan, Gove, Norton, Graham, Trego, Phillips, Rooks, Ellis, Smith, Osborne, and Russell Counties, Kansas)
- Sunflower Resource Conservation & Development District (Sumner, Harper, Kingman, Pratt, Barber, Comanche, and Kiowa Counties, Kansas)
- Four Rivers Resource Conservation & Development District (Jewell, Republic, Mitchell, Cloud, Ottawa, Lincoln, Ellsworth, and Saline Counties, Kansas)
- Ozarks Regional Commission
- Big Lakes Regional Planning Commission (Pottawatomie, Riley, Geary)

Federal:

- U.S. Department of Agriculture, Soil Conservation Service
- U.S. Fish and Wildlife Service
- U.S. Army Corps of Engineers, Kansas City Office
- U.S. Environmental Protection Agency, Kansas City Office

broader interest group (Kansas and adjoining states) and included presentations covering geological, agricultural and hydrological applications. The third was held in the western section of the state at the Agricultural Experiment Station in Hays, Kansas and stressed agricultural and agribusiness interests.

Periodically and/or as results are obtained from completed or ongoing projects, seminars or conferences are held to convey the findings to other interested agencies. A conference of this type was held March 29 - 30, 1973 under the sponsorship of the Governor's Office of the State of Kansas and the Space Technology Center. This conference was attended by eighty eight persons representing forty two different agencies and organizations. Governor Robert Docking keynoted the conference, stating in reference to Space Technology and specifically remote sensing: "We must use the expertise and knowledge available so that its potential is realized and brings beneficial results to all Kansans." Presentations by agency participants in demonstration and pilot applications projects funded in whole or in part by the Applications grant constituted the major part of the program. Twenty two persons representing ten agencies, divisions or industries met in a workshop session on March 30th to discuss establishment of a remote sensing coordinating group for state agencies through efforts of the Space Technology Center and with the support of the Governor's office.

As agencies have become more familiar with the potential of remote sensing they have frequently indicated interest in having their own personnel become trained in image interpretation. During 1974 two image interpretation workshops were taught by KU/NASA Applications personnel.

The first of these, held October 2 - 4, 1974 at Garden City, Kansas, centered around problems pertinent to users working in the southwest quarter of Kansas. Subjects covered included image acquisition and location, and interpretation of and measurement on LANDSAT and high altitude imagery. Practical exercises were included as part of the instructional program. Persons attending this workshop were prepared to accomplish at least elementary interpretative and mensural work in their local offices.

In attendance were local representatives of the Kansas Extension Forestry Service, Kansas State Board of Agriculture, Kansas Department of Economic Development, Kansas Forestry, Fish and Game Commission, Kansas Parks Authority, Kansas Highway Commission, U.S. Soil Conservation Service, U.S. Agricultural Stabilization and Conservation Service, Pawnee River Watershed District, local agricultural extension service, and Garden City Agricultural Experiment Station. Sufficient

background was transferred to enable these persons to, in many cases, perform interpretation tasks in their own offices. In addition, the workshop provided a useful forum for identification of decision oriented problems to which remote sensing techniques might contribute. Contacts and communications established have aided in furthering the effectiveness of the KU/NASA Applications Program.

A second training workshop was held during December of 1974 in Kansas City, Kansas. A geographic base file project, which was initiated in 1972, had by 1974 reached the level of sophistication where land use data concerning every parcel of land in Kansas City/Wyandotte County could be stored in the file. To determine if this project was feasible the city hired six college students over the 1974 Christmas holidays. Using high resolution aerial photography and collateral sources these employees interpreted and encoded the land use of every parcel of land in a ten square mile area of the innner city. The interpreters were trained by KU/NASA Applications Program personnel, but management and financing of the project were provided entirely from City resources. Based on the results of this work the Department will use part time employees in the summer of 1975 to collect land use data on the entire city.

A recent article written for the Kansas Government Journal (May, 1975) is also contributing to dissemination of information concerning uses of remote sensing and the nature of the KU Applications Program (Appendix I). This journal is widely read in Kansas, especially by decision makers at the state and local government levels. The article complements and supplements information provided through the Kansas Environmental Resources (KERS) Newsletter. Published periodically since spring of 1972, the Newsletter reaches over 550 readers with news of current applications activities (Appendix II).

Wide distribution of two data products has also aided in publicizing the Kansas Applications Program. A LANDSAT-1 mosaic of the State of Kansas has been circulated to nearly 1,000 actual and potential state and local user agencies, schools, libraries, businesses and private individuals. It serves as a constant reminder of the work of the KU/NASA Applications group to a wide audience in Kansas.

The mosaic was originally compiled by the General Electric Company for the KU/NASA Applications project. Applications personnel composed a descriptive text, added annotation and the mosaic was then reproduced by the University of Kansas Press. The mosaic has been a valuable tool for arousing interest in LANDSAT and other remote sensing techniques in Kansas, and has helped initiate several successful projects.

General data on the distribution of area-extensive land uses provide an important input to state and regional planning, especially when the distribution of some of these land uses are subject to high rates of change or are ill known from c her data sources. No small scale map of land use in Kansas had been prepared since 1951 until such a map was prepared by Applications staff members.

Since the distribution of that map was limited and the utility of the map apparent, the Planning Division of the Kansas Department of Economic Development proposed to fund publication of the map as an interim planning base until 1:250,000 scale maps of Kansas become available. The map, which is printed in color at a scale of 1:1,000,000, shows twelve types of land use, and provides immediate evidence of the utility of remotely sensed data.

Since the map was printed it has been widely distributed, both within and outside of Kansas. Contacts with recipients likely to be able to use the map in the decision making process are being maintained so that decisions derived from the map may be identified as they occur.

Coordination with Agency Officials

Experience gained in the Applications Program points up a need for the Project Director and indeed all team members to carry out an aggresive program of repetitive contacts with local, regional and state decision makers. It is not sufficient to hold conferences, publish newsletters, or make occasional calls. A continuing association with key administrators and their staffs is necessary to develop their interest, convince them of the Applications Group's knowledge of and access to remotely sensed data and of its willingness to contribute its expertise to solving the agencies problems, and finally obtain agency commitment of time and resources to a project.

During the last year we have increased our personal visits to the offices of agency heads to increase and maintain their awareness of the Application Group's capability and its desire to assist their personnel in the exploitation of the benefits of the aircraft and satellite remote sensing programs. These visits are resulting in better communications between Space Technology Center investigators and agency personnel than was possible early in the program. This is occurring primarily because of two factors: (1) previously established knowledge of the KU/NASA Applications Program, and (2) examples of uses to which remotely sensed data has been applied by other agencies with KU assistance.

THE APPLICATIONS TEAM

Responding to Agency Requests

The response of state and local officials during the past three years has demonstrated their increasing interest in the utilization of remote sensing data in the decision process. The response from many varied interests suggested early that the Kansas Applications Program should include a core group representing certain critical disciplines which could react knowledgeably to specific requests and provide the framework from which a pilot or demonstration project could evolve. It was also apparent that such a core group could respond quickly to specific decision oriented problems utilizing short term studies. During the current grant year the core group consisted of an engineer, an environmental pollution specialist, several geographers, and interpreters. This group, together with agency personnel and additional students and faculty when required, have been involved in a number of decision oriented projects requiring both quick response and longer term effort. Experience to date shows that competent helpful response on short term requests by the core group personnel opens the way to longer term projects of more importance later. The short term projects in effect allow communications and some understanding of capability to be established prior to a major commitment of resources or time by either the Applications group or the user agency.

The core group concept is now functioning well and it is believed that it is the most viable approach to the challenging problems encountered in the application of remotely sensed data to real situations. We expect to continue and strengthen this Space Technology Center Applications Team as we interact with state and local agencies on new and continuing projects.

Personnel

The Applications Program is administered by Dean B. G. Barr, Professor of Engineering and Director of the University of Kansas Space Technology Center. Barr, a specialist in technical management, has been active in transmitting new technologies to industry and state agencies for over ten years.

Don Williams and Jerry Coiner, two Geography doctoral candidates with considerable professional experience as photo interpreters (five and nine years military) carry significant responsibilities in the urban and rural components of the program.

Mr. James Merchant, also a Geography doctoral candidate, handles the habitat analysis area and will also assume increased responsibilities upon completion of his doctoral work. Mr. Ted Talmon, a full time analyst-interpreter who has been involved in the program since its inception, provides the continuity and quick response that is required in an action oriented program. Mr. Ron Shaklee a Geography masters candidate with several years military interpretation experience has been active in all phases of several projects.

Projects requiring major scientific effort are staffed primarily by graduate students from the various academic disciplines assisted by faculty advisors when appropriate. Personnel from the various state and local agencies are involved in their applications projects at no cost to the NASA grant. We shall continue to work with the various extension agencies in the state to gain their assistance in translating remote sensing technology to a broader audience.

FACILITIES

The Satellite Applications Laboratory located on the second floor of the KU Space Technology Center serves as the headquarters of the Applications Program. Light tables, Bausch and Lomb Zoom Transfer Scope and other equipment needed by the Applications Group have been provided by the Space Technology Center for the demonstration projects. In-house Graphic Arts and Photo Services facilities offer complete cartographic and film processing services.

The 70,000 square feet Space Center was designed to house many of the investigators involved in the University's Interdisciplinary Space Research Program, and special attention was given to the establishment of a physical environment and support services which would be conducive to productive interactions between the disciplines. Approximately thirty laboratories and eighty offices are available for faculty and students from Business, Engineering, Social, Biological, Physical and Mathematical Sciences.

Several STC offices have been set aside for visitors and are available for use by personnel from state agencies who need to work with Applications Laboratory personnel during certain phases of their agencies' project. Increased probability of use of data by other activities also occurs since approximately 200 faculty members and students from most of the major University departments are housed in the Space Technology Center. Operational procedures ensure the retention of the normal relationships to academic departments while encouraging close association with investigators from other disciplines on space oriented projects.

The Space Technology Center includes a large, well equipped remote terminal to the University's GE Honeywell 635 computer, as well as an in-house IBM 7094 and smaller PDP 15/20 computer system. These computational facilities are staffed with qualified computer systems specialists. Similarly, a central reports room is staffed to serve the document needs of the occupants in cooperation with the main University library. These facilities provide the investigators with ready access to the University's modern high-speed computer, in-house computational capability, and extensive library resources.

DATA BASE FOR APPLICATIONS PROGRAM

During the past several years the University of Kansas Space Technology Center has accumulated a large volume of information on remote sensing which will contribute to application studies in progress or being considered.

1. Substantial library of remote sensor imagery including:
   a. complete multidate cloud free LANDSAT coverage of Kansas
   b. aerial photography largely acquired through NASA Earth Resources Aircraft Program. Film includes panchromatic black/white, color and color infrared acquired at variety of scale factors. Coverage includes a variety of test sites in and outside of Kansas.
   c. SKYLAB imagery of much of Kansas
2. Reference material on remote sensing in general, including reports, articles, periodicals, professional journals, symposia proceedings, manuals, textbooks, etc.
3. Specific technical information on remote sensor instrument characteristics and performance.
4. Specific and general information on scientific and technical aspects and objectives of the various spacecraft and aircraft remote sensing programs.

In order to expand the usefulness of the Applications Program, the Space Technology Center has established a data base of LANDSAT and SKYLAB imagery acquired over the State of Kansas, and through the NASA scientific monitors maintains an awareness of the data obtained by LANDSAT and SKYLAB experimenters in adjacent states. The data base contains not only imagery, but reference information concerning

remote sensing, specific information concerning LANDSAT imagery such as ground truth availability, etc. These data are made available to user agency respresentatives participating in the Kansas Applications Program.

II. PROGRAM CF WORK APRIL 1, 1974 - MARCH 31, 1975

A. CCMPLETED PROJECTS

INTRCDUCTION

The period April, 1974 - March, 1975 witnessed the completion of two major projects. During this time KU/NASA Applications personnel provided data bearing upon (1) the decision to cancel the construction of the Pattonsburg Reservoir and to proceed with completion of Interstate 35 (northwest Missouri), and (2) development around Clinton Reservoir (northeast Kansas) designed to preserve the natural environment. These projects are now in the Continuing Support Phase and are discussed below.

DECISICNS CN COMPLETICN CF INTERSTATE I-35 AND CANCELLATION OF CONSTRUCTION ON PATTONSBURG DAM, NORTHWEST MISSOURI

In early 1973 the Governor of Missouri was faced with a decisional situation concerning completion of Interstate 35 and the proposed Pattonsburg Reservoir project in northwest Missouri (Figure 3). Completion of I-35 had important economic consequences for the Kansas City metropolitan region, since the highway provides a direct route from Chicago to Kansas City. At that time I-35 was complete except for a fifteen mile segment in the area of the proposed Pattonsburg Reservoir. In addition to the traffic hazard problems created by the detour over a narrow, dangerous two-lane highway (U.S. 69), engineers had estimated that construction of a crossing over the proposed reservoir would cost $30 million, while construction of the segment without the crossing would cost considerably less.

The Governor's staff determined that a need existed for additional analysis on the desirability of the reservoir project before committing funds for the completion of the more expensive reservoir bridge crossing for I-35. The Applications Laboratory was requested to provide objective data to support the group conducting the supplementary analysis.

The U.S. Congress in 1965 had authorized the U.S. Army Corps of Engineers to construct a reservoir on the Grand River in Missouri. The $100 million project was to be a multipurpose impoundment designed for flood control, power generation and recreation. The surface area of the lake would have been 42,000 acres at normal levels; 77,000 acres at flood pool, and would have required the purchase of some 139,000 acres of land. Three towns, eighteen archaeological sites, and a signifi-

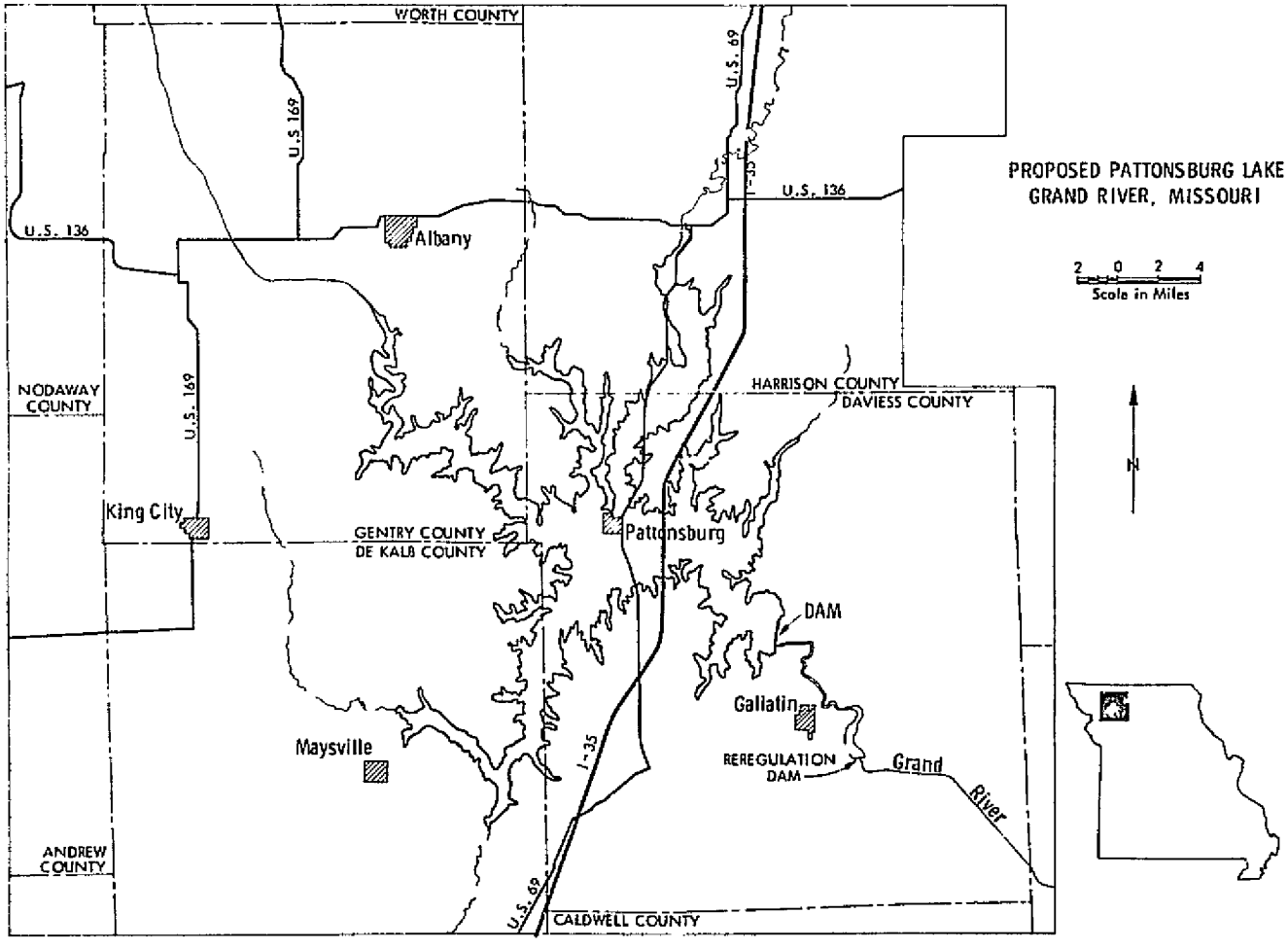


Figure 3. Controversy over the construction of Pattonsburg Reservoir delayed completion of a fifteen mile segment of Interstate 35.

cant amount of prime agricultural land would have been inundated.

A heated controversy surrounded the proposed reservoir for several years as studies were conducted. There was considerable argument over whether the value of land protected periodically would exceed that permanently inundated. Opponents of the lake claimed that a $10 million agricultural industry in northwest Missouri would be adversely affected and that benefits would not outweigh costs. While the debate over reservoir construction went on, completion of Interstate Highway 35 was delayed because an 8.5 mile stretch would cross the proposed lake site. If the lake was developed, the roadway would require the construction of a high bridge at a cost of $30 - 33 million; in the absence of a lake, a low level crossing of the Grand River could be completed for $10 - 12 million.

In the spring of 1973 the Governor of Missouri initiated a restudy of the proposed reservoir to be completed in the summer of 1973. As an important element of this investigation, the Governor's office and the Governor's Council on Water Resources Planning required , in a short period of time, current and accurate information on land use in the area to be inundated and on the extent of flooding and the character of land use in the area to be protected downstream from the damsite. Remote sensing appeared to be the prime technique for procuring the data. The University of Kansas Applications Group, as an unbiased outside party, was requested to assist in acquiring and interpreting imagery.

The area under consideration is evident on Band 7 LANDSAT imagery (Figure 4) taken during the May 9th pass of LANDSAT at the height of the 1973 flooding in the Missouri River Basin. This image and low altitude multiband aerial photography were used to map the extent of flooding downstream on the Grand River to the confluence with the Missouri River at Brunswick, seventy miles away.

The latest aerial photograph held by the Corps of Engineers was at least ten years old. Consequently, low altitude multiband and color infrared aerial photography was gathered by the KU aircraft over the reservoir site. Imagery was interpreted for land use and acreage calculations were made using a Hewlett-Packard Digitizer and Calculator.

Four classes of land use (crops, pasture, forest, and urban) were interpreted for the Governor's committee and compiled into a map of the proposed inundation area (Figure 5). Statistics on acreage of each land type to be inundated above and protected below the dam were provided. (Table 3) These statistics compensated for a deficiency in the original Environmental Impact Statement which, because it had been prepared for the entire Grand River Project, did not separate data for the

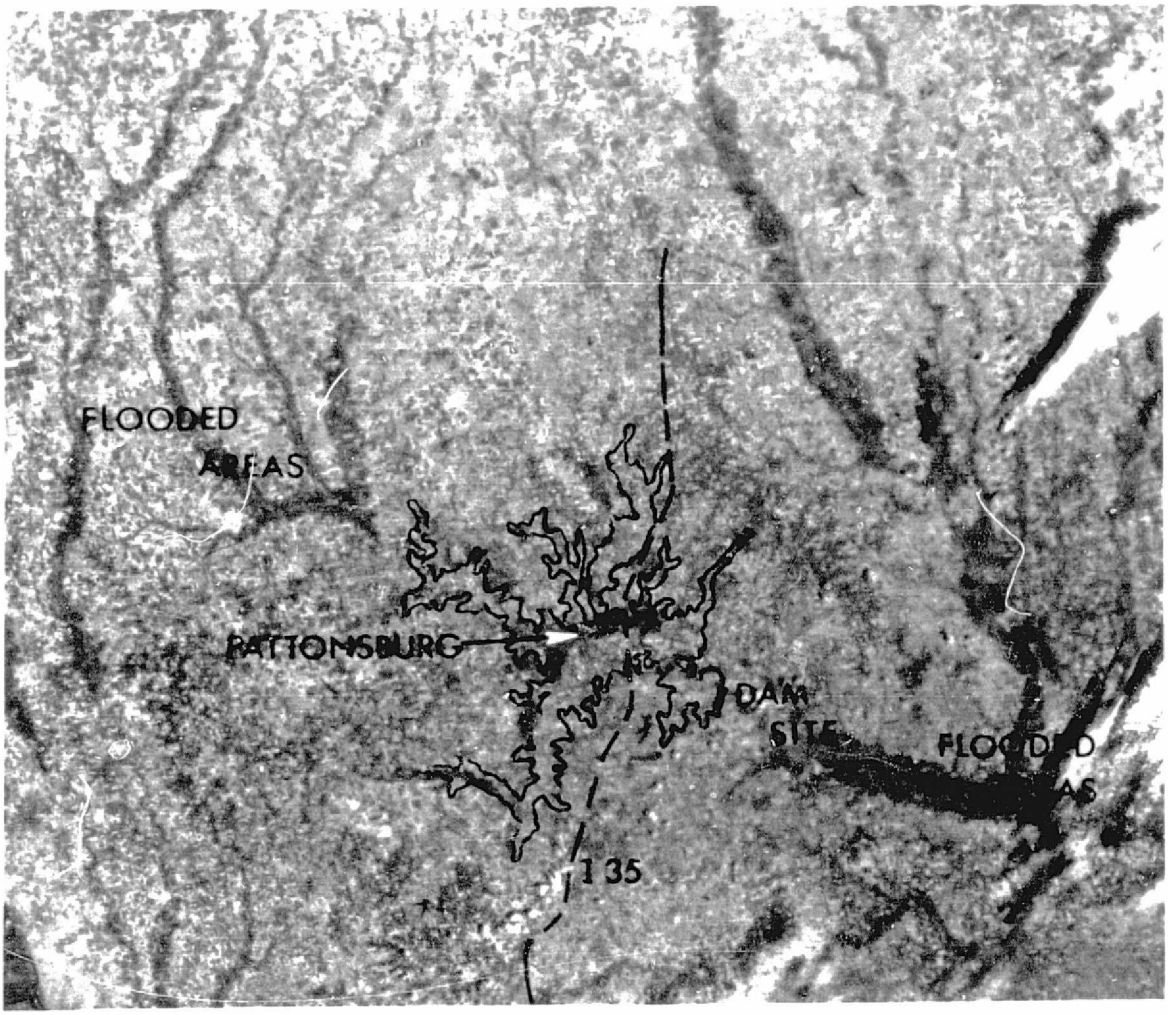


Figure 4. The extent of flooding in the Grand River valley in Spring, 1973 was mapped from infrared LANDSAT imagery.

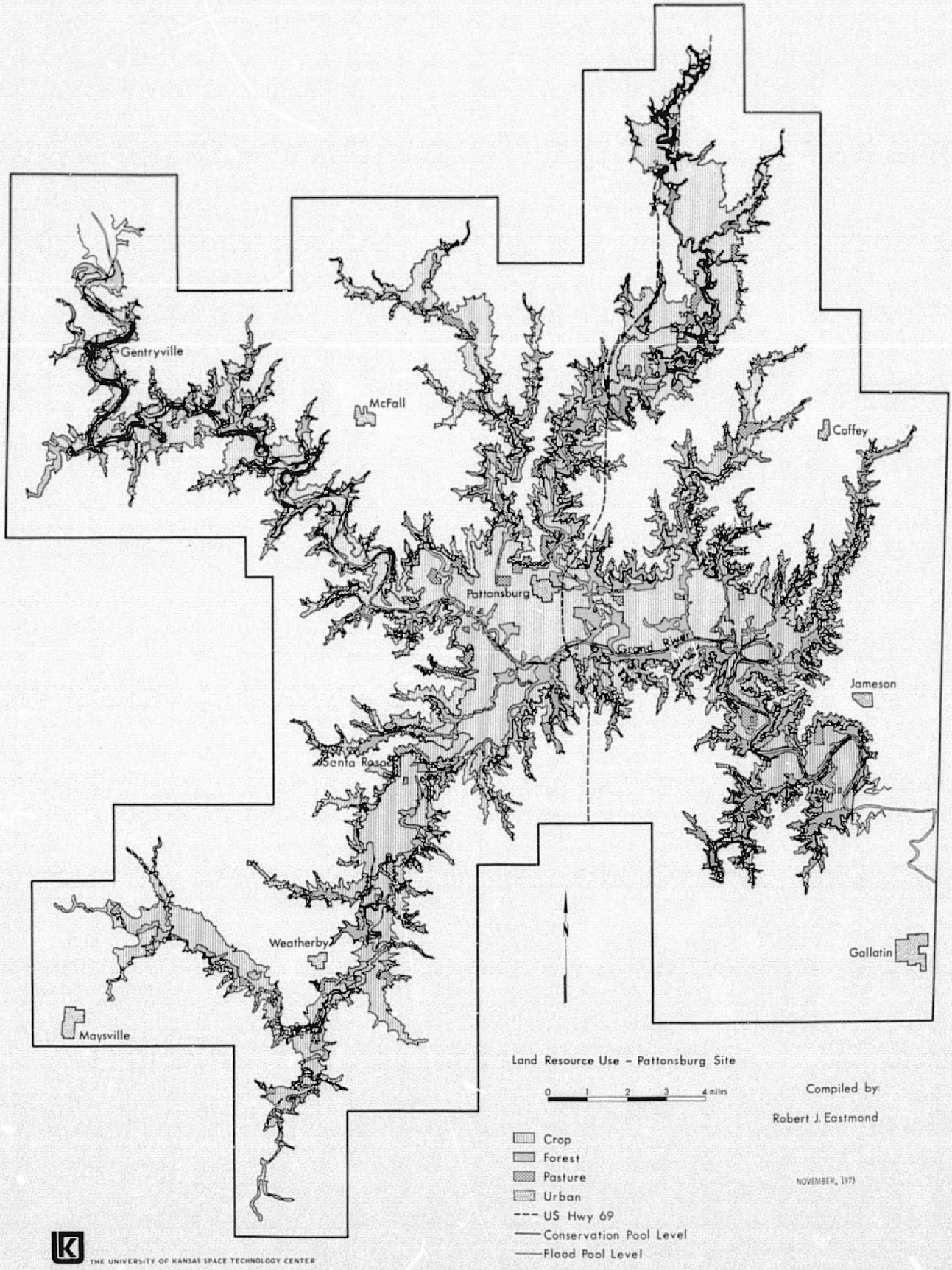


Figure 5. Large Scale Multiband Photography was Interpreted to Provide Accurate Cropland Acreages in the Pattonsburg Reservoir Area.

Table 3

ANALYSIS OF AREAS

	Reservoir Pool		Flood Plain Below Dam	
	Acres	Percent	Acres	Percent
Crops	47,900	59.8	113,000	84.3
Pasture	6,600	8.3	3,000	2.3
Forest	25,300	31.7	16,000	11.9
Urban	200	.2	2,000	1.5
Total	80,000	100.0	134,000	100.0

Table 4

CROPLAND (ACRES)

	With Dam	Without Dam*	Quality	Difference
Reservoir Pool	-	43,080	Prime	+43,080
Flood Plain	113,000	101,700	Poor to Fair	-11,300
Total	113,000	144,780		31,780

*Flood loss frequency ten years.

Pattonsburg Reservoir from that for several other projects on the river. Analysis of these statistics revealed that without the dam 144,780 acres would be available for agricultural production, while with the dam, agricultural land would be reduced to 113,000 acres (Table 4). Based on USDA data related to crop values and the image analysis, it was estimated that the loss of agricultural production between 1980 and 2020 would average approximately $5 million per year if the dam were constructed.

The analysis and related maps were sent to the Governor's Committee on July 31, 1973, approximately 90 days after the initial request. On August 27, 1973, the Committee reported to Governor Bond its conclusion that it would be an unwise use of public funds to proceed with the high bridge crossing and the Pattonsburg Reservoir project with the information currently available. The Governor then decided to postpone construction of the high bridge crossing of the Grand River one year and asked the Corps of Engineers to restudy the justification for the Pattonsburg project in collaboration with several state and federal agencies. On August 18, 1974, at the end of the restudy , the Corps of Engineers announced that the reservoir had been cancelled. The following day, the Missouri Highway Department announced that work would begin immediately on the design of a low crossing of the Grand River to allow the completion of I-35.

The decision to cancel the proposed Pattonsburg Reservoir project and thus save $20 million in the construction of I-35 rested substantially on an analysis supported by remotely sensed data.

Marvin J. Nodiff, Director of the Division of Planning and Policy Development of the Missouri Department of Natural Resources, informed Professor B. G. Barr, Principal Investigator of the KU/NASA Applications Program: "An essential part of the state's position with regard to the reservoir was that the agricultural economy of northwest Missouri must be our prime concern, and that construction of a large reservoir would create unacceptably adverse impacts on this economy. The land use mosaic which your Center prepared, identifying the various types of land use in the project area, was extremely beneficial in providing state personnel with a thorough understanding of the agricultural and other related uses in the area. I feel this was a significant contribution to our restudy effort".

MEASURING THE IMPACT CF CLINTC N RESERVC IR

In contrast to the preceding problem of whether or not to build a reservoir, Clinton Reservoir is now being constructed by the U.S. Army Corps of Engineers near Lawrence, Kansas. When completed in 1978, the lake is expected to attract heavy recreational use from the two million residents of the Topeka-Kansas City Corridor. Perry Reservoir, the only comparable facility in the area, has been subjected to overuse and uncontrolled development of the adjoining lands. Citizens of the Clinton Reservoir area, which includes the City of Lawrence, Kansas, have demanded an orderly development program for the reservoir site which will preserve the environmental quality of the area.

Clinton Reservoir is located in close proximity (about two miles) to Lawrence, a community of some 45,000 people. When completed, the multipurpose reservoir will have a surface area of 7,000 acres and at flood capacity, 12,000 surface acres. Clinton has been designed as a multipurpose reservoir to provide flood protection for the lower Wakarusa and Kansas River watersheds as well as recreational and water supply usage. The reservoir will be one of the most scenic in Kansas, having seventy two miles of wooded shoreline and bordered by a landscape of undulating hills with a variety of scenic vistas.

The Clinton project is also included in the so-called Top-Kan (Topeka, Kansas City) Corridor, one of the fastest growing urban regions in Kansas. Clinton Reservoir's recreational potential is expected to be a substantial attraction due to its proximity and scenic beauty, to people living within a fifty mile radius from the reservoir. It is therefore expected that the recreational value of the lake will draw a considerable number of people from the leading population centers of the area, Kansas City and Topeka, thus placing an unanticipated burden on local services such as the major trafficways through Lawrence and areas surrounding the reservoir. The economic and physical growth of Lawrence and Douglas County thus is expected to experience a considerable impact due to the reservoir construction.

The overwhelming potential for development, whether it be recreation, commercial or residential, is irrefutable and the local citizenry voiced concern for orderly development and development in concert with preserving the natural ecological and environmental quality of the area. As a consequence, the Lawrence-Douglas County Planning Commission in late 1972 placed a moratorium on any planning or zoning efforts until existing natural and man-made resources could be identified and a thorough planning study made. The Commission directed the Lawrence-Douglas

County Planning Department to develop a comprehensive plan for the area by July 1973. The purpose of the comprehensive plan would be to formulate planning policy decisions for those lands held by private ownership in the project area. The plan would identify:

1. Land best suited (or having few limitations to remain rural, natural or agricultural.
2. Land areas well suited (or having few limitations) to urban development.

Because of the time constraint (approximately eight months) placed on the planning staff to develop a comprehensive plan, the Planning Department asked the KU/NASA Applications Program at the University of Kansas for assistance so that planning policy could be based upon current unbiased data.

In response, the Applications Program developed this project with the Lawrence-Douglas County Planning Department staff to assist them in describing specific and existing characteristics in the Clinton project area necessary for planning policy decisions. The Applications program staff utilized existing remote sensing data and technology to interpret and compile information on surface water, mineral resources, natural vegetation, wildlife habitat, transportation routes, scenic areas and residential, commercial and agricultural areas. The Planning Department utilized existing data resources obtained from the Kansas and U.S. Geological Survey and USDA Soil Conservation Service to locate and describe flood prone areas, soil capabilities and slope gradient limitations, etc. Other existing data resources were used by the Planning Department to locate historic sites, utilities and to determine land values.

Applications and Planning Department personnel evaluated LANDSAT-1 imagery as the basic source for data interpretation and it was determined the LANDSAT imagery would not be suitable due to the level of detail required. The LANDSAT-1 imagery was useful, however, in providing a regional view with which to reference the Clinton Reservoir to nearby urban centers, reservoirs and general terrain features. High aititude imagery probably would have been useful, but none was available at the time the study was conducted.

The remote sensing imagery primarily used for the resource inventory was acquired by the Center for Research, Inc. with a light aircraft and Hasselblad quadricamera system in July 1972. Both color infrared and black and white multiband (green, red and near infrared) 70 mm format imagery was acquired. The interpretations were performed using enlarged color infrared transparencies. In addition a photo mosaic was prepared using the black-white red band imagery at a scale of 1:24,000. The interpreters thus used a combination of the black and white photo mosaic and color infrared

imagery to analyze and map the natural resources and environmental characteristics. The color infrared photography was used primarily to map woodlands and wildlife habitat and the black and white infrared was primarily used to map cultural features, agricultural land use and other characteristics. Considerable supplemental data including ground truth was collected and used during the interpretation process and color infrared aerial imagery acquired by NASA aircraft during 1969 over the northeastern part of the project area was used as a comparative data source.

Applications Program interpreters compiled four maps for the Planning Department. They were:

1. Existing Vegetation
2. Value of Land Areas for Wildlife Habitat
3. Scenic Value
4. Existing Land Use

The vegetation map delineates ground cover or vegetation types throughout the planning area in six general categories: (1) dense woods, (2) open woods, (3) grassland with scattered trees, (4) native grasslands, (5) tame grassland and pasture, and (6) cropland. The categories of prime importance to planning decisions are dense woods and open woods. The Planning Department assigned the category dense woods a high compatibility rating for agricultural and open land use, and open woods was rated to be of moderate compatibility for urban development. The Planning Department recommended and the Planning Commission adopted the policy that densely wooded areas "be treated as a unique resource and retained wherever possible". The desirability of this policy becomes obvious when the extensive time required for maturation is recognized. From a development viewpoint, such woodlands provide ideal visual points as well as delimiting lines or buffers between land use types. They provide for excellent wildlife habitat, reduce erosion problems, and provide recreational and educational opportunities. On the other hand, the open woods can enhance urban development if an attempt to work around existing "quality" trees is encouraged and conversely, land scalping is avoided.

The wildlife habitat of the Clinton project planning area was evaluated and inventoried on a quarter section (160 acre) basis. This is to say, each quarter section in the project area was graded for availability of food, cover, grassland and their distribution size, interspersion, and routes of travel to and from feeding areas. The potential values of land areas for wildlife habitats were then split into three levels: high, moderate and low. These values are, in particular, referenced to upland game and song birds, although the values do give some indication of the potential for deer and smaller mammals. The habitat potentials were then evaluated as to their compatibility with urban development. The "high"quality category was adjudged to be compatible to

open and agricultural land use while a "low" quality category was considered compatible with urbanization. The Planning Commission adopted the policy to preserve those areas shown as "high" quality, while those areas designated as being "low" quality will be subject to urbanization and development.

Areas of scenic value in the Clinton project planning areas were determined from the aerial remote sensing data by Applications personnel and refined by the Planning Department. The purpose of a scenic value map was to isolate areas of physiographic character which provide a unique visual experience. These scenic areas are considered a resource around which the future community could develop its physical structure while retaining an optimal visual setting.

In order to adjudge the suitability of any one particular area for continued open space and agricultural land use or for urban development, the Planning Department needed a method of comparing factors which would have a bearing on the final judgement. The method used was to select factor maps and overlay them. In doing this, they were able to study and determine what factors would be detrimental or conducive to usage for:

Dense woods and Open woods
High quality and Low quality wildlife habitat
Scenic areas

When the factors of dense woods, high quality wildlife and scenic areas are concurrent in any one area, that area is then adjudged to have the positive factors and least restrictions compatible for open space and agricultural use.

When the factors of open woods and low quality wildlife and scenic areas are concurrent in any one area, that area is then adjudged to have the positive factors and least restrictions compatible for urban development.

After studying these factors as well as others (e.g., flood prone areas, slope gradient, soil bearing capacity, utility roads, suitability of soils for septic tanks, etc.) the Planning Department developed a Guide Plan for all of the Clinton Reservoir site.

Throughout the project planning area, land can be found that would meet the minimum physical requirements for urban development, or where development would create minor environmental problems. Nevertheless, only that area to the northeast of the reservoir is within what might be called the high urbanization impact area. Proximity to services, utilities, employment and recreational centers and street networks indicates continuance of the urbanization trend from the present city limits of Lawrence westward with encroachment on the reservoir site. In essence, the

northeast sector of the reservoir site lies in the direct path of current urban expansion from Lawrence and this would be the case even without Clinton Reservoir. This northeast area then has been scrutinized in more detail and the Guide Plan reflects current planning decisions for development.

Maps of each of the development factors were combined to produce a development potential map. The potential map (Figure 6) has the following structure; areas with dense woods, high quality wildlife habitat, and scenic areas were most suitable for preservation; areas with open woods, low quality wildlife habitat and scenic areas were most compatible with urban development. Based on these data, the Planning Department recommended a development policy and the Planning Commission made the following policy decisions.

1) Densely wooded areas were to be treated as a unique resource and retained wherever possible.
2) Areas of high wildlife habitat quality would be preserved while those of low quality would be available for development.
3) Areas of steep slopes would be denied to development.

The first test of this policy came in late 1974 when a local developer requested rezoning for the Yankee Tank Subdivision. (Figure 7) This subdivision of some 440 acres is a Planned Unit Development including single family, multi-family and commercial center development. The Subdivision includes some 178 single family residents lots having a current market value of $1,780,000. The entire development, when completed, is expected to carry a minimum investment of $15,000,000. The developer has utilized the guide plan extensively along with remote sensing imagery obtained from the KU/NASA Applications Program to develop the site plan in conformity with the natural terrain, and preserving where possible the wooded nature of the tract. A lake has been built to provide a setting in concert with the surrounding wooded hills, and provisions have been made for open corridors in the form of walking and bridal paths, again conforming to the Commission's Planning Policy decisions. The Planning Commission required only one minor change to the submission, and with the incorporation of the change, the Commission has subsequently approved rezoning the tract from agricultural to residential.

In this case remotely sensed imagery was used to provide input to one of the most controversial problems in the United States today: land development. A significant aspect of this project, which points out the strength of remotely sensed data, was the use of the same imagery by both the Planning Commission and the developer in establishing their positions and policies.

DEVELOPMENT POTENTIAL

CLINTON RESERVOIR AREA

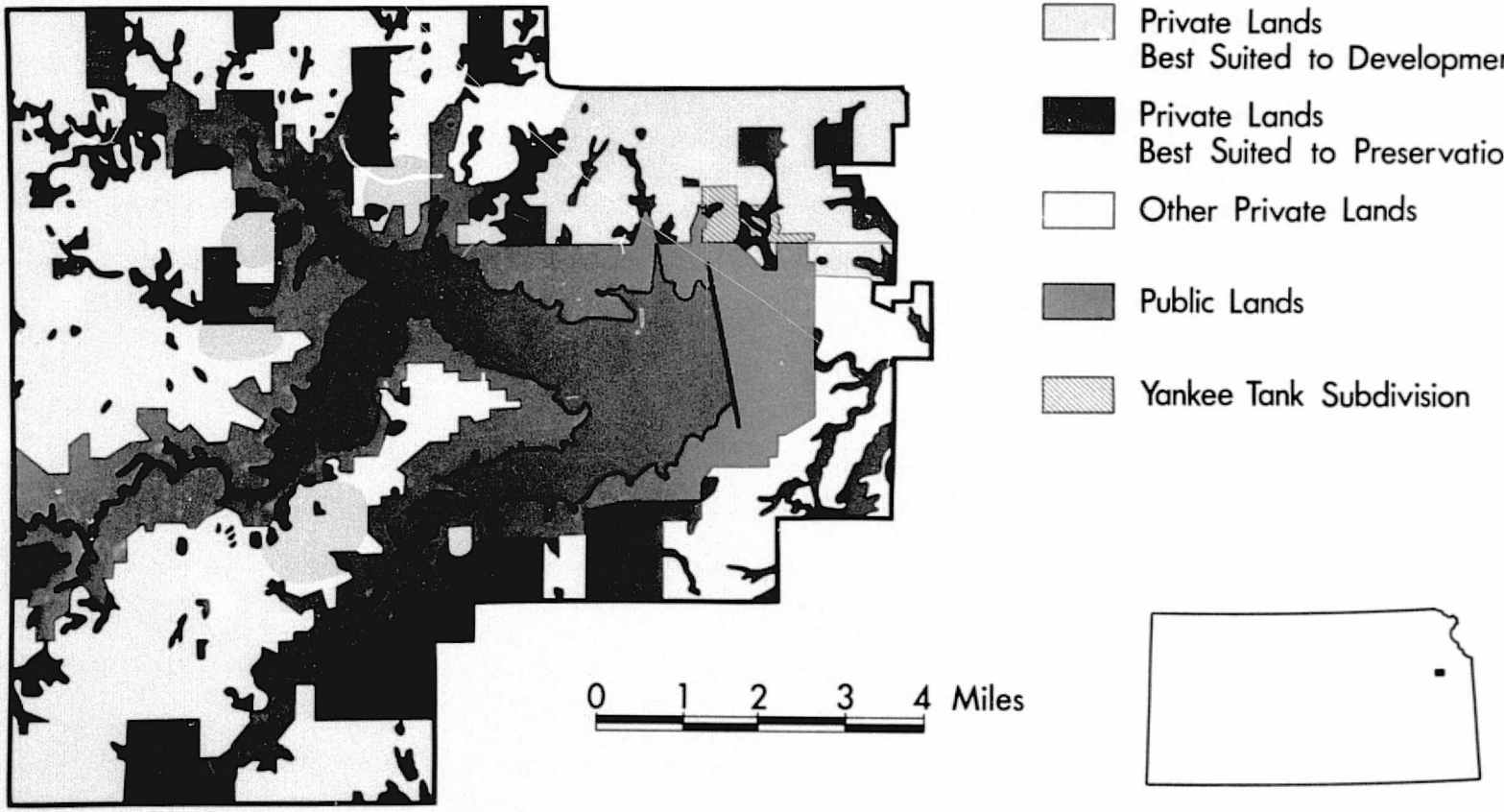
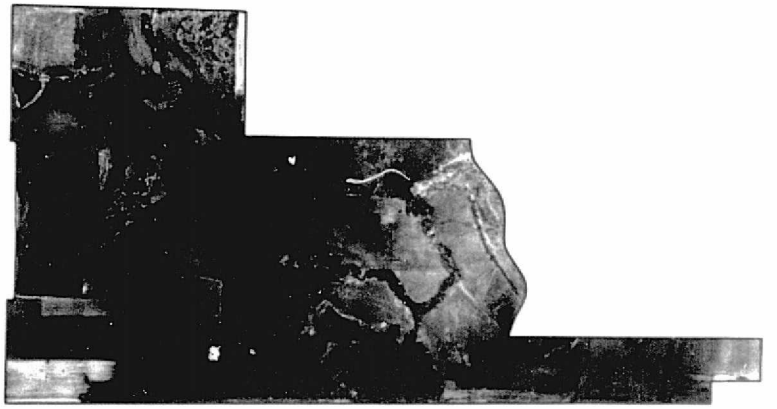


Figure 6. A map of development potential around Clinton Reservoir was compiled from data originally extracted from aerial photography

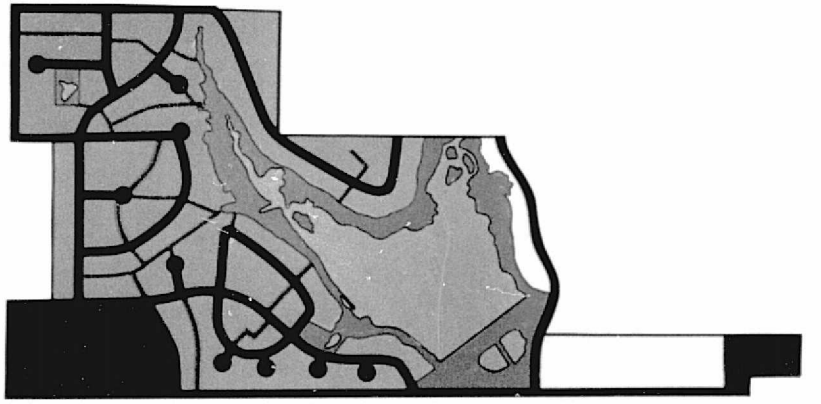
YANKEE TANK SUBDIVISION

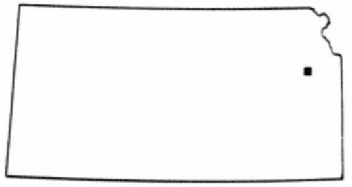
CLINTON RESERVOIR AREA

Color Infrared Photograph



General Site Plan





Single Family Residential

Multiple Family Residential

Commercial

Open Space Areas

Open Space Easements

Figure 7. Developers of the Yankee Tank Subdivision used aerial photography to design a site plan which would preserve the character of the natural environment

B. PROJECTS NEAR COMPLETION

Numerous projects are in the Completion Phase of project organization. These are outlined below, grouped as follows: (1) rural development, (2) urban projects, and (3) habitat management and environmental analysis. Some projects obviously are concerned with more than one of these areas.

RURAL DEVELOPMENT PROJECTS

1. Kansas Land Use Patterns Map

As a preliminary phase of any planning function, accurate and current data on the land use of a planning region are required. Planning agencies, such as the Kansas Department of Economic Development (KDED) and the Kansas Water Resources Board (WRB) have limited resources to target against basic data acquisition and must therefore seek methods of acquiring such data which result in the production of accurate and timely information at relatively low cost. More detailed and therefore potentially more useful maps, such as those being prepared by USGS, may become available in the future, but as of 1973 no general land use map of Kansas had been published since 1951.

During 1973 the research team of a LANDSAT-1 investigator, Dr. S. A. Morain, prepared a land use map of Kansas. The particular technique employed in preparing this map was specifically developed by J. C. Coiner and D. L. Williams, members of this research team, for the purpose of extracting statistics about Kansas agriculture. The technique, originally developed for a research site in Finney County, Kansas, was based on mapping regions which exhibited homogeneous or constantly repeating patterns of shapes, tones, and object sized on the LANDSAT-1 image.

On the basis of these image characteristics, the acreage of each ten different types of land use was estimated within each region. Results were demonstrated to be accurate within $\pm$ 5 per cent for county sized areas. This technique was then applied to the entire state by Williams and B. L. Barker, similar mapping regions were aggregated, and a land use map of Kansas was produced. This map was still a research tool, yielding statistics on irrigation, strip cropping, and other farming practices. Traditional data collection methods have never yielded statistics on strip

cropping and are always several years out of date on irrigation because of its rapid rate of expansion in Kansas.

In its status as a research tool, this map received very limited distribution. However, personnel from both KDED and WRB examined the map and discussed the accuracy and preparation time requirement with the authors. This examination and discussion led to the following actions.

KDED decided that this map, with slight modifications and updated to 1973, would provide a valuable interim planning tool until more detailed land use maps become available. They supplied the funding required for the Kansas Applications Program to convert the map from its original research status to a widely useable tool and published the map in sufficient quantity to make it generally available. Although preparation of this map represented only a modest monetary saving to the agency as compared to a map prepared from agricultural census data, the map based on LANDSAT data permitted better locational accuracy since the agricultural census data is available only for township units with average sizes greater than 36 square miles.

The map (foldout in back) which is printed in color at a scale of 1:1,000,000, shows twelve types of land use, and provides immediate evidence of the utility of remotely sensed data.

Since the map was printed, it has been widely distributed, both within and outside of Kansas. Contacts with recipients likely to be able to use the map in the decision making process are being maintained so that decisions derived from the map be identified as they occur.

2. Regional Land Use Map for the Four Rivers Resource Conservation and Development District, Kansas

The Four Rivers Resource Conservation and Development (RC&D) District includes eight counties in north central Kansas. For over two decades this region (like several others in Kansas) has suffered from out-migration. The 1970 population of the region was reported to be 99,576, down from 114,985 in 1970. Leaders in the counties desire to reverse the declining demographic trend through economic development. The RC&D project was conceived by a group of individuals in the eight county area for purposes of isolating problems and needs, developing project objectives and planning action to implement measures to solve these problems and accomplish the project objectives.

The Four Rivers RC&D Project is one of many other similar multi-county regional

planning and development units in the United States, all provided with some technical and financial aid by the U.S. Department of Agriculture (USDA). These projects are, however, locally initiated, sponsored and directed. Their purpose is to provide for unified planning and development of economic and natural resources over a broad area. In the case of the Four Rivers RC&D this area is over 6,000 square miles.

A vitally important prerequisite for initial planning and for the continued USDA assistance in a newly formed RC&D project such as Four Rivers is a map of current land use in the region. James Habiger, Four Rivers RC&D Project Coordinator, has emphasized that one of the project's main objectives is regional land use planning. "The use of land reaches every aspect of the sociological and economical makeup of the region. It is of prime importance to know land use: the wheres, whys and hows. This is a large task as the project covers nearly 4,000,000 acres and time is of prime concern. People need to be knowledgeable about land capabilities and existing land use before making any future land use and treatment decisions."

Given limited local financial resources, time and manpower, and the large area, this presents a formidable undertaking. Meetings were held at which Four Rivers RC&D project personnel and KU/NASA Applications Group representatives discussed the possibility of using LANDSAT-1 imagery to provide generalized land use information for the region.

A cooperative project was initiated in the fall of 1973. It was agreed that USDA would provide stable base drafting materials, ground truth as needed, and final drafting and reproduction services. KU Applications personnel would supply eight land use maps and eight water body maps keyed to county 1:125,000 scale highway maps. The land use classification to be employed was adopted from USGS Circular 671, "A Land Use Classification System for Use with Remote Sensor Data".

After thoroughly discussing what could be mapped using this system, the following categories were decided upon:

01. Urban and build up
02. Agricultural land
    - 02.01.01 Cropland
      - 02.01.01.01 Irrigated
      - 02.01.01.02 Dry
03. Rangeland
04. Forestland
05. Water including natural drainage, irrigation canals, water bodies (reservoirs, ponds, municipal sites, etc.)

06. Wetland

07. Barrenland

LANDSAT-1 imagery was interpreted on a Bausch and Lomb Zoom Transfer Scope. In general, land use was mapped from Band 5 (red) imagery and water bodies mapped from Band 7 (infrared). Boundaries were cross-checked on color composites and on multidate imagery.

Following initial compilation, the maps were presented to local RC&D representatives for correction and criticism. Although some errors were found, the maps were judged by project personnel to be "Adequate and far superior to any existing land use maps for this total area". After revision, the maps were forwarded to the USDA Drafting Facilities in Lincoln, Nebraska for final reproduction. The final compilation map (Figure 8) has been incorporated into the Four Rivers RC&D Project Plan (March, 1975). The project has been an impetus for stimulating several spin-off projects which are in developmental phases.

Project Coordinator Habiger has written that: "The use of these maps in the project and other planning organizations will probably vary greatly. The Four Rivers RC&D Project will spend considerable time using these maps on numerous projects. General planning of the area, land use patterns and land use conversion will probably require much time and study of existing land use conditions. The possible locations for recreational facilities, agribusiness locations and urban development can be effectively planned from the available information. Land use treatment need priorities can be established by knowing how land is used and where it lies. It is impossible to prepare a complete list of ways these maps will be used. I believe it is sufficient to say all of the 38 active committees will use these maps in every future project dealing with the use of land. We, of the Four Rivers Project, are pleased to take part in this pilot project. The use of LANDSAT and other imagery as a practical planning tool to local people indeed credits NASA and the KU Space Technology Center's desire to serve the people with the best information available in the least amount of time."

In conclusion, the land use maps were vital to the initial establishment of planning and development activity necessary to attempt a reversal of the population outflow in the Four Rivers RC&D District. LANDSAT-1 provided a means to acquire this information in a accurate, timely, and relatively inexpensive fashion. Futhermore, the maps have provided impetus for several new Applications projects which will be conducted in the eight county region during FY 75-76.

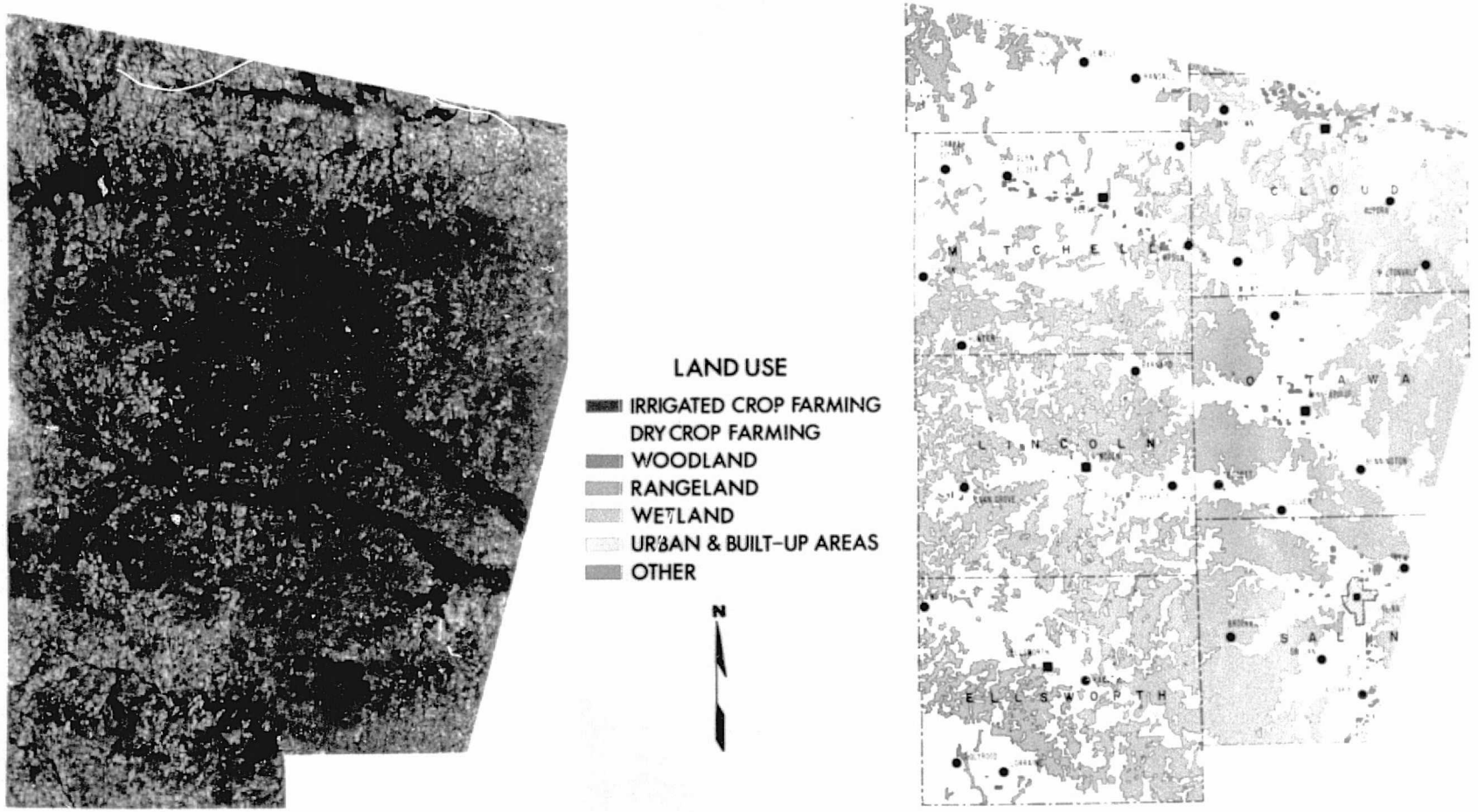


Figure 8. LANDSAT imagery was used to construct a current land use map of the Four Rivers RC&D Project

3. Land Use Map of Cherokee County

The University of Kansas Space Technology Center and Kansas Geological Survey (KGS) in cooperation with the Kansas Department of Economic Development (KDED) and Cherokee County, Kansas Commission undertook a pilot project in 1973 to demonstrate to local, regional and state decision makers the value of land use inventory information development and planning purposes. The Center acquired the aerial remote sensing imagery and interpreted and compiled the county land use maps while the Survey interpreted and compiled detailed land use maps for two of the largest communities in the county, Galena and Baxter Springs

Cherokee County is located in the southeastern corner of the state in an area where coal has been surface mined for years. Another major extractive industry has been that of mining lead and zinc deposits by subsurface methods, these deposits being a part of the tri-state mineral district. Except for a small coal strip mine near Crestline, Kansas there is no mining now being done in Cherokee County. The mining industry has created a total of 24,000 acres of disturbed land, about 6.5% of the total county area. Only about 4,000 - 5,000 acres of the strip mined land has been reclaimed for agricultural use. The lead and zinc tailings have created areas of barren, useless land covered with rock from the subsurface mining operations. These areas are incapable of supporting vegetation.

County officials and local citizens have been aware of the impact the mining industry has played on the economy. Economic prosperity flourished during the period of active mining but the area has subsequently experienced a considerable depression of the economy with the termination of activity. Until this project was undertaken, there was no ready source of information about how the land was being used or what resources existed in the county capable of development.

The more detailed mapping of the Baxter Springs and Galena areas was done from low altitude photography flown by the Center for Research, Inc. The county wide land use mapping (Figure 9) was primarily interpreted from a NASA high altitude (65,000 ft.) flight of February 1973. In conjunction with the high altitude photography, low level (CRINC) photography was used in areas where questionable land use practices were not as easily identifiable using the high altitude coverage.

The land use classification used in this study was a modification of the one proposed by U.S. Geological Survey Circular 671, A Land Use Classification System for Use with Remote Sensor Data. This classification was designed to be used with satellite and high altitude photography from which only the broad categories (Levels I and II) are recognized. Level III uses which can be discerned by photointerpreters from

NASA High Altitude February, 1973

Figure 9. High altitude photography was interpreted to produce land use maps of Cherokee County, Kansas.

low altitude photography were added to more fully define land use in Cherokee County.

Base maps were prepared for Baxter Springs and Galena which include road and railroad networks as well as drainage. The county base map was enlarged from available county road maps. Overlays were prepared to include the following categories

1. Urban and built up
2. Agricultural land
3. Forest, water and mined land

The land use mapping is now complete and the maps, data and summary report prepared by the Survey, have been provided to all organizations involved.

On January 12, 1975, representatives from the KU/NASA Applications Program and from the KGS visited with the Cherokee Commissioners in Columbus, Kansas. The method used for compiling the inventory, limitations of the data and some suggested uses for the data, was discussed. It is apparent the Commission is not fully aware of the potential of the inventory information to support action programs or decisions as they may relate to public or private sector development and improvements. Some of the nonuse may be a function of a lack of communication and coordination of all concerned with the project and the follow-up coordination has been discussed with KDED. The KU Applications Program has been given the opportunity to provide the element of primary coordination by KDED in order to stimulate usage of the date in action oriented programs of benefit to the local or regional governmental units. Several spin-off projects now appear to be forthcoming for FY 75-76.

4. Test of Automatic Land Use Map Updating Procedure

Land use maps produced by the United States Geological Survey are expected in the next several years for the state of Kansas. If these maps are to serve an optimal role as a planning base, they must be regularly updated so that they continue to provide an accurate picture of land use in the state.

The objective of this project was to employ LANDSAT-1 digital data on hand in the Space Technology Laboratories and computer programs developed under a KU LANDSAT-1 investigation to test the feasibility of updating land use maps of the type prepared by USGS. This project was to be carried out in such a way that personnel of KDED became more familiar with the problems and potentials of LANDSAT-1 type imagery and automatic classification.

The study was based on detailed mapping of a test area and general mapping of three full LANDSAT-1 digital tapes, each covering one quarter of a LANDSAT -1 image frame. These maps were prepared by fully automatic processing of the digital

data. Kansas Applications Project personnel then analyzed the products in terms of accuracy and suitability. An evaluation of outputs for the test area was made and the products were determined to be only marginally suitable for the intended purpose. However, a small experiment conducted in the same test area has demonstrated that human interpretation of LANDSAT color composite images is quite suitable for the purpose. Funds for product evaluation and human interpretation experiment from Applications Grant; all other funds from Kansas Department of Economic Development.

5. Applications of Remote Sensing in Lawrence-Douglas County, Kansas

Since May, 1972 the KU/NASA Applications Program has developed a rapport with local government officials and offices and the University community to acknowledge the availability of imagery and services at the University of Kansas Space Technology Center. The data base is available to any interested user for the application of remote sensing information.

Several flights were made covering all or parts of Douglas County through May 1972 to October 1973. A Hasselblad 70 mm camera system employing green, red, color infrared and black and white near infrared photography was flown to obtain the greatest optimum use of the film. In June, 1972 a workshop seminar was held to acquaint county and city officials with the film flown and of the capabilities that the KU/NASA Applications group could provide. Many uses have been made of the data base, some of which are listed below:

1. Interpretation of surface materials for a heat island study of Lawrence, Kansas.
2. Updating of land inventory information for publication of the Douglas County Soil Survey by the Soil Conservation Service.
3. Interpretation of road surface materials in Douglas County.
4. Development of site planning for the Kansas University Endowment Association (Clinton Reservoir).
5. Accessibility of roads and trails to future research areas along the Kansas River. (University of Kansas Department of Systematics and Ecology).
6. Investigation of success of revegetation operations of a landfill site southwest of Lawrence, Kansas (Lawrence, Kansas City Engineers Office)

Several projects are in progress and several others have been completed that have used or are using this remote sensing data base for Douglas County, Kansas and the City of Lawrence.

URBAN PROJECTS

Over the last two years the KU/NASA Applications Program has developed two major entree into the urban and regional decision matrix in the Kansas City Metropolitan Region. At the regional level this contact is through the Mid America Regional Council (MARC), while at the city level it is conducted through cooperation with the Kansas City, Kansas Department of Planning and Development. These relationships are similar to the three year association which the applications group has had with the Lawrence-Douglas County decision makers.

Kansas City, Kansas is a city of 180,000 located at the confluence of the Missouri and Kansas Rivers. The city is part of the Kansas City Standard Metropolitan Statistical Area (SMSA) of approximately 1,250,000 (1970 census). In recent years, Kansas City, Kansas, has suffered the ill effects of urban decay noted in many U.S. Cities and the city government has faced demands for improved services throughout a growing urbanized area. These conditions have in turn increased the pressure on the governmental agencies for data to support the decision making process. In the main, responsibility for the acquisition of data about conditions in the city has fallen to the Department of Planning and Development. The growing requirement for specific social and economic indicators about the city and the increased cost for acquiring a unit of data caused the city planner to initiate a search for alternative methods of data gathering.

1. Flood Disaster Response

The Department of Planning and Development first came into contact with remote sensing techniques through conferences held at the University of Kansas Space Technology Center. However, the utility of the techniques was driven home by events which occurred during the Kansas and Missouri River flooding of October 1973. Image interpreters of the Applications Laboratory provided data on a rapid response basis to support the Kansas City, Kansas/Wyandotte County Civil Defense efforts by identifying weakened areas of dikes, points where dikes were breached, debris jammed into bridges, and assessing flood damage.

Based on the flooding experience, the Department of Planning and Development recognized that remote sensing couldprovide them with timely, accurate data not available from other sources. They then requested the KU/NASA Applications Program to aid in an assessment of remote sensing data collection for the city government based on examples of high resolution color and color infrared, medium resolution color and color infrared flown by the NASA U-2 aircraft, and LANDSAT photographs.

2. Sanitation Route Allocation in Kansas City, Kansas

Solid waste has normally been collected by a single company for the entire Kansas City, Kansas/Wyandotte County area. However, when the 1975 bids were opened the costs were over that estimated by the City. This caused the City's Finance Commissioner to consider alternatives to the present single contract system. He decided to divide the city into five contract zones and let each contract separately, hoping to attract more bidders, especially the smaller minority businesses that the large size of single city wide contract had excluded.

To establish the zones so that they represented equal tonnage of waste in each zone, and to design collection routes that would most efficiently utilize fuel, a network allocation technique was used. Because parts of the county are rural, 1970 census data were toocoarse to allow allocation by use of the census data alone. The City then asked the KU/NASA Applications Program interpreters to count dwelling structures from the 1969 census city flight for the two rural Census tracts. When these data were encoded and loaded to the existing geographic base, the allocation process allowed the city to define collection zones and provide bidders with accurate estimates of numbers of dwelling units in each collection zone, thus reducing the risks to the bidders.

The Department of Planning and Development of Kansas City, Kansas, with the assistance of the KU/NASA Applications Program, has completed the conversion from total acquisition of data by contact methods to the acquisition and use of data from remote sensors. At the present time this data is mainly provided by low altitude aerial photography, however, as interpretation sophistication of the departmental staff increases, more and more emphasis is being shifted toward the use of high altitude and satellite data.

3. Evaluating Environmental Impact of Road Construction

In Spring, 1974, Applications personnel were requested to assist in providing data for an environmental impact statement for the proposed 57th Street, in Kansas City, Kansas.

The area analyzed consisted of a 7,380 foot corridor parallel to the proposed route. Low altitude large scale aerial photos acquired by the KU aircraft in May 1974 were used in the analysis. This corridor was divided into 153,820 ft. x 820 ft. cells for which land use, structure type and number, and existing road was recorded. Also an uncontrolled photo mosaic, and three map thematic land use maps were prepared.

This system was used to develop the initial impact statement that has since been

forwarded to the state for their consideration and will then be forwarded to the U.S. Environmental Protection Agency as well as making up part of the request for federal funding. In addition, the images developed for the environmental impact statement have been used as an exhibit for the public hearings.

Based on data provided from this study it was decided to widen the highway corridor in order to diminish the impact of noise to surrounding areas.

The environmental impact data interpreted from 70 mm imagery provided the city with social, economic and physical environment data in a 5km^2 (2mi^2) corridor for a total cost of less than $500.00, including data interpretation.

4. Kansas Geographic Information System; Cherokee and Wyandotte County Pilot Projects

A major problem limiting the use of remotely sensed data has been its unique handling requirements, which in the past have made it unsuitable for incorporation in existing nonautomated urban information systems that support the political decision structure. With the introduction of the concept of a geographic information system, which retains the spatial component of both socio-economic and environmental data, an opportunity to introduce remote sensing data into the flow of information supporting decision makers arose. This opportunity rests on the fact that data from LANDSAT-1 and small scale, medium resolution sensors on platforms such as the U-2 retain spatial information critical for creation of the geographic base file. Within this context U-2 imagery of Cherokee County, Kansas has been used to create a small, 900 cell, 15 data element grided array. And based on this file Wyandotte County and Kansas City, Kansas are exploring a U-2 data base file to supplement and expand their existing base file created from census data.

The objective of this project was to context remote sensing data in terms of an overall information system that includes data acquisition, interpretation, storage, analysis, and display. A preliminary pilot project using a segment of Cherokee County, Kansas was undertaken to demonstrate that: (1) base files containing useable socio-economic and environmental data could be created from U-2 imagery, (2) the interpreted data points could be stored on a UTM based grided array, and (3) using the grided array, the data points could then be thematically mapped using Calcomp computer driven plotters.

A 50 sq. km area of Cherokee County, Kansas was interpreted. This interpreted data was overlayed with a 125 m x 125 m grid, each cell equalling 6.25 hectares. The information was then put into computer format for a series of 15 pre-selected data

elements concurring present land use, physical environment and cultural factors. These data elements were then stored on computer tape and used to create a series of color thematic maps of various data elements.

The above system has been explained to state and local officials, and to the Czark Regional Council. All have expressed interest in its use.

Data to support the various administrative departments of the Kansas City, Kansas government are maintained in a series of computer files, known generally as an urban information system. These base files contain a map of the urbanized area constructed from the transportation network. The geographic base file project, which was initiated in 1972, had by 1974 reached the level of sophistication where land use data concerning every parcel of land in Kansas City/Wyandotte County could be stored in the file. To determine if this project was feasible the city hired six college students over the 1974 Christmas holidays. After training by Applications Laboratory personnel and using high resolution aerial photography and collateral sources, these employees interpreted and encoded the land use of every parcel of land in a 16 km^2 (10 mi^2) area of the inner city.

5. Census Tract Division: Mid America Regional Council

The Mid America Regional Council (MARC) is a regional planning body, consisting of elected officials from eight counties in the Kansas City Metropolitan Area (Leavenworth, Wyandotte and Johnson Counties in Kansas and Jackson, Platte, Clay, Ray and Cass Counties in Missouri).

KU/NASA Applications staff members were asked to provide data to divide nine suburban census tracts for the 1980 census. This project used U-2 imagery to establish rational census tract boundaries, which conform to census tract requirements for minimum population variance from tract to tract. This will allow the Census Tract Committees (local citizen groups) to have more objective data than is now available from estimated population changes and aggregated data on new dwelling unit construction. In turn, more rational division of census tracts would provide more accurate social indicators to aid in urban program decisions.

Enlarged U-2 color infrared aerial photography was delivered to MARC planners. Suggested tract boundaries, based upon housing density and population estimates were outlined on overlays. MARC personnel indicated that the support data had been obtained from more conventional sources. A definitive decision on the tract boundaries will be shortly forthcoming.

1. Mapping Center Pivot Irrigation in Southwest Kansas

Center pivot sprinkler irrigation is a recent innovation to agricultural practice in the Great Plains of North America. The circular shape of fields irrigated with center pivots is anomalous on images of Kansas because most fields are rectilinear. Consequently, center pivots are readily distinguishable on aerial photographs and on images produced by LANDSAT.

One area of high suitability for the use of center pivot irrigation is in southwestern Kansas. Since center pivot irrigation was introduced into this region in the early 1960's it has undergone a rapid expansion and by early 1974 2,223 center pivots had been installed in 12 southwestern Kansas counties, thereby bringing more than 300,000 acres into sprinkler irrigated crop production. This represents approximately 12 per cent of all land annually harvested from crops in the region. Expansion has been and continues to be rapid throughout the region primarily because the availability of center pivot systems has made possible the opening of new land to cultivation and has proved extremely productive in terms of crop yields on these newly cultivated lands (Figure 10). The availability of well drillers and sprinkler systems appears to be the only factor limiting installation rates.

Because of the periodic coverage supplied by LANDSAT, it has been possible to monitor the annual increase of center pivots in the region. How growth may be charted is exemplified by the case of one county where 11 center pivots were present in 1965. U.S. Department of Agriculture aerial photographs acquired in 1971 were interpreted to indicate an increase in 252 center pivots by that year. The annual increases for 1972 through 1974 were, respectively 86, 121 and 131 new installations, giving the total of 590 units in the county in 1974. The pattern of growth illustrated by Figure 10 clearly demonstrates the continued rapid diffusion of the innovation in this region.

The primary impact of growth of center pivots may be stated with respect to three factors. (1) This irrigation system has affected crop production in two ways: (a) by shifting production away from wheat and into feed grains, particularly corn, and (b) by sharply increasing total production of agricultural corps in the region. (2) Natural vegetation is being removed from substantial areas, particularly in the Sand Hills south of the Arkansas River, because of the effectiveness of center pivots on sandy soils. The new irrigation system has, then greatly reduced the area of native grassland and replaced it by irrigated cropping. (3) The use of ground water to supply this irrigation system as well as flood irrigation systems already in place is leading to a decline in the

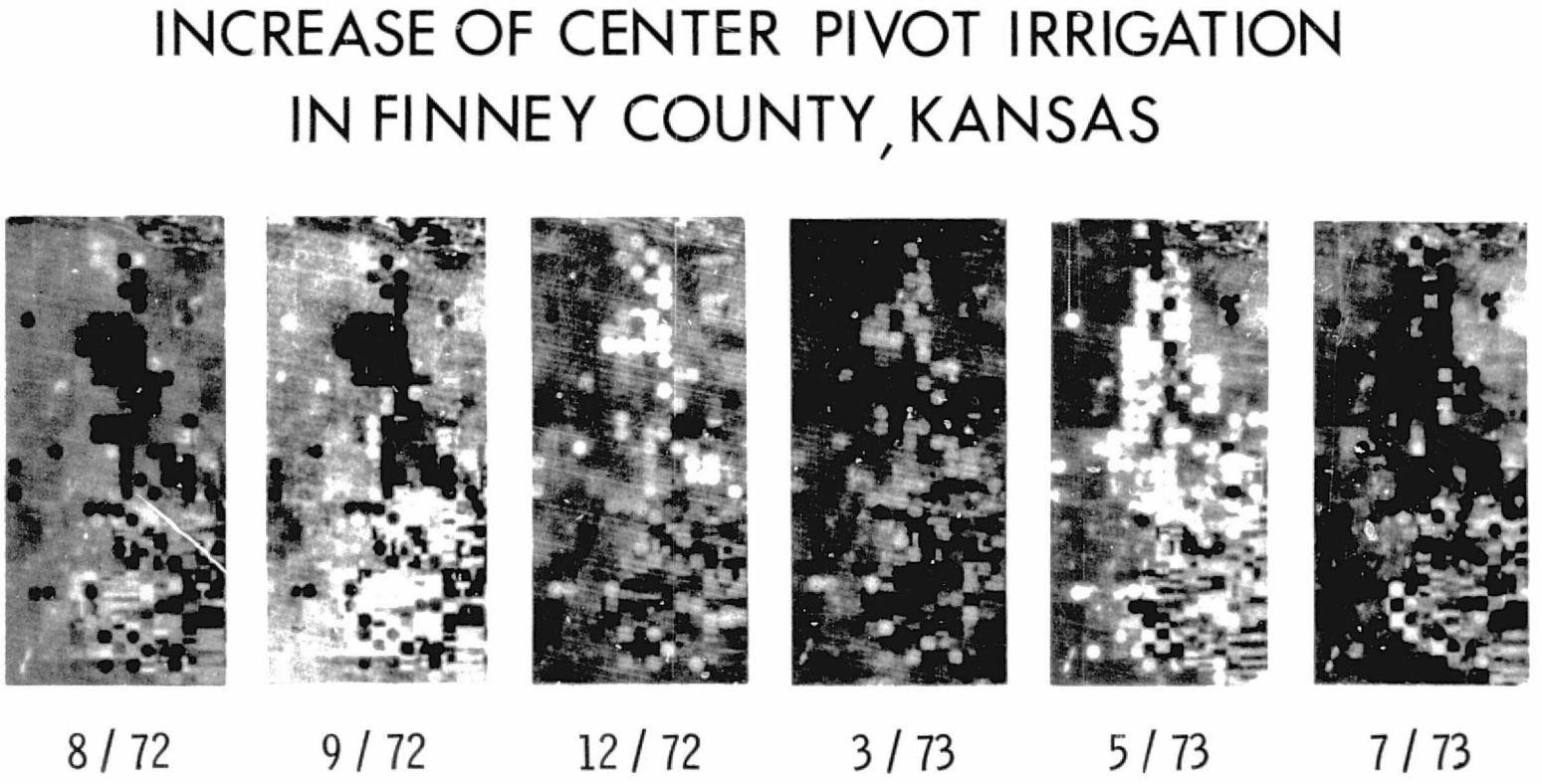


Figure 10. The rapid increase in numbers of center pivot irrigation system is evident on LANDSAT imagery.

availability of groundwater since use exceeds the recharge to the rock formations which yield water in this area.

Personnel of the Kansas Forestry, Fish and Game Commission are engaged in a conservation effort aimed at stabilizing or increasing the desirable habitat of the lesser prairie chicken. In the last hundred years the range of this bird in the United States has diminished considerably, due principally to destruction of its habitat, native grasslands. Southwest Kansas has remained one of its last major refuges. Game biologists view with concern the growing number of center pivot systems which are usurping a considerable area of native grasslands. In the past, however, there has been neither the time, manpower, nor money to accurately keep track of the number of locations of the center pivots. LANDSAT-1 imagery can be used to provide this needed information.

A previous study of center pivot irrigation systems in the region was conducted in the summer of 1972 (Williams, Barker). This particular study included the counties of Hamilton, Stanton, Morton, Stevens, Seward, Meade, Clark, Ford, Hodgeman, Finney, Kearney, Gray, Haskell and Grant. LANDSAT-1 data from the summer of 1973 was used to update the number and distribution of irrigation systems (Figure 11).

In the fall of 1974, KU/NASA Applications personnel held a workshop in Garden City, Kansas to train game managers and others working in the southwest Kansas area to use LANDSAT-1 imagery. As a result they are now able to monitor changes in the systems themselves. This allows them to more efficiently plan the concentration of their management efforts.

The information was presented to the regional office in the form of a clear transparent overlay delineating center pivot irrigation systems on a base map of the fourteen county area at a scale of 1:500,000. The map has been used extensively.

Knowledge of the extent of center pivot irrigation is important in order to better manage the prairie chicken population. This data is enabling the management program personnel to locate new areas of center pivot irrigation and to begin developing cooperation with local center pivot irrigation in maintaining and preserving wildlife habitat for the prairie chicken population.

Recently, the Kansas Water Resources Board has also indicated an interest in monitoring the expansion of center pivot irrigation. Pumping ground water for irrigation in southwest Kansas, as well as in other parts of the Great Plains, has substantially lowered the water table. Again, there has been no adequate means for keeping an accurate tabulation of new systems. Using maps compiled from LANDSAT-1 imagery,

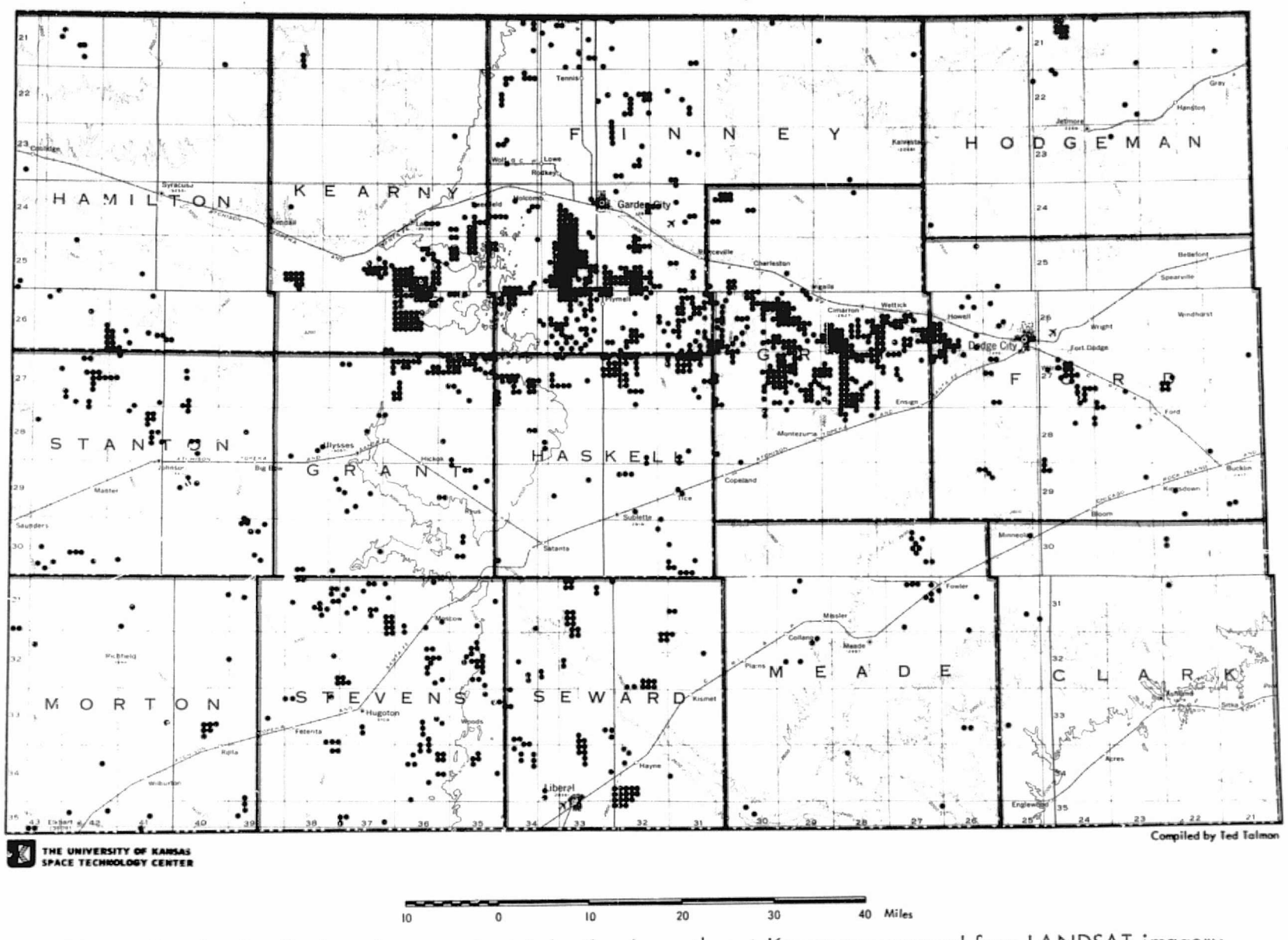


Figure 11. The distribution of center pivot irrigation in southwest Kansas was mapped from LANDSAT imagery

superimposed on groundwater maps, water managers can relate the number of new irrigation systems to the average quantity of water pumped for each in gallons per unit time and arrive at a more accurate estimate of groundwater depletion rates. Furthermore, they can locate more easily areas in which further expansion of center pivot irrigation would be feasible. The Kansas Water Resources Board, the Kansas Geological Survey, and a State legislative committee seek to correlate the expansion of center pivot irrigation with groundwater utilization.

Maps of center pivot systems are being updated to show expansion during 1974 and 1975. This project will provide the critical data to be used in the development of a series of state policy statements on irrigation based on existing well records of water table drawdown and areal expansion elements from LANDSAT. Regulatory agencies will use this to decide how Kansas' limited water resources should be used for the maximum social benefit with minimum environmental impact. Major funding of this effort is expected from the Kansas Water Resources Board and the Kansas Geological Survey in FY 75-76.

2. Using Remote Sensing for Wildlife Habitat Inventory in Kansas

The Kansas Forestry, Fish and Game Commission is charged with the responsiblity of managing the wildlife resource of the state (over 82,000 square miles). In these times of environmental awareness the maintenance of healthy natural eco-systems would, in itself, merit careful attention to decision making with regard to wildlife. Additionally, however, hunting and related outdoor activities are major revenue producing concerns in Kansas. These considerations mean that decisions made by the Forestry, Fish and Game Commission must be made on the basis of as accurate and timely data as possible.

An integral part of the data base for any wildlife management operation should be an inventory of the spatial distribution, areal extent, and degree of interspersion of current and potential wildlife habitat types. In addition, there must exist the capability to update this inventory at regular intervals.

To date in Kansas the only intensive inventories of this scope have been conducted on public land near state lakes and reservoirs or on other land where a local problem has been recognized. Areas covered are usually not in excess of several square miles. Yet 95 per cent of the small game harvest in the state is off of private land, almost all uninventoried. A much more extensive inventory is needed.

Current modes of data collection (largely "pencil and paper") are much too cumbersome and inaccurate for the type of state wide habitat survey which is required. The Forestry, Fish and Game Commission is, therefore, extremely interested in assessing the capabilities of remote sensing for acquisition of habitat information.

A pilot study conducted in Jefferson County, Kansas using available imagery, showed high altitude aerial photography to have both the resolution and the expansive spatial coverage necessary for a statewide habitat inventory. LANDSAT imagery appeared to be of secondary value, but may have considerable utility as a tool for repetitive monitoring of regional change in habitat condition.

Analysis of high altitude (65,000 ft.) color infrared imagery of Jefferson County, Kansas was completed in March, 1974. Though this imagery was acquired at a less than optimal time of year (March), and was accompanied by no concurrent ground truth, it has been useful in several ways:

1. it has aided in the development of a habitat mapping classification viable from the standpoint of the imagery limitations and, equally important, useful to Forestry, Fish and Game resource managers;
2. it has aided in the development of image interpretation and data recording techniques specialized for the habitat mapping problem; and
3. it has provided a basis of interaction between FF&G and CRINC personnel, helping us each become aware of the others needs and problems.

Working on Jefferson County imagery it was decided to make the 10 acre cell the basic unit of classification. Within each cell dominant and secondary habitat types are indicated. Commensurate with agency requirements, all data recording is oriented toward computer storage, retrieval, processing and mapping. (Figure 12) A published report on this work has received largely positive response from game management personnel. Some modifications in the land use classification were suggested and a revision has been circulated.

On May 15, 1974 NASA provided high altitude coverage of a transect across northern Kansas. Contained on this photography are images of test sites in three counties previously selected as representative of the major ecological units of the state; the short grass prairies (Thomas County), mixed prairie (Ottawa County), and tall grass-woodland mosaic (Jefferson County). Analysis of this more optimal imagery of these test areas has been completed and should provide the basis for a final evaluation of the proposed habitat inventory system. A report is in preparation.

Kansas Forestry, Fish and Game Commission personnel have been engaged in all

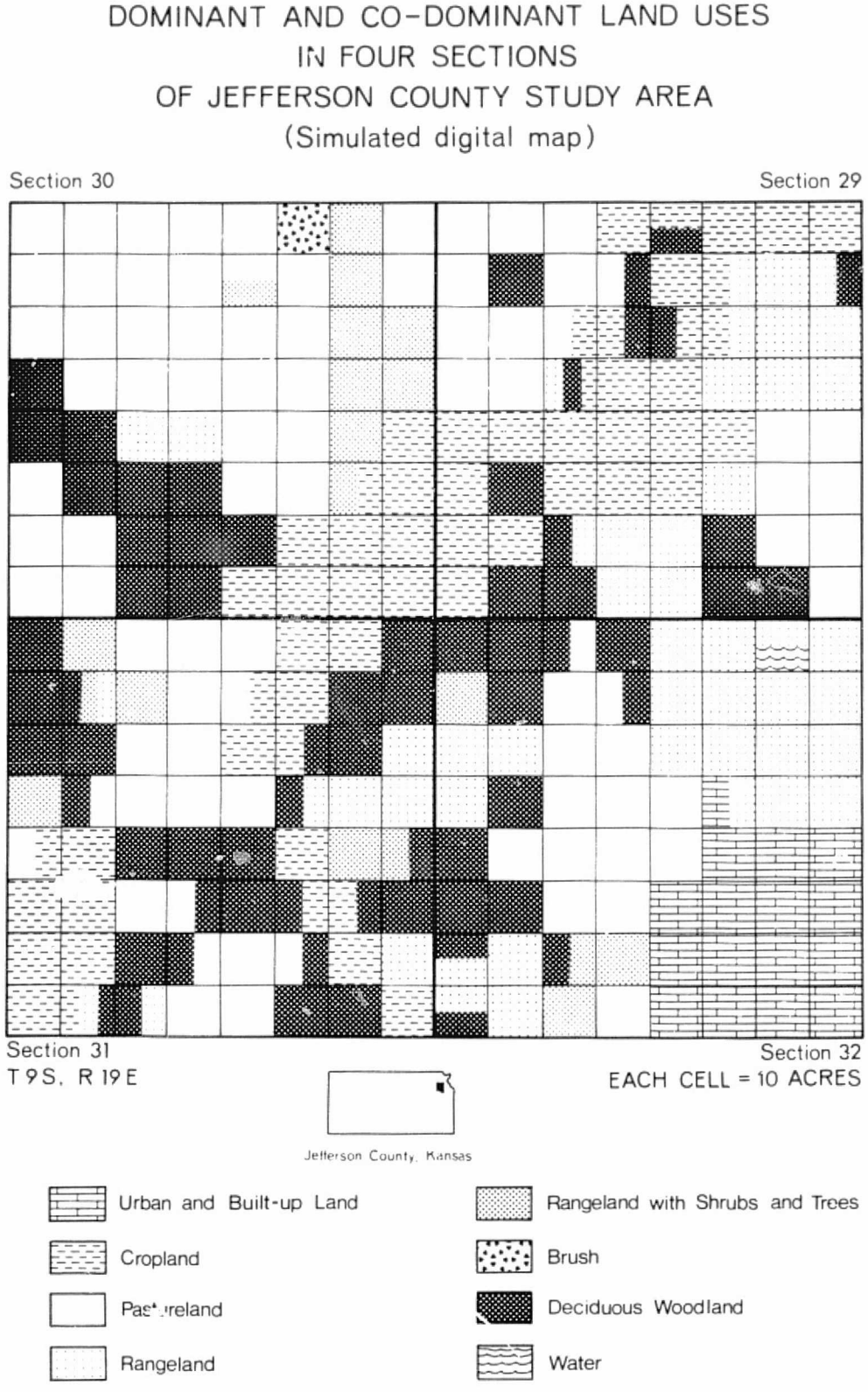


Figure 12. High altitude photography provided the data for a cellular map of wildlife habitat in Jefferson County, Kansas.

major decisions and are actively participating in all phases of the study. Mr. Bruce Waddell (a wildlife biologist) has been hired by the agency to work full time on this project. As a result of our findings, KFF&G has proposed to the Water Resources Council that a habitat inventory of the state be conducted based largely on remotely sensed data. During the next six months the Commission expects to receive a response to this request. Should federal funding not be forthcoming, state action on such a plan is expected. Furthermore, KFF&G has let a $6,000 contract with Bendix Aerospace to investigate the potential for automatic habitat identification from LANDSAT tapes.

3. Habitat and Stream Order Mapping of the Chikaskia River Basin

Watersheds comprise convenient natural units for a multitude of resource planning purposes. Fish and game management personnel have expressed interest in obtaining land use and stream order maps and statistics for several drainage areas in southwest and south central Kansas including the Chikaskia River, Walnut Creek, Arkansas River, Cimarron River, Medicine River, and Salt Fork Watersheds.

The Chikaskia River Watershed, an area of some 2,100 square miles in south central Kansas, will be the focus of a great deal of developmental activity in coming years, possibly including two major reservoirs. KFF&G personnel, the U.S. Fish and Wildlife Service, and planning personnel in the Sunflower Resource Conservation and Development (RC&D) District all require data on the area. Habitat and stream order maps, prepared from 1973 SKYLAB photography and LANDSAT-1 imagery, have been completed and, along with statistical data, have been delivered to the agencies concerned. The data have been used to determine accurate acreages of habitat types, to develop environmental quality plans for the basin, and to decide upon sampling areas for more intensive analysis. A recent U.S. Fish and Wildlife Service report in which this information was used strongly recommended that methods other than large reservoirs be considered for satisfying the water resources needs of the basin. During the FY 75-76 we will document decision related uses of these maps by wildlife agencies and regional planning groups working within the watershed, and will produce a final report outling a methodology for accomplishing similar watershed studies which will be used as a means for demonstrating to management personnel working in other areas the techniques for producing such information themselves.

4. Mapping and Monitoring of Vegetation in Cheyenne Bottoms Waterfowl Management Area.

The Cheyenne Bottoms Waterfowl Mangement Area, encompassing approximately 19,000 acres in Barton County, Kansas (Figure 13) comprises perhaps the most important waterfowl and shorebird habitat in the state. Sustained elevated waterfowl and shore bird population levels at Cheyenne Bottoms (and similar waterfowl management areas) are largely dependent on the degree to which optimal habitat conditions are maintained in the marsh. These conditions include adequate water levels, dependable water supply, and vegetation favorable for feeding and distributed so as to provide sufficient cover.

Dikes, canals and other structures have been installed under the direction of the Kansas Forestry, Fish and Game Commission to insure a constant water supply and to provide water control. An important part of the management of this large wetland area involves draining and filling some of the five pools annually in order to plant and/or control vegetation within the tract. However FF&G personnel indicate that not enough is known concerning the overall effect of the dewatering on perimeter vegetation, or of the effects of other changes in water level on distribution of plants such as cattail. It would be highly valuable for them to predict the effect of watering and dewatering on vegetation. Monitoring of changes in vegetal characteristics over a period of time could provide an indication of more opportune watering and dewatering periods.

Another of the major challenges facing the managers at Cheyenne Bottoms is to increase the vegetation-water interspersion in various sections of the marsh. In general, waterfowl and other marsh denizens prefer to inhabitat a highly interspersion environment having open water for feeding, nesting and travel. Locating problem areas where vegetation has left little open water can be difficult in itself. Monitoring these sites to determine if management techniques are having the desired effect of opening the vegetation has previously been nearly impossible.

Habitat management of Cheyenne Bottoms is presently in the hands of three persons, all of whom have other duties as well. It is difficult, if not impossible, for these men to accurately know what effects changing water levels are having on critical vegetation in the various pools. Changes in vegetation distribution and coverage can be quite rapid. Periodic aerial surveillance of vegetation conditions would be extremely beneficial in enhancing management of the wetlands. KU/NASA Application's personnel, working with Kansas Forestry, Fish and Game Commission

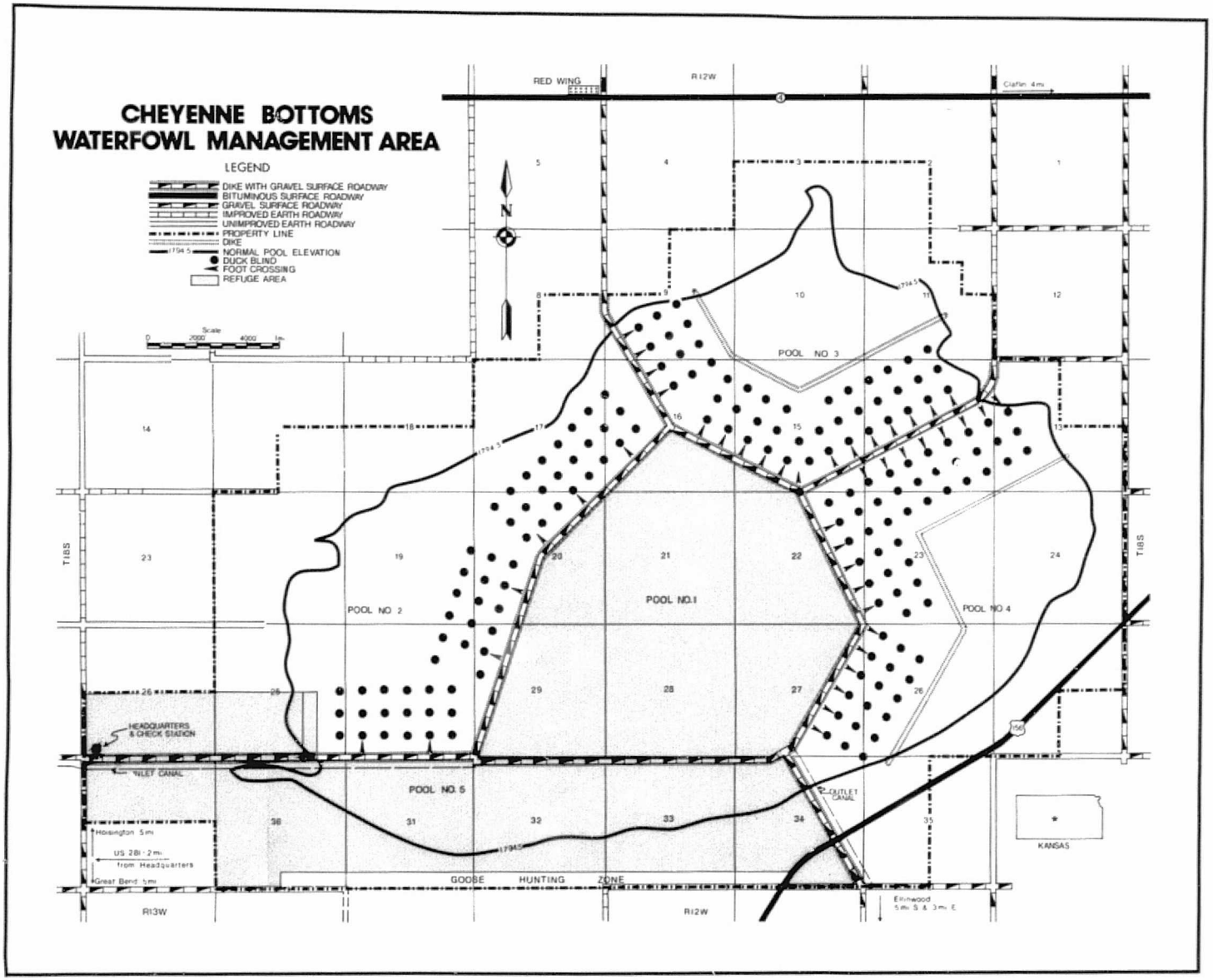


Figure 13. Dikes divide the 19,000 acre Cheyenne Bottoms Waterfowl Management Area into five pools.

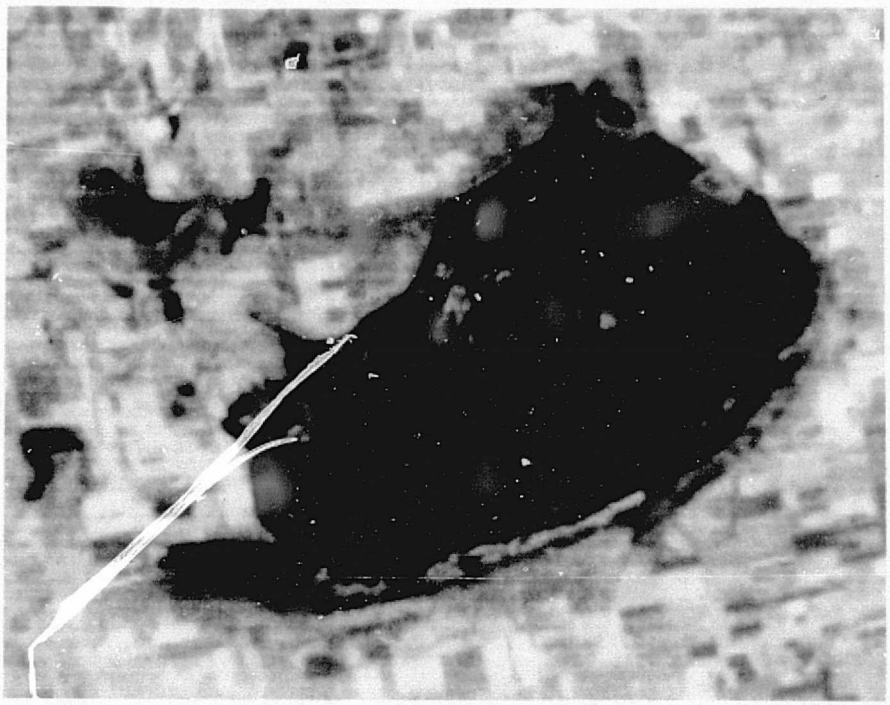
managers and biologists on the use of remote sensing for habitat management, have introduced LANDSAT-1 imagery and multiband aerial photography as a management tool at Cheyenne Bottoms.

The primary objective of this project is to test the feasibility of using LANDSAT-1 imagery to map and monitor changes in wetland vegetation in Cheyenne Bottoms Waterfowl Management Area to a degree of detail and accuracy suitable for FF&G management programs. A secondary goal is to aid FF&G regional management personnel in becoming familiar with and developing some skill in using in their routine management programs LANDSAT-1 imagery and multiband aerial photography. In the fall of 1974 Mr. Robert Bartels, Kansas Forestry, Fish and Game, District Game Biologist at Cheyenne Bottoms, attended a workshop conducted by KU Applications personnel to train game managers and others to use LANDSAT imagery. This has aided in his adoption of these techniques.

Black and white infrared aerial photography was acquired over Cheyenne Bottoms by the KU aircraft in August, 1974 and has been supplemented by color infrared photography acquired commercially in September, 1974. This imagery is serving as an immediate tool from which biologists at the marsh are making management decisions and also provides base line "ground truth" from which vegetation changes monitored on LANDSAT imagery may be compared and measured. The aerial photography has been mosaiced and delivered to management personnel and is being used to map existing aquatic vegetation and to locate areas of cattail to test some techniques designed to promote better vegetation-water interspersion.

A series of time sequential "pool histories" have been compiled from LANDSAT imagery and delivered to wildlife biologists working at the "Bottoms". Managers can observe on this imagery changes in each pool that have occurred since July 1, 1972.

Infrared (Band 7) imagery appears to be much more useful than other spectral bands for distinguishing vegetal communities. Seasonal changes in growth and distribution of marsh plants and alterations in vegetal patterns from year to year are readily apparent (Figure 14). This temporal formation was previously unavailable to the managers. The "pool histories" provide information on vegetation species and distributions which may ultimately lead to decisions related to restructuring the watering and dewatering periods within the various "pools" in order to produce



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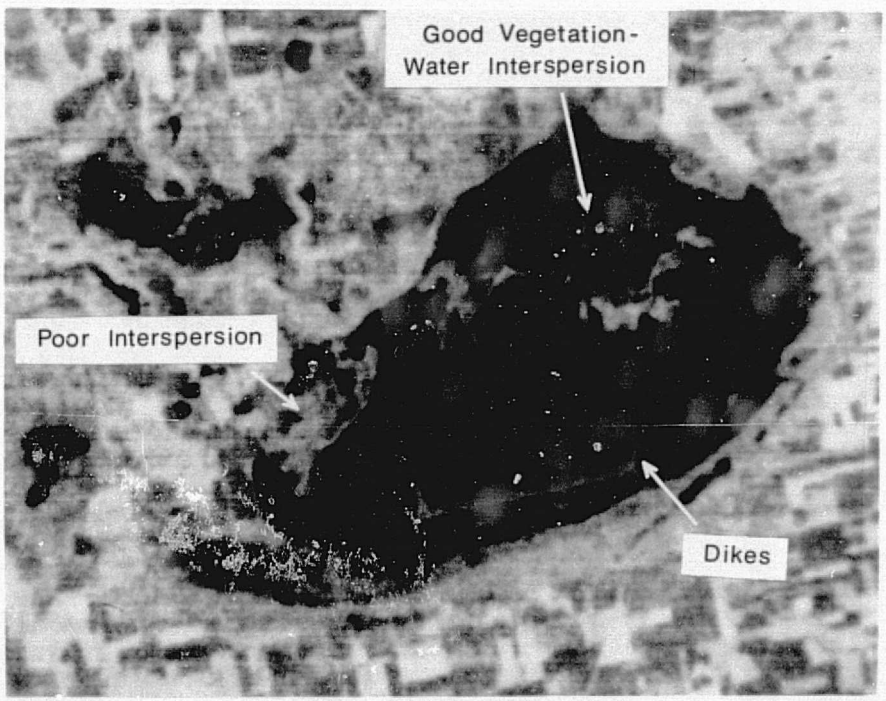

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Figure 14. Annual changes in marsh vegetation at Cheyenne Bottoms are evident on infrared LANDSAT imagery.

more optimal habitat conditions. Already the imagery has been used to determine percentages of vegetation and open water for the National Wetlands Inventory, to observe effects of changing water level on wetland plants, and to locate areas in which managers may attempt to promote better vegetation-water interspersion.

III . CONCLUSION

The projects completed by the KU/NASA Applications Program and outlined in the preceding chapters point to the expanding role of remote sensing in state and local frameworks in the State of Kansas. During the past three years personnel of the KU/NASA Applications Program have brought to the attention of decision makers in Kansas an introduction to the potential of remote sensing as a data collection source. This introduction has been achieved by a variety of specific assistances as well as general information activities. Specific activities in FY 74-75 have included assistance to state, local and regional officials on over 15 projects upon which products have been delivered. These projects, now in the completion phase of development, are in a wide variety of areas from rural development and urban projects to habitat management and environmental analysis.

KU/NASA Applications staff members have also contributed to (1) provision of data bearing upon the decision to cancel the construction of the Pattonsburg Reservoir and to proceed with completion of Interstate 35 (northwest Missouri), and(2) to adopt a course of development around the Clinton Reservoir (northeast Kansas) designed to preserve the natural environment. General activities have included production of a map of Kansas Land Use Patterns from LANDSAT-1 imagery and two workshops demonstrating the use of remote sensing imagery to a diverse group of state and local officials. As a result of the establishment of these contacts and demonstration of ability to meet specific case needs in a state, regional and local setting a number of programs have emerged at these governing levels. These programs provide the basis for continued work.

APPENDIX I

Kansas Government Journal, Article

APPENDIX II

Selected "KERS Newsletters"

KANSAS ENVIRONMENTAL RESOURCE STUDIES

NEWSLETTER

Volume 3, Number 9
October 1974

Mapping and Monitoring Vegetation in the Cheyenne Bottoms Waterfowl Management Area

The Cheyenne Bottoms Waterfowl Management Area, encompassing approximately 19,000 acres in Barton County, Kansas, constitutes some of the most important waterfowl habitat in the state. In the course of managing the tract, Kansas Forestry, Fish and Game personnel periodically fill and drain each of the area's five pools in order to control vegetation.

In coming months applications project personnel Jim Merchant and Ted Talmon will be working with Forestry, Fish and Game biologists to determine if ERTS-1 imagery, acquired every 18 days over the Cheyenne Bottoms area, can be used to monitor changes in vegetation as water levels in the pools fluctuate. Management specialists would find it highly valuable to be able to accurately predict effects of watering and dewatering. Monitoring of changes in vegetal distribution over a period of time could provide an indication of more opportune watering or dewatering periods.

Initial data collection began in September and will include low altitude photographic coverage of Cheyenne Bottoms by the CRINC aircraft. Further information on this project may be obtained by contacting either Jim Merchant or Ted Talmon at the KU Space Technology Center, phone (913) 864-4775.

Mapping of Cherokee County is Completed

The Satellite Applications Laboratory personnel announce the recent completion of land-use mapping for Cherokee County, Kansas. The maps are at a scale of 1:63,360 and consist of a set of three thematic transparency overlay maps and a base map. The thematic maps include a land-use map, a woodland map and and a water body map. The thematic maps were prepared by the staff of the Satellite Applications Laboratory by analysis of ERTS-1 imagery, high altitude and low altitude photography. The land-use categories were derived and modified from U.S. Geological Survey Circular 671, "A Land-Use Classification System for Use with Remote Sensor Data." The mapping was performed as a cooperative effort including the KU Satellite Applications Lab, Kansas Geological Survey, Cherokee County, Kansas Commissioners, and Kansas Department of Economic Development.

Ozalid paper copies of the maps are available at cost from the Satellite Applications Laboratory.

Aircraft Acquisition

The University of Kansas Center for Research, Inc., announces acquisition of a second twin Beech aircraft. This aircraft has been acquired

by donation transfer from the government and it is anticipated to be airlifted from the former Olathe Naval Air Station to Lawrence Municipal Airport in the near future. The aircraft will not be certified for flying but will be used as a source of spare parts and improvements for the operational twin Beech.

Meetings

The Institute for Graphic Communication announces an intensive conference to be held at the IGC Conference Center, Castle Hill, Ipswich, Massachusetts, October 6-8, 1974. The title of the conference is "The Surface of the Earth--Tomorrow's Information Needs for Economic, Energy and Environmental Planning." The conference will specifically deal with mapping and remote sensing and will include a technology and business forecast. Fee is $385.00. For further information contact the IGC at 375 Commonwealth Ave., Boston, Mass., 02115 (tel. 617/267-9425) or R. L. Walters, KU tel. 913/864-4775.

Publications Received

The following is a list of new publications received in the STC Reading Room for reference:

Wanderath, Sandra, et al., 1974, Multispectral Photography for Earth Resources, 257 pp., West Hills Printing Co., Huntington, N. Y., $19.95. From the author's preface: "This manual has been written for those persons involved (or expect to be involved) in the routine applications of multispectral photography with regard to space or aircraft assessment of the environment. Many individuals fall into this category: The users whose prime interest lies in the photo interpretation of the final results; the photo technicians whose principal concern rests with the precision processing of multispectral imagery; the student who desires to know what multispectral photography is all about; and the aerial photographer who wants to broaden his background."

Martin, K. R., and F. J. Wobber, 1974, "Flooding Analysis by Satellite Imagery," Photographic Applications in Science, Technology and Medicine, vol. 9, no. 4, July 1974, pp. 18-21, 38. The authors describe how satellite remote sensing can be a new source of information in assessing flood damage. Specifically, the authors examine the use of ERTS-1 imagery acquired pre-flooding, during and post-flooding to determine the extent of flood water inundation which occurred during April and May 1973 in the Mid West.

Schwarz, G., 1974, "Applications of Equidensities," Photographic Applications in Science, Technology and Medicine, vol. 9, no. 3, May 1974 pp. 30-32. The author describes the methods involved in the use of Agfa Contour Film to investigate false color enhancement, edge enhancement, and contour information extraction through the use of the equidensity properties of the film.

Blanchard, M. B., and R. Greeley, 1974, "Use of visible, Near-Infrared and Thermal Infrared Remote Sensing to Study Soil Moisture," NASA Technical Memorandum TM X-62,343, 4 pp.

ABSTRACT: Measuring soil moisture is an objective for many investigators. Applications of remotely determined soil moisutre range from agriculture (where moisture relates to crop growth) to civil works (where moisture relates to slope failures in levees, dams, and along highways). Two methods are used to estimate soil moisutre remotely using the 0.4-to 14.0-micron wavelenth region: (1) measurement of spectral reflectance, and (2) measurement of soil temperature. The reflectance method is based on observations which show that directional reflectance decreases as soil moisture increases for a given material. The soil temperature method is based on observations which show that differences between daytime and nighttime soil temperatures decrease as moisture content increases for a given material. In some circumstances, separate reflectance or temperature measurements yield ambiguous data, in which case these two methods may be combined to obtain a valid soil moisture determination. In this combined approach, reflectance is used to estimate low moisture levels; and thermal inertia (or thermal diffusivity) is used to estimate higher levels. The

reflectance method appears promising for surface estimates of soil moisture, whereas the temperature method appears promising for estimates of near-subsurface 0 to 10 cm). Both methods require additional laboratory and field investigations.

Articles of interest appearing in Photogrammetric Engineering, vol. 40, no. 6, June 1974:

Evans, W. E., "Marking ERTS Images with a Small Mirror Reflector," p. 665-671. The author describes a method of generating identifiable artificial landmarks on ERTS imagery by use of a small mirror carefully positioned to reflect the sun's energy into the satellite's optical sensors at the time of an overpass.

Ciesla, W. M., "Forest Insect Damage from High-Altitude Color-IR Photos," pp. 683-689. The authors report the results of analyzing color infrared photography taken from a U-2 aircraft flown at high altitude over known insect damaged forestland.

Reeves, R. G., "Education and Training in Remote Sensing," pp. 691-696. The author describes the functions of the EROS Data Center including training and assistance in the transfer of technology of extraction of information from remote sensor data, and the application of remote sensing to resources and environmental problems.

Vizy, K. N., "Detecting and Monitoring Oil Slicks with Aerial Photos, pp. 697-708. The author reports a method for detecting oil slicks by aerial photographic reconnaissance utilizing standard black-and-white aerial film. Significant detection was found in the ultraviolet and blue regions of the spectrum, less in the near infrared and almost none in the green and red.

Singh, R. S., and J. P. Scherz, "A Catalog System for Remote Sensing Data," pp. 709-720. The authors describe a practical, workable system employing cards for cataloging, indexing, filing, and retrieving remote-sensing data.

Articles of interest appearing in Photogrammetric Engineering, vol. 40, no. 5, May 1974 (issue featuring multispectral techniques):

Raines, G. L., and K. Lee, "Spectral Reflectance Measurements," pp. 547-550. The authors describe an economical filter-wheel photometer for measurement of spectral properties of rocks and soils in situ.

Kreitzer, M. H., and B. Gilbertson, "Exposure for Multispectral Photos," pp. 551-557. The authors describe a method whereby exposures for narrow spectral bands can be accurately made. They report that a simple radiance measurement on a target can be related to a pre-selected density on film for a specific spectral band.

McDowell, D. Q., and M. R. Specht, "Determination of Spectral Reflectance Using Aerial Photographs," pp. 559-568. The authors report that a relationship can be developed between the exposures incident on a color film and scene spectral reflectance providing a method by which spectral reflectance curves can be generated from film-density data.

McDowell, D. B., "Spectral Distribution of Skylight Energy for Two Haze Conditions," pp. 569-571. The author reports the results of measuring the spectral distribution of incident energy on a hazy day and clear day and effects on color balance and exposure.

van Roessel, J. W., "SLAR Mosaics for Project Radam," pp. 583-595. The author describes how semi-controlled SLAR mosaics were prepared for most of northern Brazil.

Derenyi, E. E. "SLAR Geometric Test," pp. 597-604. The author reports that his studies indicate side-looking radar imagery at 1:250,000 scale had errors sufficiently small to qualify it as a class B map.

Articles of interest appearing in Photogrammetric Engineering, vol. 40, no. 4, April 1974.

Kelemas, V., et al., "Inventory of Delaware's Wetlands," pp. 433-439. The authors report that the combination of visual and machine photoanalysis of multispectral high altitude imagery is a cost-effective and rapid mapping method.

Kolbl, O.R., "Combined Restitution of Air and Satellite Photos for Topo Maps," pp. 441-450. The author reports that satellite imagery at 1:2,000,000 can be used economically along with aerial photos to compile 1:50,000 to 1:100,000 maps in developing areas.

Driscoll, R. S., and M. E. Coleman, "Color for Shrubs," pp. 451-459. The authors describe the use of large-scale, 70 mm, color and color infrared aerial photos to identify various shrub species in different plant communities.

Reeves, C. C. Jr., "An Apollo Photo and the Texas-New Mexico Line," pp. 461 - 465. The author reports that the state-line signature on the Apollo photo does not result from the political differences in the management of groundwater between the two states.

Turinetti, J. D., and O. W. Mintzer, "Low-Cost Computerized Land-Use Classification," pp. 479-488. The authors report that it was possible to identify correctly land uses from a variety of combinations of multiformat, non-registered multispectral imagery using a densitometer and a computer to perform the numerical evaluations.

Articles of interest in the Highway Research Record, No. 421, 1972 (special issue on Remote Sensing for Highway Engineering).

Dellwig, L. F., and C. Burchell, "Side-Look Radar: Its Uses and Limitations as a Reconnaissance Tool."

Stingelin, R. W., "Airborne Infrared Imagery and Its Limitations in Civil Engineering Practice."

Lowe, D. S., and C. L. Wilson, "Multispectral Scanning Systems: Their Features and Limitations."

Rib, H. T., "Partnership in Research: A Cooperative Remote Sensing Research Program."

Noble, D. F., "Utilization of Remote-Sensing in the Preliminary Aerial Survey-Highway Planning Stage in Virginia."

Stallard, A. H., "Use of Remote Sensors in Highway Engineering in Kansas."

Wagner, T. W., "Multispectral Remote Sensing of Soil Areas: A Kansas City Study."

Contributors to this issue of KERS Newsletter: James Merchant and Robert L. Walters.

The Kansas Environmental Resource Studies Newsletter is a publication of the University of Kansas Center for Research, Inc., with facilities located in the Space Technology Center, Nichols Hall, at the University of Kansas. Contributions of research findings, announcements of meetings, publications, and information pertinent to area environmental studies are encouraged. Inquiries and contributions should be addressed to Pat Nicholas, Editor, KERS Newsletter, KU Center for Research, Inc., 2385 Irving Hill Drive - Campus West, Lawrence, Kansas 66045.

The University of Kansas Center for Research, Inc.
KERS Newsletter
2385 Irving Hill Drive - Campus West
Lawrence, Kansas 66045

KANSAS ENVIRONMENTAL RESOURCE STUDIES

NEWSLETTER

Volume 3, Number 10
November 1974

High Altitude Aerial Photographic Coverage of Kansas

Aerial photography obtained from altitudes above 50,000 feet is available for somewhat less than half of Kansas at the present time. The National Aeronautics and Space Administration (NASA) has flown approximately a dozen high altitude missions over the state since 1969. Some areas in northwest and southeast Kansas have been photographed only once during this period. Others, such as the Topeka-Kansas City Corridor, have been covered many times.

High altitude photography is characterized by small scale (usually 1/2" = 1 mile or smaller), large area coverage (usually 175-300 sq. miles per frame), and, yet high resolution. It is, consequently, quite valuable for surveying land use, urban problems, wildlife habitat, water resources, and related phenomena over expansive areas.

On the accompanying map (see inside) all areas of Kansas covered with any high altitude photography since 1969 are shown (boundaries of photography are approximate). Persons wishing to determine exact dates of missions, mission number or other information can contact either: EROS Data Center, Sioux Falls, South Dakota 57198, or Jim Merchant, Bob Walters, Ted Talmon or members of the Applications Group, University of Kansas Space Technology Center, 2291 Irving Hill Drive, Lawrence, Kansas 66045, 913/864-4775.

Assistance in image acquisition, interpretation, and utilization is also available from Applications' personnel.

New Applications Studies

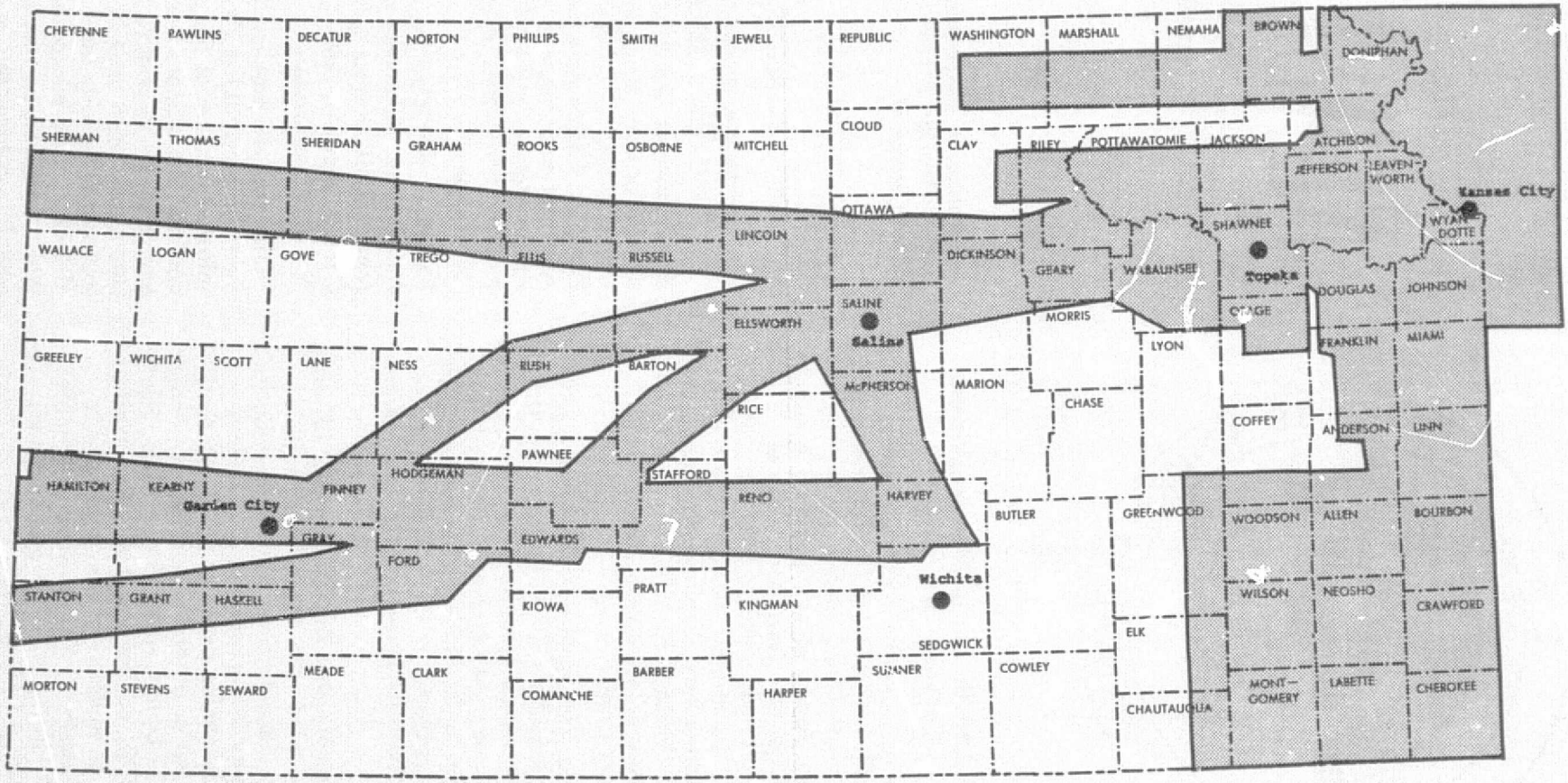
Environmental Impact of Proposed 57th/59th Street Route, Kansas City, Kansas

Environmental impact statements are now required for even minor modification of existing transport routes. The Kansas City, Kansas Planning Office enlisted the KU Satellite Applications Group to develop simple image interpretation methodologies to supplement existing techniques of environmental impact statements.

Personnel participating in the study include Mr. Thomas Palmerlee and Mr. H.K. Mendenhall, Kansas City, Kansas, Planning Office, and Mr. Jerry Coiner of the KU Applications Group.

In the analysis process, the CRINC team flew over the area taking 70 mm. color and color infrared imagery of the proposed route corridor and prepared an aerial photo-mosaic and land-use overlays. The results from the study have been used in public hearings on the route and the city has requested several alternatives be evaluated in the same manner. Work continues on that part of the study with completion expected in early 1975.

HIGH ALTITUDE PHOTOGRAPHIC COVERAGE OF KANSAS
AND KANSAS CITY METROPOLITAN AREA
1969 - 1974



A Study to Map Areas of Agricultural Land Converted to Urban Land Uses in the Kansas City Metropolitan Region Between 1969 and 1974

Land use changes in the areas around major urban complexes, such as Kansas City, can rapidly deplete available good agricultural land. Aerial photographs from high altitude aircraft and spacecraft have been demonstrated effective in mapping urban-related land use and changes in agricultural land use.

This project will use small-scale aerial photography obtained from high altitude aircraft to urban land uses for the Kansas City Metropolitan Region (KCMR) for the period 1969-1974.

The study is being conducted for the Mid-America Regional Council (MARC). KU Applications personnel include Dean Bill Barr, faculty investigator, and Mr. Jerry C. Coiner and Donald L. Williams, investigators in the Applications Laboratory.

➤Joint Soil Moisture Meeting ◄

The Remote Sensing Laboratory hosted a meeting of The Joint Soil Moisture Experiment Group at the STC on 23-24 October 1974. Participants represented all research groups involved in this project, namely NASA/Johnson Spacecraft Center, NASA/Goddard Space Flight Center, Texas A & M University, Environmental Research Institute of Michigan, University of Arkansas, United States Department of Agriculture, and the University of Kansas. The KU group consisted of Fawwaz T. Ulaby, Jay Holtzman, Josef Cihlar, Ray Mueller and Percy Batlivala.

The attendees reviewed preliminary results obtained from analysis of data collected in two experiments which were undertaken this year. The controlled ground-based experiment carried out in Texas (KERS Newsletter, vol. 3, no. 7) was regarded as very successful. The data collected suggest that it may be possible to design a radar sensor sensitive to soil moisture and relatively insensitive to other environmental parameters. Preliminary results of an airborne experiment (Phoenix, KERS Newsletter, vol. 3, no. 5) are less definitive, primarily due to small soil moisture differences observed in the test site. It appears that these data must be combined with those from other airborne experiments before further analysis is undertaken.

Since research on the soil moisture experiment will continue next year, the participants spent considerable time discussing specifications of the future experiments. Two flight missions are tentatively proposed for 1975: one mission in Phoenix over the same test site as this year, and one mission over a newly established Lawrence Test Site in eastern Kansas. The test site, located between Lawrence and Topeka, is quite variable in terms of topography, soils, etc., and will therefore provide a more complex environment in which the accuracy of the developed algorithms can be effectively tested. The site overlaps with the test area used by the State Highway Commission several years ago. Following an inspection of the site from an airplane, the investigators agreed on the suitability of the site for their soil moisture research. Each mission will include simultaneous overflight by two aircraft carrying a variety of remote sensors including radar, microwave radiometers, thermal infrared imagers and photography. Also, a group of about 40 scientists and engineers will comprise a ground crew which will collect soil samples for various fields in the test site.

➤Soviet Group Visits STC ◄

Agricultural remote sensing investigations underway at the STC were explained to two dozen Russian visitors to KU and the Lawrence area during the latter part of October. The tour to the U.S. was sponsored by the Council on International Exchange of New York and arranged by KU political science professor Roy D. Laird and John Conard.

Don Williams, senior research scientist at the STC, explained the research programs at the Center giving emphasis to wheat production in Kansas and the use of irrigation. He discussed the use of ERTS-1 imagery in present agricultural research and its potential for future use.

After the stop at the Space Technology Center, the Russian Group toured area farms including a dairy, a feedlot operation, a soybean-wheat-corn farm and an American farm home.

Top-Kan Symposium Held

(Contributed by Rod A. Hardy, Director, Information and Education, Kansas Geological Survey.)

The results of a two-year investigation of a Topeka-Kansas City Corridor study were presented at a Planning Symposium held in the Apollo Room in Nichols Hall on November 8.

Top-Kan, as the project is called, is an intensive review of resources in an area which is quickly urbanizing. According to population experts, the urban corridor is expected to grow by 500,000 people in the next 26 years.

The Kansas and U.S. Geological Surveys recognized this population trend and combined efforts to complete a pilot study of the six-county area. The end result is descriptive materials of the geologic and hydrologic information that is important for land-use analysis at the city, county, regional and state levels. The Symposium was designed to give decision-makers an opportunity to interface with the authors prior to publication.

Minerals -- Regulatory agencies and planners must give consideration to the preservation of mineral resource areas for future needs. Specifically, these individuals must plan around locations of building stone, sand deposits and acreage with potential for underground gas storage. Larry Brady, Mineral Resources Section of the Kansas Geological Survey, presented several recommendations.

Soils -- Large segments of prime agricultural lands are urbanized every year in the United States and the Top-Kan Corridor is no exception. Harold Dickey, Soil Conservation Service specialist, stressed maintaining areas for crop production in the Kansas and Missouri River valleys and encouraged continued agricultural use of the glacial loess areas of Shawnee, Jefferson and Leavenworth counties.

Water -- The amount of available water in the Corridor for domestic and industrial uses is limited and availability and quality of that water will determine growth patterns in the future. As a result, water must play a major role in the development and maintenance of this six-county area. Howard O'Connor, Kansas hydrologist, investigated the significance of water in geology and to humans with an eye to the present water and our future needs of it.

Waste -- Thomas McClain, Environmental Geology Section of the Kansas Survey, reviewed the problem of waste disposal in our industrial society and made general recommendations for sanitary land fill sites in the Top-Kan Corridor.

Man-Earth Problems -- Floods, landslides, land subsidence, erosion and sedimentation are among many natural processes which have been acting since the beginnings of time to modify the face of the earth. They only become "geologic hazards" when man in ignorance or defiance of the effects of these processes attempts to build or live on the earth's active zones as discussed by Frank Wilson, Environmental Geologist.

Contributors to this issue of KERS: Jerry C. Coiner, James W. Merchant, and Robert L. Walters.

The Kansas Environmental Resource Studies Newsletter is a publication of the University of Kansas Center for Research, Inc., with facilities located in the Space Technology Center, Nichols Hall, at the University of Kansas. Contributors of research findings, announcements of meetings, publications, and information pertinent to area environmental studies are encouraged. Inquiries and contributions should be addressed to Pat Nicholas, Editor, KERS Newsletter, KU Center for Research, Inc., 2385 Irving Hill Drive - Campus West, Lawrence, Kansas 66045.

The University of Kansas Center for Research, Inc.
KERS Newsletter
2385 Irving Hill Drive - Campus West
Lawrence, Kansas 66045

APPENDIX III

Supportive Letters

STATE OF KANSAS

OFFICE OF THE GOVERNOR
State Capitol
Topeka

ROBERT B. DOCKING
Governor

August 1, 1974

The Honorable Frank E. Moss
Chairman, Committee on Aeronautical
and Space Sciences
United States Senate
Washington, D. C. 20510

Dear Senator Moss:

Thank you for your letter of June 24th requesting information on the use of the Earth Resource Technology Satellite system by the State of Kansas.

I have followed the progress of the investigations conducted in Kansas with the ERTS system since they were first proposed under the Kansas Environmental and Resource Study Program. We were very pleased to have investigators at the University of Kansas Space Technology Center, the Kansas Geological Survey and Kansas State University funded by NASA to do research with this new technology. It has been a major objective of the Kansas program to translate the results of the initial research studies into applications within various state and local agencies. In this regard I have called two Governor's Conferences on the application of satellite remote sensing designed to introduce directors and key personnel of Kansas state agencies and those in adjoining states to the potential it offers.

We have been pleased with the success made to date in applying ERTS imagery to a wide range of problems in a number of state agencies. Some such problems could only be addressed with this new view of our landscape, or painstakingly with far greater expense through conventional means over extended periods. I am enclosing a brief summary of the initial research investigations conducted with the Earth Resource Technology Satellite and a listing of some of the applications projects completed or underway in Kansas. I have been pleased to see the progress made in the application of this new technology to the management of Kansas' critical resources; however, I am assured by those more actively involved in our universities and in our agencies that we have only scratched the surface. It is my understanding that the realization of the true potential of satellite based earth observation data will only be achieved when such systems

are made operational and the agencies can depend on receiving the transmitted data in a timely and continuing manner. Additional benefits, of course, are expected as the resolution of the sensors are improved based on experience and new developments.

The ERTS-1 research investigators at the University of Kansas Space Technology Center have demonstrated a number of uses for satellite imagery. These uses might be reasonably implemented if data were available from an operational satellite. Among these applications are estimates of crop acreage, particularly winter wheat, which may be prepared on an acceptably accurate and quite timely basis. Satellite images may also be used to monitor the expansion of cropland under irrigation. Since irrigation tends to deplete groundwater supplies, knowledge of the location and amount of land being irrigated is quite helpful. Other types of major land use change may also be monitored from an operational satellite. Water quality as a function of sediment and pollution in Kansas reservoirs may also be monitored.

These results lend to the argument that it would be desirable to assign the ERTS system to a mission agency and change its status to operational.

With every good wish.

Yours sincerely,

Robert Docking
Governor of Kansas

RD:nkm
Enclosures

cc: Dr. B.G. Barr, Director
Space Technology Center
University of Kansas - Campus West
Lawrence, Kansas 66045

Mr. Charles Buzby
National Governors' Conference
1150 17th Street, N.W.
Washington, D.C. 20036

State of Kansas
Utilization of ERTS Imagery

The University of Kansas Space Technology Center is coordinating a program to assimilate, analyze and disseminate ERTS data as it applies to Kansas land and water resource problems under a program known as the Kansas Environmental Resource Studies Program (KERS). . . .

Applications Studies or Demonstration Projects

The Satellite Applications Program of the University of Kansas Space Technology Center is conducting an Applications Program with local, state and regional agencies. This program is a need-based multidisciplinary program designed to acquaint state and local agency personnel with the latest state-of-the-art sensing interpretation techniques employed by NASA and its contracting agencies for ERTS imagery. This program has successfully initiated applications studies using ERTS imagery with the agencies shown. Professor B.G. Barr, Director of the Space Technology Center, is the principal investigator for the Applications Program and other scientific and engineering expertise is provided on the individual projects by the persons shown.

1. A Regional Land Use Map for the Four Rivers Resource Conservation Development Project - Kansas Department of Economic Development and U.S. Department of Agriculture. Project personnel: Robert Walters, Don Williams, Ted Talmon.

ERTS-1 imagery was used to create a general land use map for the eight-county area (Cloud, Jewell, Mitchell, Republic, Ottawa, Saline, Lincoln, and Ellsworth) in North Central Kansas. An atlas of maps for each county has been prepared and delivered to county committees. Citizens on the committees are now making ground truth surveys and some updating of maps is planned, based on more critical interpretations of later ERTS images and low level flights of the more congested areas. Decisions related to routing of a new section of I-35, development of a new industry, conservation of forested areas, and development of prime agricultural land are expected.

2. A Wildlife Habitat Inventory of Kansas (demonstration project, in Thomas, Ottawa and Jefferson Counties) - Kansas Forestry, Fish and Game Commission. Project personnel: James Merchant, Geography Department, University of Kansas; Bruce Waddell, Kansas Forestry, Fish and Game Commission.

This project is designed to assess the utility of high altitude multispectral photographs and ERTS imagery as a means to inventory the wildlife habitat of the State of Kansas and to relate it to management decisions for the agency.

3. Map Irrigation Growth in Little Arkansas River Basin, NW of Wichita - Kansas Water Resources Board. Project personnel: Don Williams.

The Kansas Water Resources Board required information on the growth of irrigation in order to determine the long term effects on the Wichita Municipal water supply. Analysis of ERTS imagery provided a prompt estimate in a matter of days as opposed to the weeks or months of laborious field checking potentially required.

4. Land Use Map of the State of Kansas - Kansas Department of Economic Development. Project personnel: Don Williams, Jerry Coiner.

A fourteen-category land use map of the entire state has been prepared from ERTS data obtained in August 1972 and updated based on '73 and '74 imagery. This map will be used by all state agencies.

5. A Feasibility Study to Update Land Use Records in Kansas By Automatic Image Processing from ERTS Digital Tapes - Kansas Department of Economic Development. Project personnel: Professor Robert Haralick, Don Williams, Amrendra Singh, Professor B.G. Barr.

This project just being completed demonstrates that several categories of land use can be updated automatically using automated techniques. This could be very helpful in documenting change in land use from an ERTS operational system.

An ERTS mosaic of the entire state has been used by several departments, (Highway, Park and Recreation, Water Resources Board, Biological Survey, and Kansas Department of Economic Development) to obtain an overview of the resources of the state in a way never before possible. Plans are underway to establish two test sites in Kansas to determine the full potential of ERTS and other high altitude remote sensors to monitor and protect our resources.

THE STATE OF KANSAS

WATER RESOURCES BOARD

4th Floor, Mills Building
109 W. 9th Street
Telephone (913) 296-3185
TOPEKA, KANSAS 66612

January 21, 1975

Mr. B. G. Barr, Director
Space Technology Center
University of Kansas
2291 Irving Hill Dr.-Campus West
Lawrence, Kansas 66045

Dear Bill:

I am pleased to learn that the University of Kansas is considering the possibility of enhancing its capability to respond to the need of state agencies for information derived from remote sensing.

The Water Resources Board is responsible for research and planning related to the long-term water needs of the state. Accordingly, we are extremely interested in new methods and approaches to gathering information about the natural and cultural changes to the earth's surface, since these factors are almost always present in projects dealing with water resource management. A current interest, and one which will continue for several years, involves understanding more about the effects on a Kansas test site of a multistate program on weather modification. It is our hope that the research the Remote Sensing Laboratory and others in the Space Technology Center have conducted over the past several years, will help us make decisions on the effectiveness of the weather modification program. We and others are spending significant sums of money on this effort, and are considering the expenditure of funds on remote sensing methods which will help evaluate the program.

I am sure that a program designed to assist state and local agencies use the latest state-of-the-art methods in remote sensing would be extremely beneficial in several areas. The Water Resources Board supports your efforts to make the expertise being developed in remote sensing at K.U. more available to the citizens of the state.

Sincerely,

Keith S. Krause

Keith S. Krause
Executive Director

KSK:ss

Sunflower Resource Conservation And Development Project

705 East Main
HARPER, KANSAS 67058
Telephone No. 316 896-3781

February 7, 1975

Mr. B. G. Barr
Project Administrator
University of Kansas
Center For Research, Inc.
2291 Irving Hall Drive
Lawrence, Kansas 66044

Dear Mr. Barr:

The Barber County Conservation District and the Barber County Resource Conservation and Development (RC&D) Council are vitally concerned with the conservation and development of the natural resources in the county. Our organizations are especially involved in promoting good range management. The native grasslands in the county are a major natural resource which supports the beef cattle industry, the backbone of the county's economy.

During the past few years, we have become concerned with the invasion of woody trees and shrubs into the native rangelands of the county. Red cedar trees are the main woody species that have invaded some of our best rangeland. Other woody species include sand sagebrush, tamarisk, sandplum, and cottonwoods. Red cedars and sand sagebrush occur mainly on the uplands, and the sandplum, tamarisk, and cottonwoods occur mainly on the very productive rangeland along the major streams. Although all of these species are of concern to us, the red cedar tree seems to present the greatest problem.

We are requesting assistance from the KU Space Technology Center in using ERTS imagery and high altitude photographs to plot the red cedar trees and other woody vegetation on a map of the county to determine the acres and extent of the problem. Also, a map showing the location and extent of the red cedar trees and other woody vegetation in previous years for a comparison would be valuable. Several previous years could be compared with the present ERTS imagery to determine a trend. We understand that aerial photographs for past years are available.

A vegetative map of the rangeland, showing plant cover and vigor, would give us some idea as to the condition of the rangelands.

The information can be used in carrying out a range management promotion program. Also, the information will be of value in setting up research projects for managing the rangelands and attacking the woody vegetation problem. The information on plant cover and vigor will show us whether the rangeland is improving or deteriorating.

This information will be used in news releases and public information meetings to inform the public as to what is happening to the rangelands in Barber County. It will be used in establishing priorities of work on the grassland resource.

We also would hope to use ERTS imagery in the future to monitor the rangeland resource and determine what progress is being made in the management of the rangelands.

The Council of the 7-county Sunflower RC&D Project in south central Kansas has set the promotion of range management as a high priority measure in the area. Native grasslands cover 1½ million acres in the project area. We have their full support in this endeavor.

If further information is needed, please let us know.

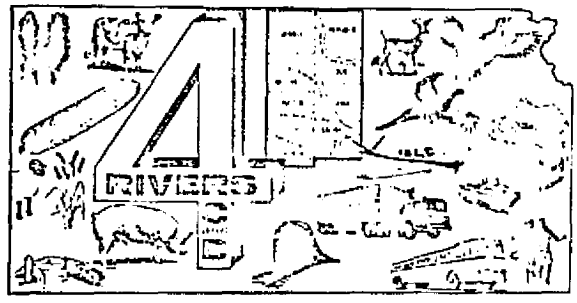
Sincerely,

James D. Mitchell
Chairman, Barber
County Conservation District

Patricia Lawrence
Chairman, Barber County
RC&D Council

FOUR RIVERS RESOURCE CONSERVATION AND DEVELOPMENT PROJECT

BOX 188 / MINNEAPOLIS, KANSAS 67467 / 913-392-3203



February 24, 1975

Mr. Ted Talmon
Research Scientist
The University of Kansas
Space Technology Center
Raymond Nichols Hall
2291 Irving Hill Drive--Campus West
Lawrence, Kansas 66045

Dear Mr. Talmon:

We are most appreciative of the excellent support and assistance provided to the Four Rivers Resource Conservation and Development Project. The land use maps and water bodies maps developed from ERTS imagery, as well as the other maps, have been utilized throughout the planning process to isolate and graphically illustrate to committee members specific resource areas and uses. These maps have also been incorporated into the plan to aid the understanding and decision making process of lay people as we implement our program.

The Executive Committee has selected Erosion Control Education, Range and Pasture Potential Study and Land Use Planning as projectwide priority measures. The information contained in the maps prepared by your organization will be the basis upon which these action programs will be developed. It is recognized the implementation of these measures will require considerable time in education, developing local interest and preparing a workable plan. We do believe considerable time will be saved through utilization of your information and that a better plan will eventually evolve.

In addition to the projectwide measures, numerous other multi-county and single county project measures will utilize the prepared information. Each county has within its council individual county maps. The use of these maps will be essential in measures such as Floodwater Protection, Critical Area Treatment, Land Use Planning, Benefit District Organization and many others. It will be very helpful in making environmental assessments and preliminary feasibility determinations which are required in federally funded projects as it provides a graphic overview of the entire project.

Thank you for your interest and support. We anticipate additional assistance will be needed as we progress towards measure development. The Four Rivers RC&D Project is grateful that the KU Space Technology Lab is one of its enthusiastic technical advisers.

Sincerely,

Mark L. McHenry
Chairman

Enclosure - Draft Copy of
Four Rivers RC&D Project Plan

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Federal Building - Room 1748
601 East 12th Street
Kansas City, Missouri 64106

January 7, 1975

Mr. B.G. Barr
University of Kansas
Space Technology Center
Satelite Applications Program
Lawrence, KS 66045

Dear Mr. Barr:

Personnel of your Applications Laboratory, under the direction of Mr. Jim Merchant, has been working for the past few months on a land-use classification of the Chikaskia River Basin in south central Kansas. The program was initiated to assist our Service and the Kansas Forestry, Fish and Game Commission in an ecological resources evaluation in conjunction with a Bureau of Reclamation water resources study of the Basin.

A land-use classification overlay, derived from the ERTS-1 imagery, was provided prior to our field evaluations in November and December. The classification includes the locations of urban areas, irrigated and non-irrigated cropland, grassland, and forestland. This overlay proved very accurate and helpful in locating various sampling areas during our ground truthing and field evaluation.

We are looking forward to your forthcoming report on the Chikaskia Basin. The breakdown of acreages for each land-use type basin-wide is invaluable and would otherwise be an almost impossible task for us, as the Chikaskia River Basin encompasses approximately 1,967 square miles. We appreciate the hard work that the Applications Laboratory staff has put into this study and are pleased with the results.

Our Service believes that high altitude photography has endless applications for wildlife habitat classification, monitoring and management; land-use changes, and water and land resource management. We are enthusiastic about the service available from the Technology Center and look forward to working with you in the future.

Again we wish to express our appreciation for your assistance.

Sincerely yours,

Paul P. Hamilton

Paul P. Hamilton
Chief, Ecological Services

cc: Mr. Jim Merchant, Lawrence, KS
KFF&G

United States Department of the Interior
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
Federal Building - Room 1748
601 East 12th Street
Kansas City, Missouri 64106

February 18, 1975

Mr. B.G. Barr
University of Kansas
Space Technology Center
Satellite Applications Program
Lawrence, KS 66045

ATTN: Mr. Jim Merchant

Dear Mr. Barr:

Personnel of your Satellite Applications Program, under the direction of Mr. Jim Merchant, have completed a land-use classification and a stream order analysis of the Chikaskia River Basin in Kansas and Oklahoma. The study was initiated to assist our Service and the Kansas Forestry, Fish and Game Commission in ecological resource planning in conjunction with a water resource study of the basin by the Bureau of Reclamation.

We have received overlays of land-use and stream order classifications, derived from ERTS-1 imagery, and your preliminary report. As stated in our letter of January 7, 1975, the land-use classification overlay was helpful in locating sampling areas during our wildlife habitat evaluation in November and December.

The existence and welfare of wildlife depends upon the quality and quantity of available habitat. Our evaluations have assessed the quality of each habitat type (rangeland, forestland, cropland). Your quantification of these habitat types increases our confidence in evaluating the existing resources and predicting future conditions. Without your assistance, the acreage of each land-use type within the basin, which encompasses approximately 2100 square miles, could only be estimated due to our lack of materials and manpower. This information will be used in our forthcoming report on the fish and wildlife resources of the Chikaskia River Basin and in developing environmental quality plans within the basin.

We will be involved in other ecological resource evaluations and planning efforts in Kansas, including portions of the Arkansas River

Basin and Kansas River Basin, in the next few years. Your Satellite Applications Program, utilizing remote sensing techniques, could be a valuable tool in our studies. We are looking forward to working with you in the future.

Thank you again for your assistance on the Chikaskia River Basin project.

Sincerely yours,

Charles K. Phenicie

Charles, K. Phenicie
Area Manager

cc: KFF&G, Pratt, KS
RD, Denver, CO (ES)
Attn: Jim Coates

KANSAS CITY REGIONAL PLANNING COMMISSION
FEDERAL OFFICE BUILDING
ONE PLAZA 64101 371-0000

November 26, 1974

Dean B. G. Barr
The Space Technology Center
2291 Irving Hill Drive
Campus West
The University of Kansas
Lawrence, Kansas 66045

Dear Bill,

In December and January, our department is planning to begin a test project for construction of an Urban Land Use File in which the geographic unit of data collection will be the parcel. One of the major resource materials that we will be using is aerial photography. We anticipate using enlargements of the 1:24,000 corps of engineers mission of April 1973 and the color positives that you recently flew for us. Five college students will be doing most of the interpretation and coding. As none of them have experience in photo interpretation, we plan to have an orientation for them. Since the Center has been so helpful in the past, I am wondering if Jerry Cointer and/or Don Williams might be able to help us in this orientation. It will be no more than one day and will take place sometime in the middle of December, probably the 16th.

I will be waiting to hear if such support is feasible and if it does not conflict with Jerry's or Don's vacation schedule.

Thank you very much for your consideration, and all your past help.

Sincerely,

Thomas M. Palmerlee
Research Director

TMP/mw

STATE OF KANSAS
Forestry, Fish and Game Commission

Box 1028
PRATT, KANSAS 67124

Cheyenne Bottoms WMA
Route 1
Great Bend, Ks. 67530
February 21, 1975

Professor B.G. Barr
K.U. Space Technology Center
2291 Irving Hill Drive
Lawrence, Kansas 66045

Dear Professor Barr,

I believe initial work with your staff concerning applications of ERTS and aircraft photos to wildlife management practices at Cheyenne Bottoms Waterfowl Management Area has provided useful information, and promises even more applications.

At the present time the aircraft infrared photos are proving to be the most useful. These photos and the resulting mosaic are enabling me to formulate a base map of the existing aquatic vegetation on the area. Due to the size of Cheyenne Bottoms (19,000+ acres) vegetative transects would be too time consuming to warrant use for obtaining the same information.

The mosaic prepared by your staff was also used to locate areas of cattail (Typha sp.) to test some control techniques. Without the mosaic, many hours of field work would have been expended to locate potential areas.

If your staff is eventually able to distinguish vegetative types from the ERTS prints, a very important new tool for formulating management practices would be at our disposal. A knowledge of vegetative types and percent cover is essential for marsh management. These two factors indicate what pools to dewater, and the time of year to carry out these practices. The ERTS technique would provide a high quality source of data, at a fraction of the present man hours expended.

The ERTS photos would enable Cheyenne Bottoms personnel to monitor vegetation changes caused by management practices. This would give a simple, quantitative method to evaluate management practices involved. This sort of rapid evaluation is greatly needed.

In summary, I believe your staff has provided much valuable information already. The ERTS technique has a great deal of potential application in waterfowl management. I'm looking forward to future work with your staff in formulation of techniques.

Sincerely,
Robert F. Bartels
Robert F. Bartels
District Game Biologist

RFB/clc

February 24, 1975

Professor D. G. Barr
Principal Investigator
Director, Space Technology Center
University of Kansas Center for
Research
2385 Irving Hill Road - Campus West
Lawrence, Kansas 66044

Dear Professor Barr:

We welcome the opportunity to cooperate with the Center for Research under our contract with you for high-altitude photography and analysis of land use trends.

Our primary interest in the technology related to high-altitude photography is in determining the rate of conversion of agriculture land to urban uses at the periphery of the urbanized area. With this data in hand for a five-year period, we can better make judgements about the distribution and density of increased population change on an annual basis.

In addition, this knowledge provides a valuable addition to our Land Factors Atlas, a graphic record of 16 urban functions and systems, including transportation, utilities, land use by density and intensity types, among other factors.

Since urban applications of this technology are so far quite limited, this project serves as a pilot to help us determine the potential of high altitude, infra-red techniques for future application in the urban and regional planning process.

I feel certain the experience gained in this cooperative project will prove useful to both your organization and ours.

Sincerely,

Richard F. Davis
Executive Director

RFD:GRM:lhs

cc: Mr. Jerry Coiner

STATE OF KANSAS

Forestry, Fish and Game Commission

Build a Pond
Plant a Bush
Grow a Tree

SOUTHWEST REGIONAL OFFICE
808 HIGHWAY 56
DODGE CITY, KANSAS 67801

February 17, 1975

Professor B.G. Barr
c/o Mr. James Merchant
KU Space Technology Center
2291 Irving Hill Drive
Lawrence, KS 66045

Gentlemen:

At the present time we are monitoring the expansion of the pivot irrigation systems of Southwest Kansas. We, of course, have very little to say about the encroachment of these systems upon prairie chicken native grass habitat. Thus, we are in a position of monitoring this expansion and trying to develop additional wildlife habitat to replace these losses.

The center pivot irrigation map that was provided by the Space Technology Center has been most useful in determining where we will try to work with landowners to save some of the native prairie or develop replacement wildlife habitat. We have also used the map numerous times to show individuals in the conservation field, in the grassland management field and persons involved in cropping activities, the tremendous effect the pivot irrigation systems are having on Southwest Kansas rangelands.

As I have said in an earlier letter, it is doubtful that we are going to stop this irrigation expansion, as wildlife always loses when economics are concerned. However, there is hope in that the new criteria for future pollution controls on farmland indicates that large scale conversion of poor quality rangeland into irrigated cropland may be subject to these new pollution restrictions.

We are working with various pivot irrigation landowners in Finney County to develop habitat for wildlife on the corners surrounding these systems. Such activities are a benefit to other upland game, such as pheasants and quail, but, of course, this has little to do with the replacement of the prairie chicken range.

I am sorry that I can't give you more conclusive information regarding the use of our pivot irrigation system map, but I have used the map many times to indicate to others the expansion of this operation and also the quality and accuracy of the data provided through imagery work. It would be virtually impossible to gather this center pivot irrigation data for the 14 county area if we had to visit each county individually and gather the data from various federal and state agencies that may or may not have good records. Also, because of the rapidly expanding pivot irrigation development, it is impossible to obtain current data on their locations. We have neither the time nor personnel to visit each county and gather the desired information on the center pivot systems. The Space Technology Center, in providing this map, has saved us many, many hours

of effort.

If you need further information or have questions regarding this, please let me know.

Sincerely,

Bill Hanzlick

Bill Hanzlick
Regional Management Supervisor

P.S. The Cheyenne Bottoms mosaic map is excellent. We are already using that map to determine vegetative communities and proposed management of these areas. An adjacent landowner has expressed interest in purchasing a copy of the map. What would be the cost of the total map and of each frame? His land is in the N^{2} Section 26, T18S, R13W.

BH:ck

cc: Bruce Waddell