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GEOGRAPHIC APPLICATIONS OF ERTS-A IMAGERY TO RURAL LANDSCAPE CHANGE, 162-III

TYPE II PROGRESS REPORT

DR. JOHN B. REHDER, P.I.
UN 212

NASA-ERTS GEOGRAPHY
Remote Sensing Project
Contract NAS5-21726

COLOR ILLUSTRATIONS REPRODUCED IN BLACK AND WHITE

Department of Geography
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Knoxville, Tennessee

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GEOGRAPHIC APPLICATIONS OF ERTS-A IMAGERY

TO RURAL LANDSCAPE CHANGE

162-III

DR. JOHN B. REHDER, P.I. - UN212

INTRODUCTION

For the past six months the NASA-ERTS Geography Remote Sensing Project at the University of Tennessee has been engaged in the equipping and preparation of the project to receive ERTS data, the generation of low altitude (10,000' alt.) imagery of the Knoxville test site for back up and ground truth data, the acquisition of RB-57 high altitude (60,000' alt.) imagery from NASA archival sources, and the reception and "first look" analysis of the ERTS-I imagery.

The study area, centered on Knoxville, Tennessee, encompasses nearly 20,000 square miles (Figure 1). Originally it had been a 10,000 square mile study area chosen to be compatible with a single image frame from ERTS. However, since launch our analysis of 5 overpasses of ERTS has led us to observe beyond the original 10,000 square mile configuration and thus to an expanded study area. Furthermore, because no two overpasses are the same, the center points of successive frames in each orbit day have been shifting southward and westward for each 18 day cycle thus changing and enlarging the coverage. Two test sites of smaller dimensions are being examined within the study area. The Knoxville Test Site, an 11 X 21 mile area over the city of Knoxville and the western portion of Knox County, has been chosen for the analysis of landscape change detection associated with urban growth. The second area, the Cumberland Plateau

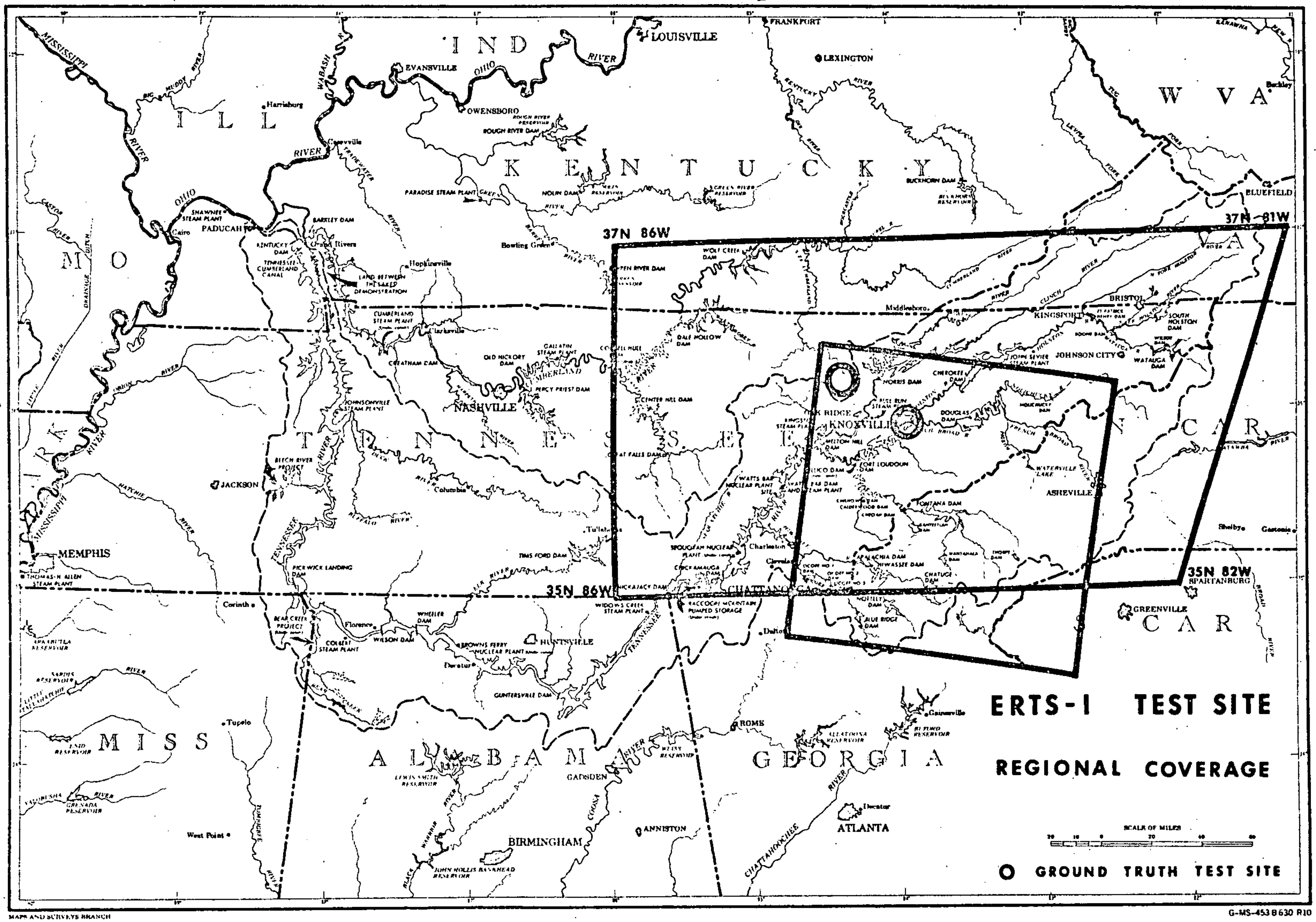


Figure 1 - ERTS-I Test Site, Eastern Tennessee

Test Site, exhibits landscape change through forest alterations and landform disturbances associated with strip mining in the area and was so chosen for its sharp contrasts in physical and human phenomena as well as its change dynamics.

PRE-LAUNCH ACTIVITIES

April - June 1972

Funding for the project, the selection of research assistants, and other initial activities prior to launch began in April. Work space comprising two rooms was initially provided in the chemistry building (Buehler Hall). This space was occupied by the project until October when it was moved to a larger two room space (408 square feet) in South Stadium Hall - Rooms 219-220, and a portion of 217.

Equipment acquired during the period included a direct reflecting projector - Map-O-Graph Model 55C, drafting tables, a light table, drafting equipment such as triangles, T-squares, and a Koh-I-Noor lettering set plus drafting supplies, a 70 mm/35 mm projector - Honeywell Rollei projector model P11, and office equipment such as file cabinets, supply cabinet, and desk lamps. Film and other photographic and office supplies were acquired during the same period.

Personnel in addition to Dr. John B. Rehder, the principal investigator, are graduate research assistants James R. O'Malley and Earl Jay Tullos. Mr. O'Malley, a Ph.D. student in geography, has been the photographic technician in the project in addition to his duties in image interpretation with specialization in strip mine detection and analysis. In this latter effort he has added to the project by submitting a joint authored paper with the principal investigator to the national meeting of the Association of American Geographers to be held in Atlanta in April, 1973.[1] Mr. Tullos, who is working on a Master's degree in geography, serves as the cartographic technician and draftsman for the project. He has also been doing a very able job in cataloging and classifying the ERTS and aircraft imagery in addition to his imagery interpretation duties. He has been particularly interested in the change detection analysis of urban growth and intends to produce a thesis on this topic in conjunction with the project.

June - August 1972

From June through August, the primary responsibility and activity of the project was to generate and otherwise acquire aircraft imagery of the study area. The purpose of this was to establish a control base of imagery which could be compared with the ERTS imagery. It was also to be used as a source of ground truth data.

Using the University of Tennessee research-aircraft Aero Commander, four missions were made at an altitude of 10,000' over the Knoxville test site on June 23, July 3, July 6, and August 14. A total of 1,141 images were made with a Hasselbad camera system in 70 mm format in color ektachrome and color infrared film. Map scale on the original imagery from the 10,000 foot altitude was established at an inch to the half mile.

Several areas within the Knoxville Test Site proved to have actual and potential landscape change elements. Figure two illustrates shopping center construction occurring in the western portions of Knoxville and Knox County. This area, the most dynamic in Knoxville, has added over 30 stores, shops, and new car dealerships since April in addition to the 75 store complex in the shopping mall shown here. Suburban growth in

Figure 2 - Low Altitude Aircraft (10,000') Image of West Town Shopping Center, Knoxville, Tennessee

the form of subdivision housing development has occurred in the same area. This growth has been at perhaps a slower rate but it still illustrates the dynamism of the west Knox County area. Highway construction, a significant element of landscape change, is illustrated in figure three. A portion of the Oak Ridge-Knoxville connector, a new four lane road to provide improved access between the two cities, can be seen in detail here. Note in figure eight from the ERTS platform the same road construction can easily be detected but more importantly, the large area coverage of ERTS shows the relationship of the road to the cities which it connects.

During this period of low altitude image generation, an effort was made to acquire imagery from other sources and at other scales. We were successful in obtaining NASA generated RB-57 imagery flown over eastern Tennessee in April 1972. The imagery in 9½ x 9½"format includes 161 frames in color ektachrome, 161 frames in color infrared, both at a scale of 1:120,000 from Wild RC-8 six-inch f/1 cameras, and 271 frames of color infrared at a scale of 1:60,000 from the 12" f/1 lens of the Zeiss camera. Coverage from the overflight includes the area from southern Kentucky (Middlesboro) and southern Virginia (Bristol) southward to and including the lower portion of the Little Tennessee River and east-west from western North Carolina (near Boone) to and including the Cumberland Plateau at Crossville, Tennessee to the west (Figure 4).

RB-57 imagery at this scale is unquestionably the best for general ground truth recognition and for correlation with ERTS imagery. Areal coverage per frame on the 1:120,000 scale imagery encompasses 289 square miles with a linear distance of 17 miles from edge to edge. Actual and potential landscape change features such as strip mining areas, interstate

Figure 3 - Low Altitude Aircraft Image of the Oak Ridge-Knoxville
Highway Connector

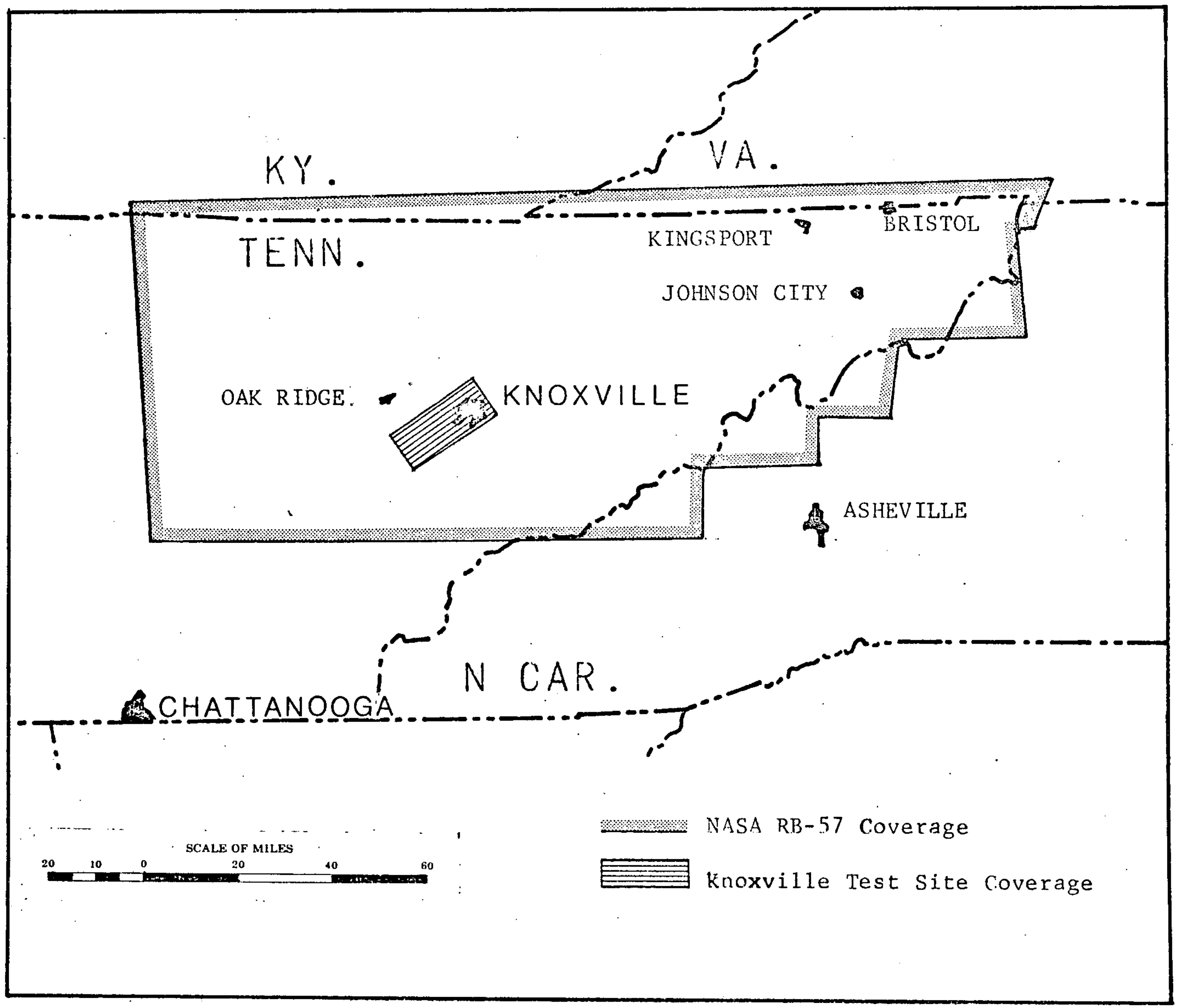


Figure 4 - Aircraft Coverage - NASA RB-57 Overflight, April 1972, and Knoxville Test Site Overflight

highway construction, forest cover, agricultural land use, and urban areas can be seen in detail as well as at a subregional spatial dimension. Figure five illustrates a portion of an RB-57 image of the Cumberland Plateau. The photo reproduction is a negative print from a color transparency and thereby enhances light colored features from the original into dark tones on the image.[2] Of particular interest are the surface strip mines in the central and northeastern portions of the photo. Etched into the surface of the Plateau, they clearly represent a product of landscape change. Because of the temporal and spatial characteristics of change associated with strip mines, the area shown here is perhaps the best selected site of regional proportions of landscape change within the study area. Note the extremely sharp contrast between the darker manmade features of strip mine scars, power transmission right of ways, and in the southern part of the image, the characteristics of cropland, roads, and the settlement features of Oak Ridge. In contrast to the dark man-made features, are the light tones which represent natural landscape features dominated by forest cover.

In July we conducted an experiment in simulating ERTS map scales by rephotographing the RB-57 imagery (9½ x 9½, 1:120,000 scale) onto 35 mm format film to a scale of 1:1 million. The smallest object size detected and identified was a 13 foot boat in one of the TVA reservoirs. However, more realistic object size features of landscape change were: strip mine scars on the Cumberland Plateau, interstate highway construction, shopping centers, suburban housing developments and field patterns on the agricultural landscape. Although most individual houses were lost from view in the scale transformation, they and many other smaller resolution objects such as automobiles were not expected to be seen nor were they entirely requisite to the study.

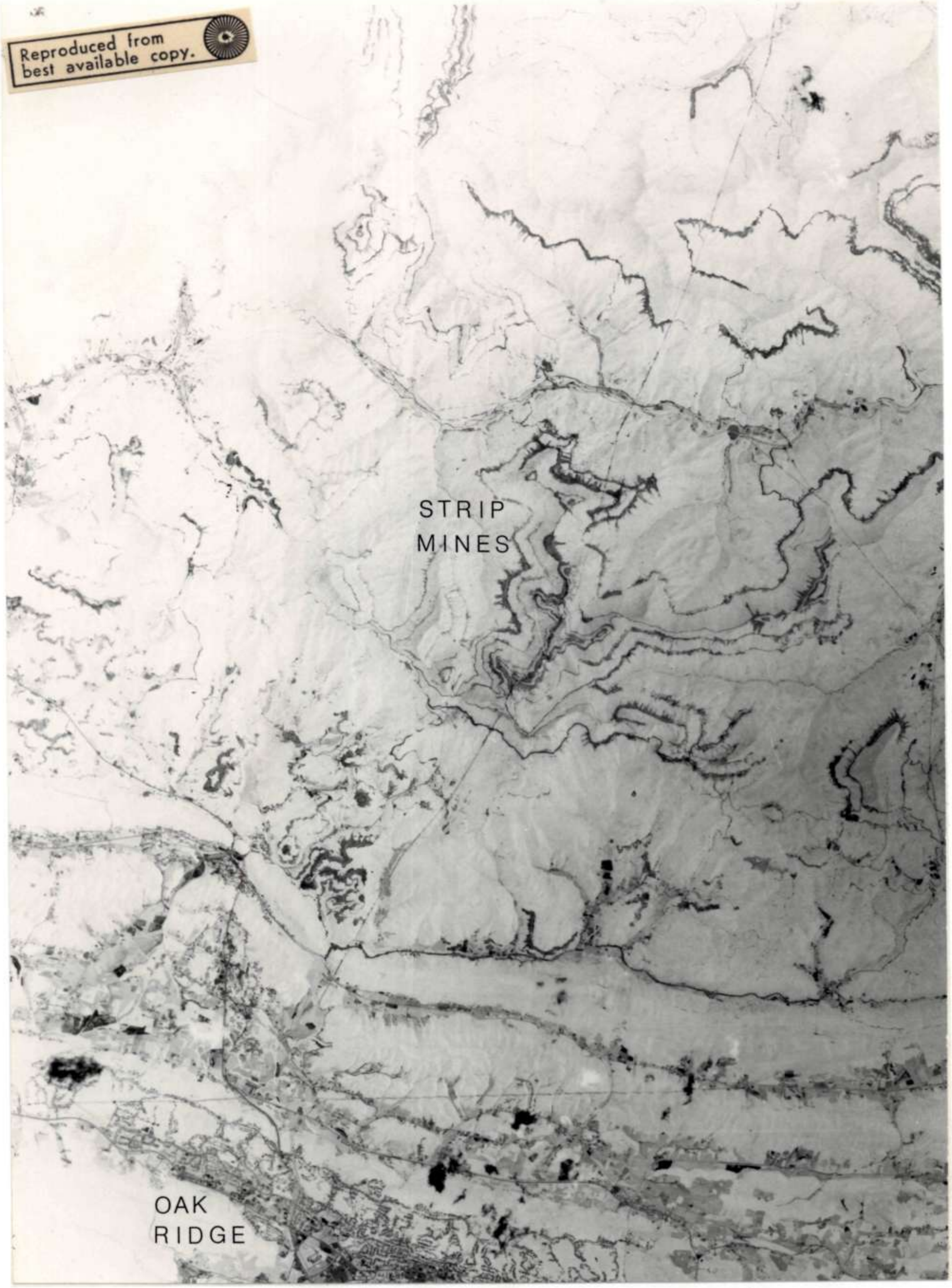


Figure 5 - High Altitude Aircraft (60,000') Image of the Cumberland Plateau Test Site

PRELIMINARY ERTS-I IMAGERY EVALUATION

As of October 9, we have to date received ERTS imagery from five overpass periods — August 21-22, September 8-9, and September 26, October 14-15, and November 2-3. Standing order, bulk imagery received thus far include MSS Bands 4, 5, 6, 7 in 9.5" x 9.5" black and white prints and transparencies, and 70 mm black and white negatives and transparencies.

The greatest single problem to date has been the high percentage of cloud cover over our test site. Although this is a problem which neither we nor NASA can do anything about, it still poses a problem for photo interpretation here in the humid East.

Of considerable interest is the large area coverage of the multi-date (2 day) and multiframe (4 frames) imagery required to bracket our 10,000 square mile study area centered on Knoxville (36^{o} N. 84^{o} W.). In many ways this is advantageous in that we are receiving data for more than one day and for more than one image frame area. In addition, the large area view supplied by this bracketing gives us a region-wide view from Lexington, Kentucky to Atlanta, Georgia which enables us to do more than infer the regional dynamics which are going on outside of our immediate study area.

Accomplishments since the reception of ERTS imagery include a basic cataloging and classifying of the data into a filing system, a densitometer analysis, the "first look" analyses, and the preparation, presentation, and future publication of professional papers from the project. Although a separate discussion of the "first look" results and a list of papers follows, this reporting period has been one of the more fruitful in terms of data acquisition and analysis. The NDPF has done a superb job of getting the data to us quickly and consistently. In fact, as might be expected, a virtual flood of imagery has descended upon the project. Fortunately, Mr. Tullos devised a catalog system which stores and catalogues the 70 mm imagery in one operation and catalogs the 9½" x 9½" imagery (Figure 6). The filing order is as follows: Date; Location - North 1st, South 2nd; MSS 4, 5, 6, 7; positive transparency; negative; print.

A densiometric product of a strip mined area is currently being produced for us by Drs. Bodenheimer and Green of the Electrical Engineering Department at the University of Tennessee. As a part of ERTS, they are receiving data inputs from our project and should be giving us some densitometric results soon. The experiment entails taking a densitometer analysis of the ERTS image showing contrasting forested (dark) and strip mine (light) surfaces of the Cumberland Plateau. Then digitizing the data and producing a computerized map printout. Furthermore, a histogram and a frequency distribution will be produced to be compared with subsequent analyses of the same area at later times using the same procedure. If successful, we should be able to compare the frequency distributions of the black, white, and grey tones on several overpass images and if the lighter tones increase in number and/or frequency then, barring cloud cover, we should be able to conclude that (1) forest cover was altered and (2) strip mine scars were increasing because of their increased number of light tone signatures.

70 mm Imagery

Index #: ______________ Date: ______________

Type: ______________

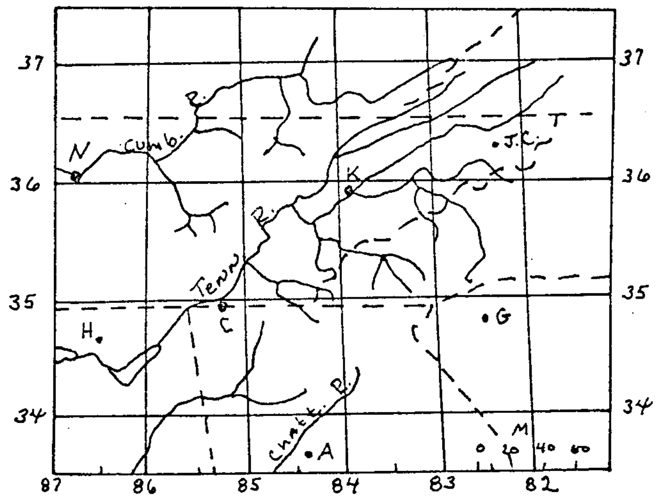
Location:

Lat. ______________ ______________

Long. ______________ Band: ______________

Cloud cover ______ Time: ______________

For comments see back.



9.5 x 9.5"
Imagery

Index # ______________ Date: ______________

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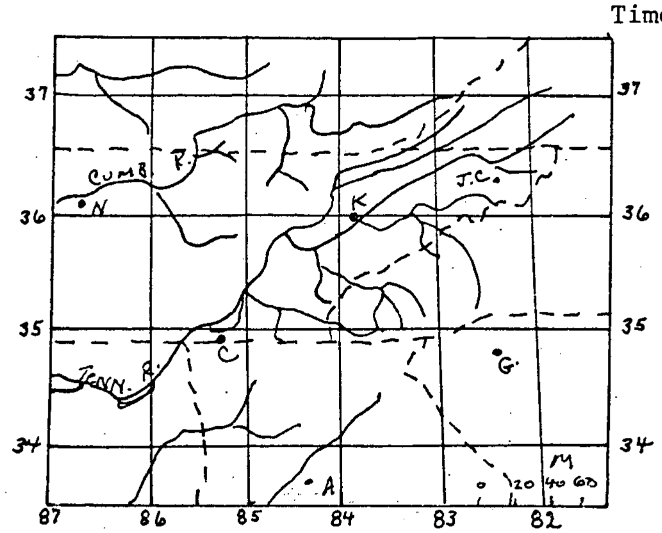

% cloud cover: ______

Comments:

Figure 6 - Examples of Catalog Cards for the 70mm and 9.5 x 9.5" ERTS Imagery Classification System.

FIRST LOOK ANALYSIS - IMAGERY CHARACTERISTICS

Comparison of Formats

Formats of the ERTS imagery are in 70 mm and 9.5" x 9.5" film sizes. They are produced in either negatives (70 mm), positive transparencies (70 mm, 9.5" x 9.5"), or positive prints (9.5" x 9.5"). A comparison of each is in order because of differences in map scales, uses, and presentation of the imagery. The 70 mm imagery is perhaps the most versatile of the formats. It can be projected, enlarged, and the 70 mm negative transparencies can be used to produce positive prints of any size. For interpretation the unprojected 70 mm image is too small a scale to be useful for basic interpretation. As a projection or enlargement, however, it is perhaps the most useful for interpretation. The 9.5" positive transparency is excellent for interpretation purposes and serves well as a product from which data can be mapped quickly. Positive prints in the 9.5" format, though no longer being shipped to us by NASA, were originally not of the same sharp quality of the transparencies but were of considerable use in quick look analysis and for presentation in small conferences where formal slide presentation could not be done. Incidentally, both 70 mm and 9.5" positive transparencies can be projected via a 2¼ x 2¼ projector and overhead projector respectively and are invaluable for presentation at professional meetings.

Comparison of Spectral Bands and Analysis

Examples of all four bands of the MSS have been received and have been undergoing evaluation and analysis since October 9. A comparison of the four bands reveals distinctive positive and negative reactions.

For our purposes of landscape analysis where contrasts between forested versus cleared lands and urban versus rural landscapes are of paramount consideration band 5 has consistently been the best for this effort. By comparison, band 4 reveals very poor contrast and because of its reflectance readings, is not as useful to our effort. Although bands 6 and 7 of the infrared range are similar, band 7 is by far the sharper, clearer, and more contasting of the two. As expected, band 7 imagery reflects water surfaces extremely well of TVA reservoirs, related streams, and occasionally flood conditions within the study area. Topographic features, (i.e. landform surfaces) are enhanced on Band 7 as well.

Figure seven, print of a band 7 image for October 15, illustrates the enhancement of both water and topographic characteristics. Note the dark shading on the north facing slopes of the Great Smoky Mountains which indicates an abnormal amount of surface moisture and wetted area. A few days preceding this overpass, a frontal system had passed over the area bringing heavy rain for the upper windward slopes of the Smokies, hence, the dark wetted surface. To the west, on the Cumberland Plateau, strip mine scars with water filled depressions appear on band 7. The dark water serves as a surrogate signature for strip mines on this band and thus is a useful backup to band 5 where strip mines appear in light tones. In the center, marked by a darkened star or fan-shaped area is Knoxville. On band 7, urban areas appear dark in contrast to the lighter tones of the surrounding agricultural scene primarily because of the reflectance characteristics of the concrete and light colored gravel surfaces which cover the roads and roofs of the city.

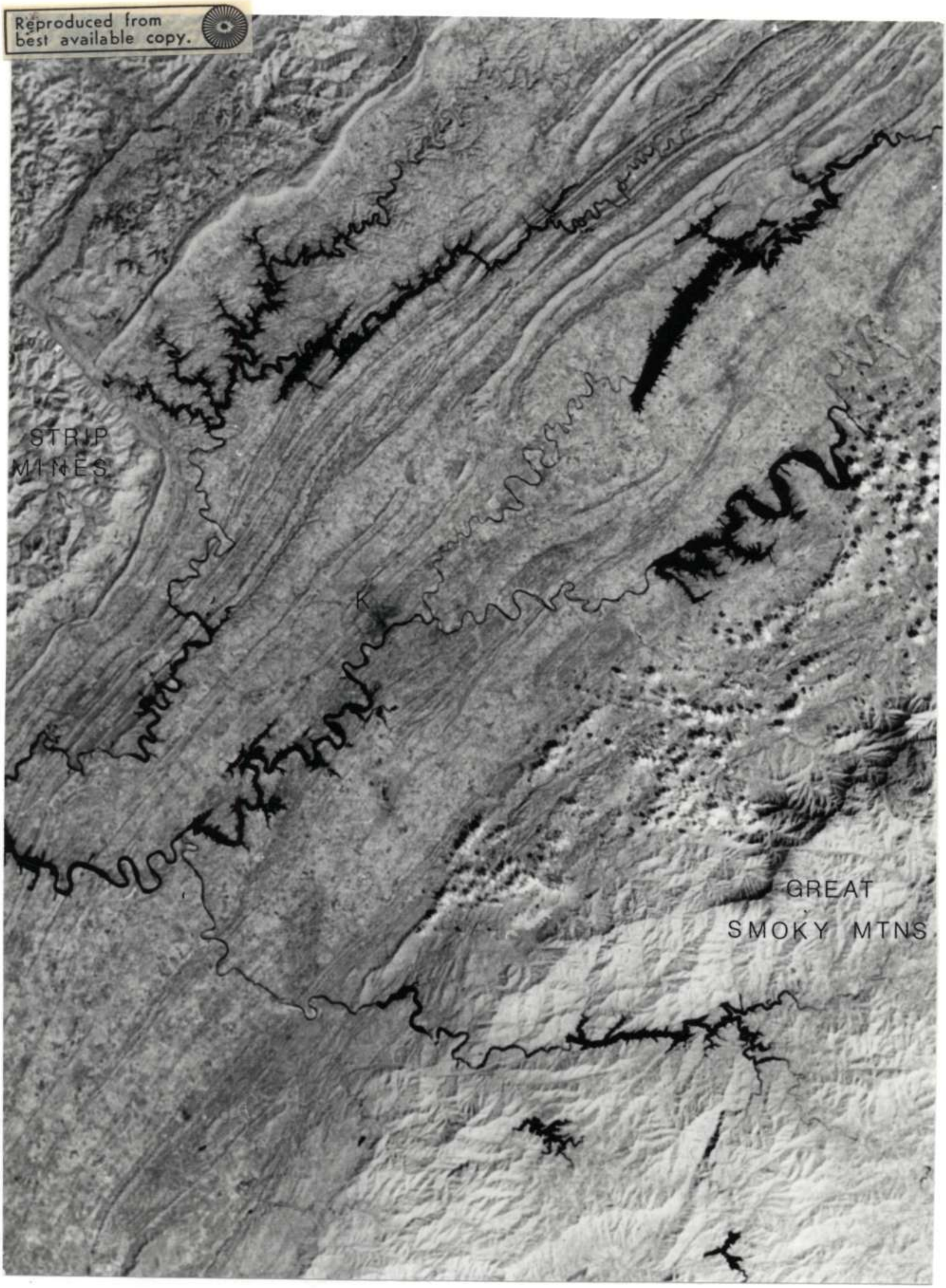

Figure 7 - ERTS-I Image (560 miles) of the East Tennessee Study Area
MSS Band 7. October 15, 1972/1084-15431-701.

Band 5, as illustrated in figures 8, 9, and 10 is unquestionably the most useful single band from the multispectral scanner (MSS). Although water features are sometimes subdued on this band, other features such as forest cover, agricultural lands, topography, road and highway networks are sharply enhanced on the imagery. Figure eight of the Knoxville and East Tennessee study area illustrates several elements of actual and potential landscape change. One of the more dynamic landscapes is the strip mine activity and forest clearance on the Cumberland Plateau north and west of Oak Ridge. In this photo, the white lines on the otherwise dark forested plateau are strip mine scars.

An experiment using a densitometer analysis on the ERTS imagery of this same test site is described on page 12.

Interstate highways are visible over much of the photo. Areas of interstate construction are usually easier to identify than those of completed interstate highways. Note the southern portions of I-75, the I-40 portion east of Knoxville, and the I-81 construction in the northeast of figure 8. In each case the construction is prior to the paving operation and has created highly reflective cleared earthen surfaces. The Oak Ridge - Knoxville (via I-40) connector mentioned earlier in this report is the diagonal (NW-SE) white line located southeast of Oak Ridge. The significance of this road is simply that it is under construction and thereby represents an object of landscape change and, further, illustrates the region-wide view offered by ERTS to show the relationship between the two cities of Oak Ridge and Knoxville and the road which connects them.

Knoxville, located at the center of the photograph, reflects as a white nodal cluster with highways radiating out from it. Internal

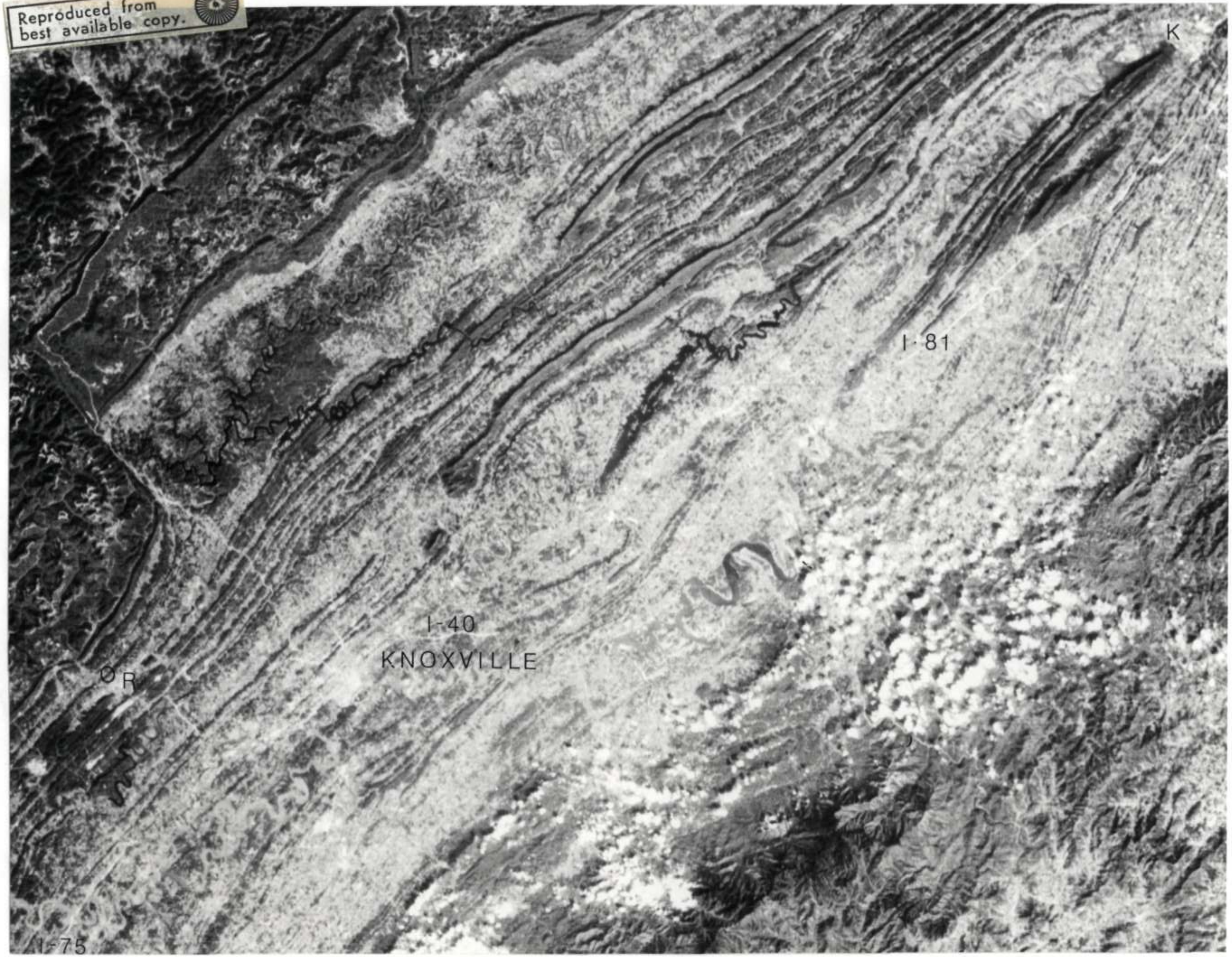

Figure 8 - ERTS-I Image of the East Tennessee Study Area
MSS Band 5. October 15, 1972/1084-15431-501

characteristics of this and other cities such as Kingsport in the northeast corner of the photo are virtually lost because of the high reflectance of a dense web of light-toned streets and rooftops. This yields to an amalgamation effect and thus blurs the minute differences of tone, texture, and pattern of the urban settlement. Thus far we have been somewhat disappointed in the loss of most detail from the urban areas. We are currently experimenting with the possibilities of photochemically enhancing the imagery to improve the contrasts but we do not expect too much success from the endeavor.

The suburban growth areas hold somewhat more promise for us in the detection of landscape changes. Southwest of the center of Knoxville is the area of dynamic growth mentioned earlier in this report. Several transportation routes principally I-40 serve access to the area, and several shopping centers, stores, new car dealerships, and business offices have moved into the area. Although cell for cell, most individual stores, or businesses are too small to detect and identify on the ERTS imagery, they collectively create relatively large resolution cells of growth. We hope that through time, such agglomerations can be monitored with the ERTS system. Subdivision housing projects are much the same in terms of areal coverage, but unlike shopping centers, subdivision settlements are developing somewhat more slowly.

Forest cover on band five (Figure 8) is sharply marked by dark tonal patterns. For the most part, mountain, ridge, and plateau surfaces are dominated by forest cover and are thus easily identified and mapped. We are currently experimenting with a photochemical enhancement technique which prints only the darker forest signatures.

It is a very simple process of underexposing the positive print and then cheating on the development time in the developer. Using high contrast print paper, the experiment has worked well and holds promise for reversed black and white photos which could transform originally light toned cultural features into dark toned enhancements.

Figure nine of the ERTS imagery covers a portion of the Cumberland Plateau north of Knoxville. The area extends from the light toned Blue Grass Basin of Kentucky in the northwest to Pine Mountain, Kentucky in the southeast. Part of the folded Ridge and Valley province appears in the southeast marked by forested ridges and cleared, settled agricultural valleys. The small area in the northwest corner of the photo is a portion of Kentucky's Blue Grass Basin, a richly settled limestone basin of past and present high agricultural value. Although its change dynamics are not likely to be of much significance to this investigation, the basin is noted for its burley tobacco and pleasure horse farms. The highly dissected Cumberland Plateau dominates the remainder of the photo. Densely forested and deeply mined for coal, the region expresses several landscape change elements. The paramount change characteristic caused by human action is the strip mining shown in the center of the image. Other changes, particularly in the seasonal defoliation and foliation of the forest cover can be expected for this densely forested region. We are particularly anxious to analyze the color composite imagery for these and other forested areas for such change detection in vegetation.

Figure ten is an ERTS image of the area south of Knoxville and the East Tennessee Test Site. In the far northwest corner is the continuation of the Ridge and Valley province marked by north-south lineations of

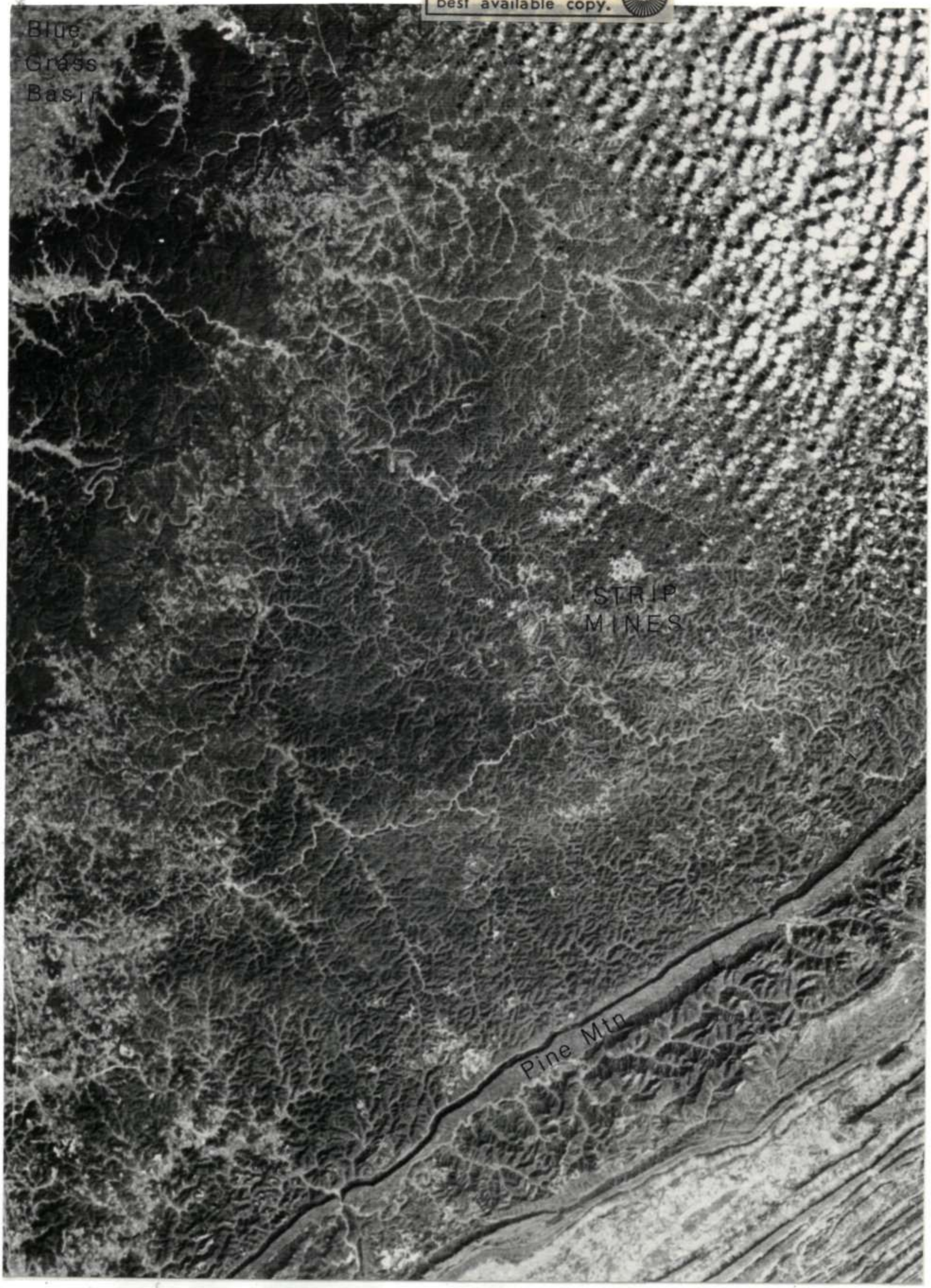

Figure 9 - ERTS-I Image of the Cumberland Plateau, Eastern Kentucky, MSS Band 5. October 15, 1972/1084-15424-501

forested ridges and cultivated valleys. East of this area is the bright, denuded Copper Basin, an area of little or no vegetation as a result of copper mining and smelting for the past 120 years. Although the area is a striking example of landscape change for the past, it does not hold too much promise for short term current changes in the area. Only if the area were to rapidly revegetate or should it expand in forest damage could we detect changes and either event is unlikely at present.

The remaining dark toned area which dominates the entire scene is a part of the forested Southern Appalachians. It is in this area that we expect to observe vegetative change on a seasonal basis, possible forest fire detection, and the growth of second home recreation developments. In the southeastern one-third of the image is a portion of the southern Piedmont area of Georgia and South Carolina. Here slopes are not as steep as the Appalachians, thus settlement, roads, and agricultural landscapes dominate this relatively light toned area. Dark tones, again, represent forest cover. Atlanta can be seen at the southernmost edge of the photo. Only the northern half of the city is covered on the image, but such landscape elements as interstates, beltways, and suburban settlements are visible.

Photomorphic Regions

Figures 8, 9, and 10 all offer excellent examples of photomorphic regions (i.e. regions which exhibit a unity or cohesiveness in either tone, shape, or pattern).[3] Such regions appear in figure 8 as the Great Smoky Mountains area, the light tones of the agricultural valleys and their contrasting dark ridges in the center of the photo, and the rough dark plateau surfaces of the Cumberland Plateau to the west and northwest.

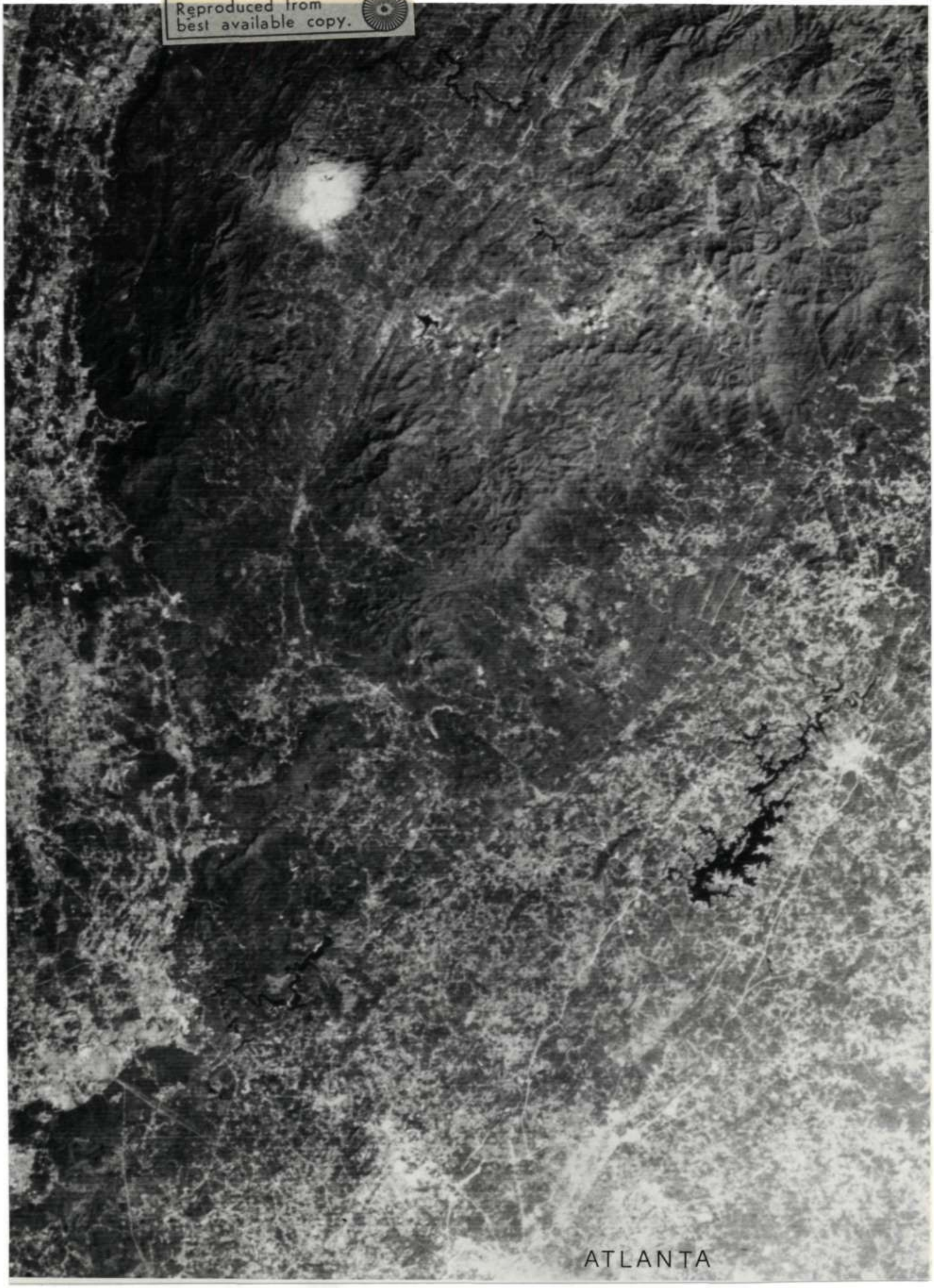

Figure 10 - ERTS-I Image of the Southern Appalachians, Tennessee, Western North Carolina, Northern Georgia. Atlanta, MSS Band 5. October 15, 1972/1084-15433-501.

Figure nine has four general photomorphic regions: the light toned Blue Grass Basin in the northwest, the dark forested region of the Cumberland Plateau in the center, the light toned agricultural and settlement area of the plateau to the southwest, and the folded ridge and valley complex to the south and southeast of the photo. Figure ten exhibits four regions as well: a mottled tone of ridges and valleys to the northwest, the white, bright Copper Basin in the northwest, the entire dark and dominating Southern Appalachian mountains and the light toned Piedmont area to the southeast.

In each photomorphic region we can determine a certain and separate degree of tonal unity and distinctiveness. But more importantly a management and landuse distinction exists in each region. For example, in Figure 8 the Great Smoky Mountains region is distinctive in tonal quality, landuse, and topography from the settled valleys and forested ridges to the west of it. Likewise in Figure 9, the Blue Grass Basin is a much different landuse, topographic and management region than the dark and surficially rough plateau surface to the south. Although these concepts are well known here on earth, one requires the regionwide view to analyze such regional variations and to express to the general public the importance of such distinctive regions. In many ways, regional variations like these reflect variations in earth resources and thus suggest a different set of values and management principles be applied to each.

Cost Benefits

Actual real time cost benefits are difficult to assess. However, the following parameters may allow an inference of the benefits to be gained from the use of ERTS data. The Tennessee Valley Authority, which has an unprecedented record of data collection and analysis for its area views ERTS as the first means for producing a Valley (TVA) wide view of the region.[4] Forest resources for which TVA has information, account for a small percentage of the total forest resource wealth of the area primarily because only relatively small samples are taken by TVA. Valley-wide inventory of forest cover is desired by TVA, and ERTS can clearly provide this for them. The agricultural resource base has in the same problem, i.e., too few sampled areas and a lack of a region-wide view of the agricultural landscapes. The Geologic Branch also sees ERTS as a means for delivering information on faults, and other lineations which would (1) improve the knowledge of faults in the area and (2) provide the engineering sections, data for locational planning of power sites, dams, transmission routeways, etc.

Water resources within the study area are a prime responsibility of TVA. However, short term flooding conditions as have just occurred (December 11-14, 1972) and their effect locally and downstream could be easily determined on a region-wide basis from ERTS data.

PAPERS AND PUBLICATIONS

Papers and Presentations

1972- Southeastern Division of the Association of American Geographers Meetings, November 19-21, 1972, Miami, Florida. "Remote Sensing of Landscape Change: A Case for the Earth Resources Technology Program".

1973 (April) - "Regional Landscape Change: A Case for ERTS-I". To be Presented at the 69th annual Association of American Geographers meetings in Atlanta, Georgia. April, 15-18, 1973.

1973 (March) - "Geographic Applications of ERTS-I Imagery to Rural Landscape Change in Eastern Tennessee". To be presented at the Second Annual Remote Sensing of Earth Resources Conference, March 26-27, 1973. University of Tennessee Space Institute, Tullahoma, Tennessee.

1973 (April) - "Geographic Applications of the Earth Resources Technology Satellite Program to Rural Landscape Change". To be presented at the First Pan American Symposium on Remote Sensing, Pan American Institute of Geography and History, to be held in Panama, Republic de Panama on April 27-May2, 1973.

Publications

1972 (June)- Geographic Applications of ERTS-A Imagery. Type I Report. NASA Earth Resources Survey Program. National Technical Information Service. Springfield, Virginia. Publication no. E72-10006.

1973 (Jan.) - "Geographic Applications of ERTS-I Imagery to Rural Landscape Change" Institute of Electrical and Electronic Engineers, Transactions on Geoscience and Electronics. Vol. GE-11, #1,January,1973.

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2. Rehder, John B. "Black and White Negative Prints from Color Transparencies: A Technique for Image Enhancement." Unpublished manuscript to be submitted to Photogrammetric Engineering.

3. McPhail, Donald D. and Yuk Lee. A Model for Photomorphic Analysis: Tennessee Valley Test Site, Technical Report 71-3. Project completed for the Tennessee Valley Authority through support of U.S.G.S., Association of American Geographers, Commission on Geographic Applications of Remote Sensing. East Tennessee State University, Johnson City, Tennessee, February, 1972.

   McPhail, Donald D. "Photomorphic Mapping in Chile." Photogrammetric Engineering, Vol. 37, 1971, pp. 1139-1148.

4. Rehder, John B. Delineation of Information Requirements by T.V.A. Interviews, Technical Report 71-2. Project completed for the Tennessee Valley Authority through support of U.S.G.S., Association of American Geographers, Commission on Geographic Applications of Remote Sensing, East Tennessee State University, Johnson City, Tennessee, December, 1971.

ERTS 1 STANDING ORDER FORM

(See Instructions on Back)

DATE Sept. 19,1972

GSFC ID NUMBER UN 212

PRINCIPAL INVESTIGATOR Dr. John B. Rehder

TELEPHONE NO. (615) 974-2418 or 4315 ☐ NEW

SHIP TO: Dr. John B. Rehder
(NAME)
Dept. of Geography
(AGENCY)
University of Tennessee
(STREET)
Knoxville, Tennessee 37916
(CITY) (STATE) (ZIP)

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	LATITUDE	LONGITUDE			START DATE	STOP DATE	TYPE	FORMAT			1	2	3	1	2	3	4	
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TELEPHONE NO. (615) 974-2418 ☐ NEW

SHIP TO: Dr. John B. Rehder
(NAME)
Department of Geography
(AGENCY)
University of Tennessee
(STREET)
Knoxville, Tennessee 37916
(CITY) (STATE) (ZIP)

☒ ADDITION
☐ CHANGE
☐ DELETION

CATALOGS DESIRED

STANDARD ☐ U.S. ☐ NON-U.S.

DCS ☐

MICROFILM ☐ U.S. ☐ NON-U.S.

☐ CHECK IF ADDRESS IS NEW

NDPF USE ONLY
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AREA NUMBER	GEOGRAPHIC POINTS		CLOUD COVER %	QUALITY	COVERAGE PERIOD		PROD		TICK MARK	QUANTITY	RBV BANDS			MSS BANDS				DELETE
	LATITUDE	LONGITUDE			START DATE	STOP DATE	TYPE	FORMAT			1	2	3	1	2	3	4	
	37 N	85 W	9	G	8-21-72	8-31-73		M		1				x	x	x	x	
	36 N	85 30'W						S		3				x	x	x	x	
	35 N	85 50'W						T		3				x	x	x	x	

29

GSFC 37-3 (7/72)

INVESTIGATOR'S COPY

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TM APP.

ERTS DATA REQUEST FORM
560-213 (7/72)

1. DATE December 7, 1972

2. USER ID UN 212

4. SHIP TO: Dr. John B. Rehder

ADDRESS ☐ NEW

Department of Geography

University of Tennessee

Knoxville, Tennessee 37916

5. TELEPHONE NO. (615) 974-2418 ☐ NEW
or 974-4315

6. CATALOGUES DESIRED

STANDARD ☐ U.S. ☐ NON-U.S

DCS ☐

MICROFILM ☐ U.S. ☐ NON-U.S

ADDDHHMMS OBSERVATION IDENTIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AR
1030-15428	N36-54/W083-09	B&W=M Color=6,7	A B C	S T	L	4	U
1030-15430	N35-28/W083-51	B&W=M Color=6,7	A B C	S T	L	4	U
1048-15432	N34-33/W083-51	B&W=M Color=6,7	A B C	S T	L	4	U
1084-15424	N37-24/W082-57	B&W=M Color=6,7	bulk/ABC	N S T	L	4	U
1084-15431	N35-59/W083-25	B&W=M Color=6,7	bulk/ABC	N S T	L	4	U
1084-15433	N34-33/W083-52	B&W=M Color=6,7	bulk/ABC	N S T	L	4	U
1102-15435	N34-23/W083-58	B&W=M Color=6,7	bulk/ABC	N S T	L	4	U
1103-15845	N37-14/W084-30	B&W=M Color=6,7	bulk/ABC	N S T	L	4	U

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ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NDPF USE ONLY
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ID

DATE December 14, 1972

PRINCIPAL INVESTIGATOR Dr. John B. Rehder

GSFC UN212

ORGANIZATION Dept. of Geography, University of Tennessee

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS* Forest	River	Mines	DESCRIPTORS
108415431-701		EEO X	X	City Anticlines Synclines Axial Stream Barbed Tributary Bedrock Braided Stream Broken Cloud (Cirrocumulus) Dendritic Drainage Divide Plateau Mountain Valley
108415431-501	X	X	X	City Anticlines Synclines Axial Streams Barbed Tributary Bedrock Braided Stream Broken Cloud Dendritic Drainage Divide Plateau Mountain Valley EEO Highway Agriculture EEO Geography Parallel Drainage EEO Urban Area EEO Rural Area

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

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GSFC 37-2 (7/72)

ERTS IMAGE DESCRIPTOR FORM

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DATE December 14, 1972

PRINCIPAL INVESTIGATOR Dr. John B. Rehder

GSFC UN212

ORGANIZATION Dept. of Geography, University of Tennessee

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Forest	River	Mines	
108415424-501			EEO X	EEO Valley EEO Gap Cumulus
103015430-701		X		Lakes Cumulus
103015430-501	X		X	Cumulus Highways City

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Forest	River	Mines	
108415433-501	X	X	EEO X	Piedmont Plateau Urban Area Highways Anticlines Synclines Valley Faults City EEO Scar Mountain Agricultural
108415433-701		X	X	EEO Lake Mountain Bedrock Faults Divide Piedmont
110215435-501				Lake Cumulus City Highways
110215435-701		X		Lakes Cumulus Piedmont

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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