LARS Information Note 022274

PREPARING RESOURCE INVENTORIES IN THE SOUTHERN GREAT PLAINS BY MACHINE PROCESSING OF ERTS-1 MULTISPECTRAL DATA

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Purdue University, West Lafayette, Indiana

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ABSTRACT

Multispectral scanner data were obtained with the Earth Resources Technology Satellite (ERTS-1) over two test sites in the Southern Great Plains. Each of the test sites covers an area of approximately 2,500 km^2, one centered around Lubbock, Texas; the other around Hobbs, New Mexico. The climate of these areas in the Llano Estacado is classed as semiarid to arid.

The objective of the study was to prepare a resource inventory of the two test sites through the use of computer-implemented analysis of multispectral data. Using both supervised (training sets) and non-supervised (clustering) computer programs, the scenes were separated spectrally and mapped into a number of classes. Classification results were correlated with ground information. A comparison was made between the computer classification results of the Hobbs Subframe (where no ground information was available) and the Lubbock Subframe (where a considerable amount of ground information was available). Classes of surface features which were successfully identified and mapped spectrally were croplands, rangelands, surface water, broad soil patterns, urban areas, drainage patterns, and major transportation arteries.

INTRODUCTION

Two areas, Lubbock County, Texas and Hobbs, New Mexico (Figure 1) located on the Llano Estacado were chosen for analysis. The areas are similar in economy, (mostly agricultural) and climate (arid to semiarid). Data were collected by the Earth Resources Technology Satellite during June 1973. Two methods of analysis were used in this study (1) unsupervised for the Hobbs, New Mexico area, and (2) supervised for the Lubbock County, Texas area.

For this analysis no ground information was available for the Hobbs area. In the Lubbock area, the analysts had a set of high quality ground information in addition to some personal knowledge of the area. The availability of ground information contributed greatly to the success and interpretation of the classification of the Lubbock County data.

PROCEDURES

Remote sensing data from the Earth Resources Technology Satellite (ERTS-1) were used in this investigation. The data are from the multispectral scanner and are in the form of computer compatible tapes.

The bands of the multispectral scanner are in the visible and near infrared region of the spectrum: channel 4--0.50-0.60μm, channel 5--0.60-0.70μm, channel 6--0.70-0.80μm and channel 7--0.80-1.10μm.

The LARSYS Version III software system is a package of computer programs, which have been designed to analyze and display remotely sensed multispectral data using an IBM System 360 computer. Five major processing algorithms were used in this study:

(1) CLUSTER, (2) STATISTICS, (3) CLASSIFYPOINTS, (4) PRINTRESULTS, and (5) PHOTO. The CLUSTER processor is an unsupervised classifier that groups data vectors into spectrally distinct classes. Mean vectors and covariance matrices are calculated by the STATISTICS processor which performs a maximum likelihood Gaussian classification on a point-by-point basis over the entire area. Results from the above analysis are displayed using: (1) the PRINTRESULTS processor to make alphanumeric maps; and (2) the PHOTO processor to display the results on the digital display.

The Digital Image Display System receives an image from a System 360 computer, stores this data in a video buffer, and displays the image in a raster scanning mode on a standard television screen. An interactive capability to edit, annotate, or modify the image is provided through a light pen and a program function keyboard. An additional photographic copying capability is also provided.

DESCRIPTION OF STUDY AREA

The areas analyzed in this investigation are on the Southern High Plains of Western Texas and Eastern New Mexico. This area, known as the Llano Estacado, is a plateau bordered by escarpments on the east, west, and north and on the south by the Edwards Plateau. The plateau surface is essentially flat with a dip of approximately $.1^{\circ}$ to the southeast.

The only topographic features on the Llano Estacado are several broad shallow draws and a large number of shallow playas. The draws are very shallow and broad except near the escarpment where they become steep sided canyons. Numerous shallow playas are present on the Llano.

The study area is arid to semiarid and generally receives from 31 to 53 centimeters (15 to 21 inches) of precipitation per year. Wheat, cotton, and grain sorghum are the major crops and are grown under irrigated and dryland conditions.

HOBBS, NEW MEXICO ANALYSIS

Data collected by ERTS on 19 June 1973 (Scene ID 1331-16585) were analyzed by unsupervised methods without ground information or air photos. Initial inspection of the data was made using a color composite photo produced from the digital display using ERTS bands 4, 5, and 7. A classification of the Hobbs area was generated by selecting a representative area, i.e. an area containing all of the expected surface features, and using the nonsupervised clustering algorithm in the LARSYS system to define the spectral classes which were present in the data. After the classification was made the results were displayed on output from the liner printer and also on the digital display (Figure 2). Photo interpretation techniques were then used to identify features in the Hobbs area using both the classification results and the color composite photos.

Detailed interpretation of both the color composite and the classification indicated that general land use categories could be easily distinguished (Figure 3). Agricultural areas, characterized by circular fields, were identified as either being in active cultivation or fallow. Pasture and natural rangeland were identified. It was possible to delineate areas of active growth of the plants both on the classification, because the areas were classified as green vegetation, and on the color composite, because of the red tones which are usually indicative of green vegetation. Man-made features such as airports, roads, oil fields, and urban areas were identified. The class containing man-made features included all highly reflective material such as natural outcrops of caliche, bare soil, and most hard surfaces. The naturally occurring highly reflective material could be separated

from man-made features because of the differences in shape and location.

LUBBOCK COUNTY, TEXAS ANALYSIS

ERTS data collected 18 June 1973 (Scene ID 1330-165331) were used in the preparation of a land use map for Lubbock County, Texas and the city of Lubbock. As in the Hobbs, New Mexico analysis, an initial inspection of the data was made using color composite photos taken from the digital display using ERTS bands 4, 5, and 7. Classifications of the Lubbock area were produced using supervised classification methods. Training areas, from which statistics were obtained to produce the classification, were selected on the basis of ground information obtained from the site. Ground information (Figure 4) consisted of high altitude (20,000 ft.) color and color IR photography, low altitude (2,000 ft.) oblique color slides, and personal knowledge of parts of the Lubbock area. Classification results were displayed on output from the line-printer and on the digital display unit.

Five classes of ground cover were identified in the classifications: (1) commercial, (2) residential, (3) green vegetation, (4) agricultural, and (5) water. None of the classes described above, with the possible exception of the agricultural and water classes, is characterized by a spectral response which is homogeneous, but rather by a combination of spectral responses from several types of materials. The commercial class is a combination of spectral responses from roofs, parking areas, and streets while the residential class is composed of roofs, streets, trees, and lawns. The green vegetation class consists of trees and grass. The agricultural class is composed of bare soil with very little vegetation on 18 June 1973. Using the above class definitions, misidentifications in the classifications can be more easily understood and explained.

Results from the analysis of Lubbock County were compared with available air photos and with the published topographic maps. In the classification of the county area (Figure 5), small towns (A. New Deal, B. Idalou, and C. Slayton), airports (D. Reese AFB and E. Lubbock Regional Airport), and some water bodies (F. Buffalo Springs Lake) can be located and are correctly classified. There are, in the county classification, scattered points which were classified as residential or commercial, these are apparently farmsteads which contained mixtures of roofs, hard surfaces, and green vegetation.

When the classification results of only the city of Lubbock are compared with the aerial photography, many features can be identified. A comparison of black and white copies of color IR and color oblique photographs with the classification results from the city of Lubbock is shown in Figures 6 to 9. Areas of interest are identified by letters on the air photo which correspond to letters on the classification.

A comparison was also made between the classification results and the published USGS topographic maps which were made in 1957 and photo-revised in 1970 (Figure 10). This comparison was made to check the classification results and also to identify areas of urban growth. The most apparent growth has taken place in the western part of the city. As in the previous comparisons, areas identified by letters on the topographic map correspond to letters on the classification results.

CONCLUSION

From the work presented in this paper it can be concluded that proper analysis of multispectral scanner data can be used to produce a useful land use map. This conclusion should be considered in two parts: (1) the proper analysis procedures and (2) the usefulness of the resulting classification.

Both the nonsupervised and supervised classification procedures are useful for producing a land use map, with the selection of a procedure based on amount of ground information available and the amount of detail required in the finished product. The nonsupervised classification of the Hobbs, New Mexico area was made with no ground information, yet a reasonably accurate classification of urban, agricultural, and pasture area was made. Since no ground information was available, assignment of names of spectral classes is tentative and based on spatial inspection of the classification results and the original data.

The supervised classification of the Lubbock County, Texas area produced a very usable and accurate map. Because of the ground information that was available, the classes to be used in the classification could be accurately named and controlled. In addition, classification results could be checked with the available photography and maps to determine its accuracy. The supervised classification, in this study, yielded the best results. For an operational system, a combination of supervised and nonsupervised classification methods would be used. It should be understood that supervised and nonsupervised methods of classification are two forms of machine-aided processing and differ only in the degree of man-machine interaction.

The results from the classification, whether produced by supervised or nonsupervised methods, have the potential of replacing, or at least supplementing to a large extent, air photos as a data source in the production of land use maps. Machine processing of remote sensing data has several major advantages in producing land use maps, such as: (1) ability to map large areas, (2) speed of processing, and (3) accuracy. Land use maps of large areas can be produced quickly, accurately, and relatively inexpensively using machine processing of remotely sensed data.

ACKNOWLEDGEMENTS

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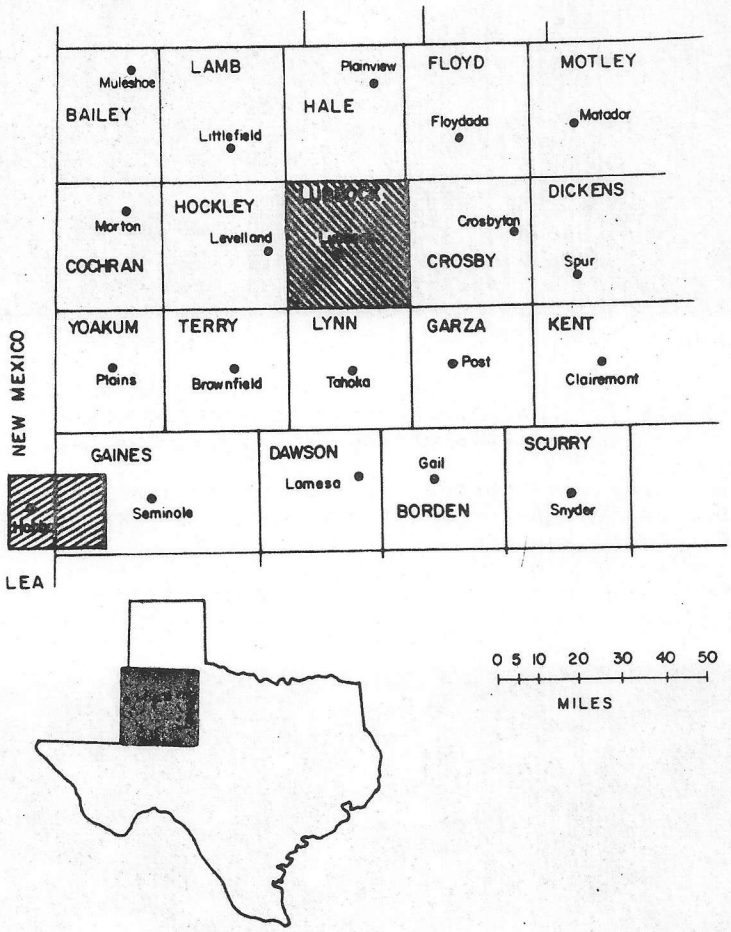

Figure 1. Index Map.

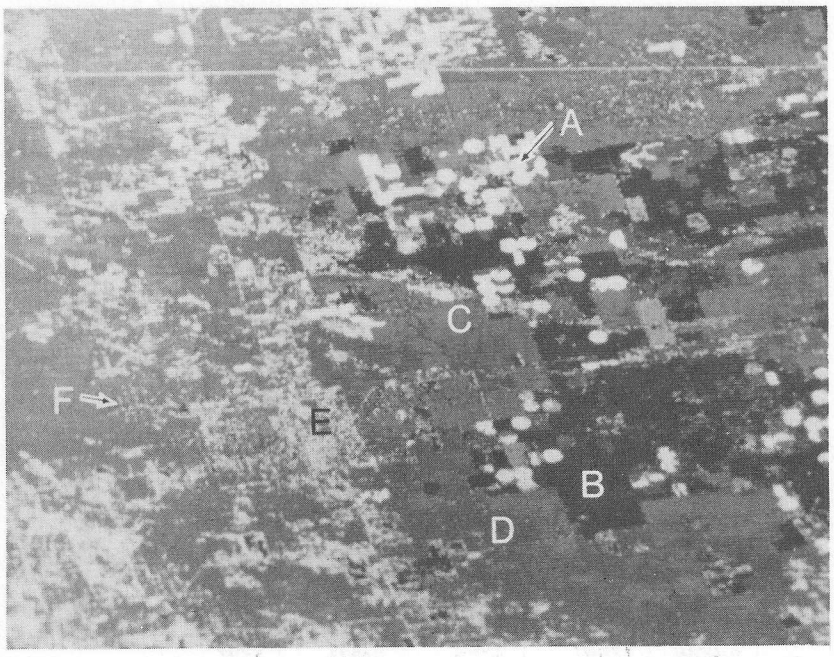

Figure 2. Unsupervised classification of an area around Hobbs, New Mexico.

A. Green Vegetation
B. Fallow
C. Green Pasture
D. Brown Pasture
E. Hobbs, New Mexico
F. Oil Field

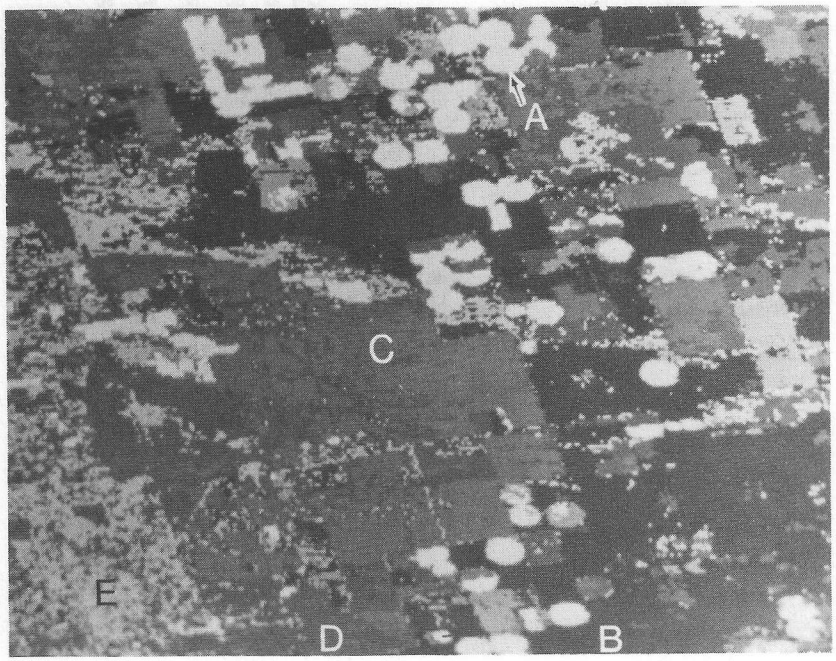

Figure 3. Enlargement of a portion of Figure 2.

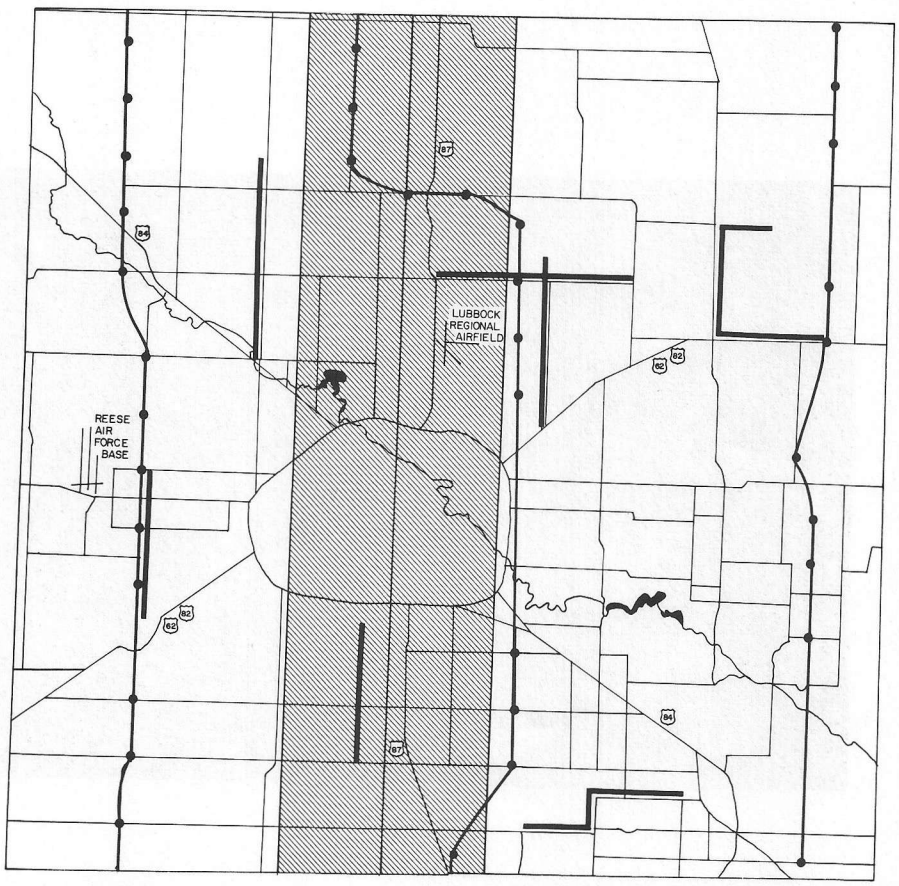

Figure 4. Location of ground information used in the analysis of Lubbock County, Texas.

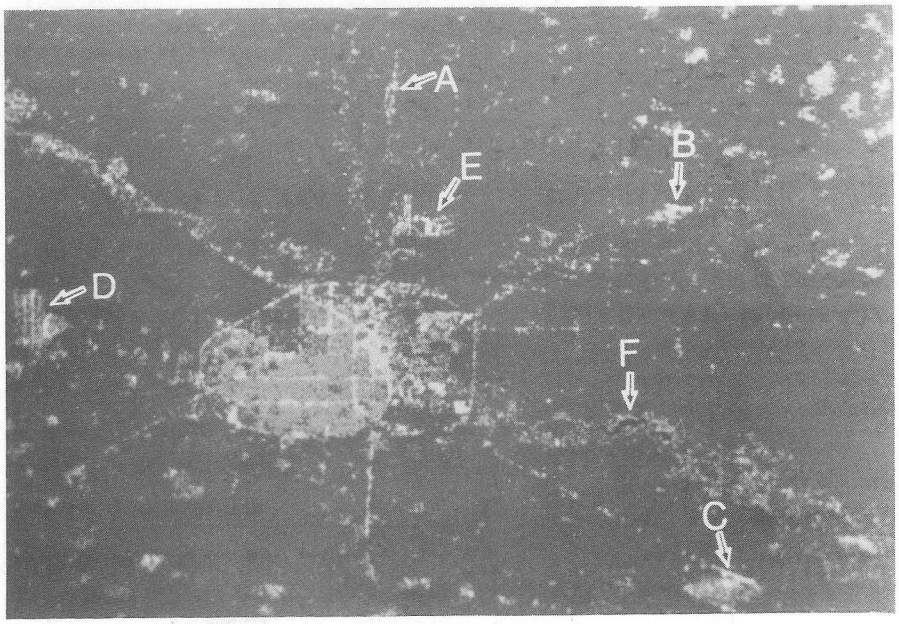

Figure 5. Classification of Lubbock County, Texas.

Black - Water
Dark Gray - Agriculture
Light Gray - Residential
White - Commercial

A. New Deal
B. Idalou
C. Slayton
D. Reese AFB
E. Lubbock Regional Airport
F. Buffalo Springs Lake

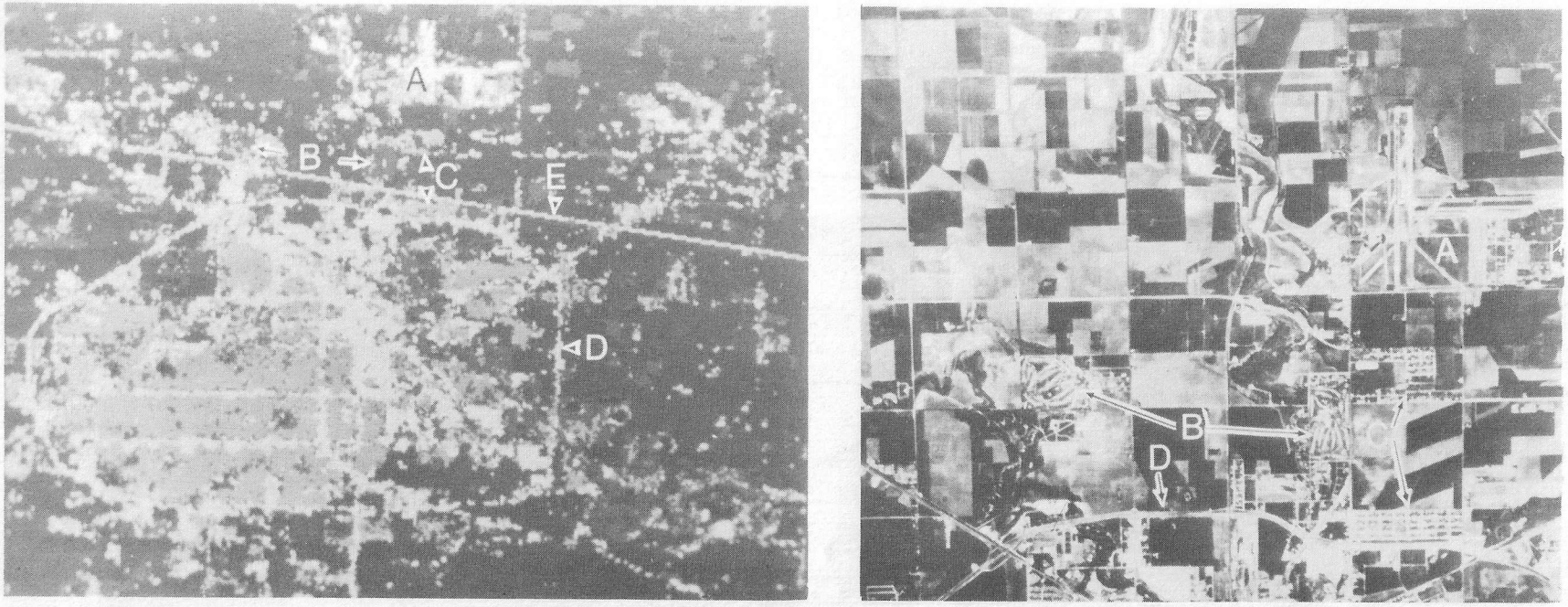

Figure 6. Comparison of classification of the City of Lubbock to a black and white copy of a color infrared photo.

A. Lubbock Regional Airport
B. Golf Courses
C. Residential Areas
D. Beltway
E. Bad Data Line

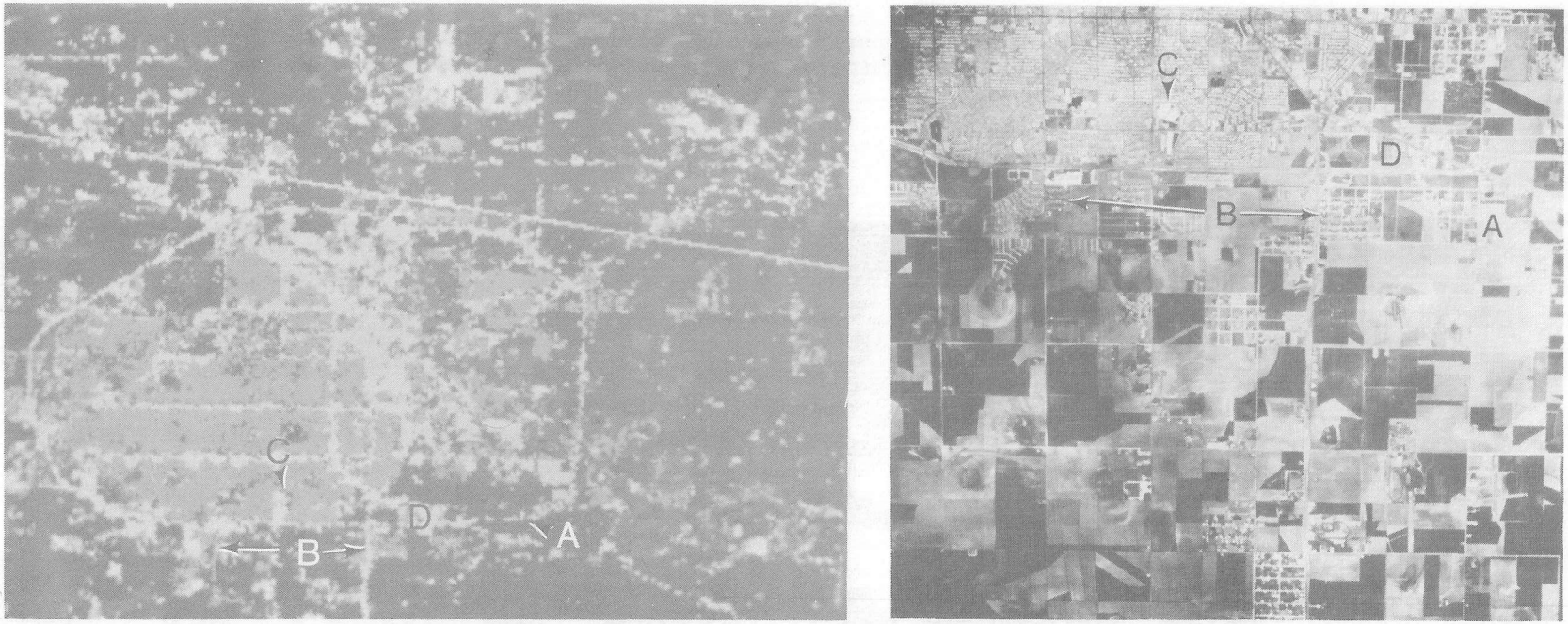

Figure 7. Comparison of classification of the City of Lubbock to a black and white copy of a color infrared photo.

A. Beltway
B. Residential Areas
C. Drive-In Theaters
D. Commercial Areas

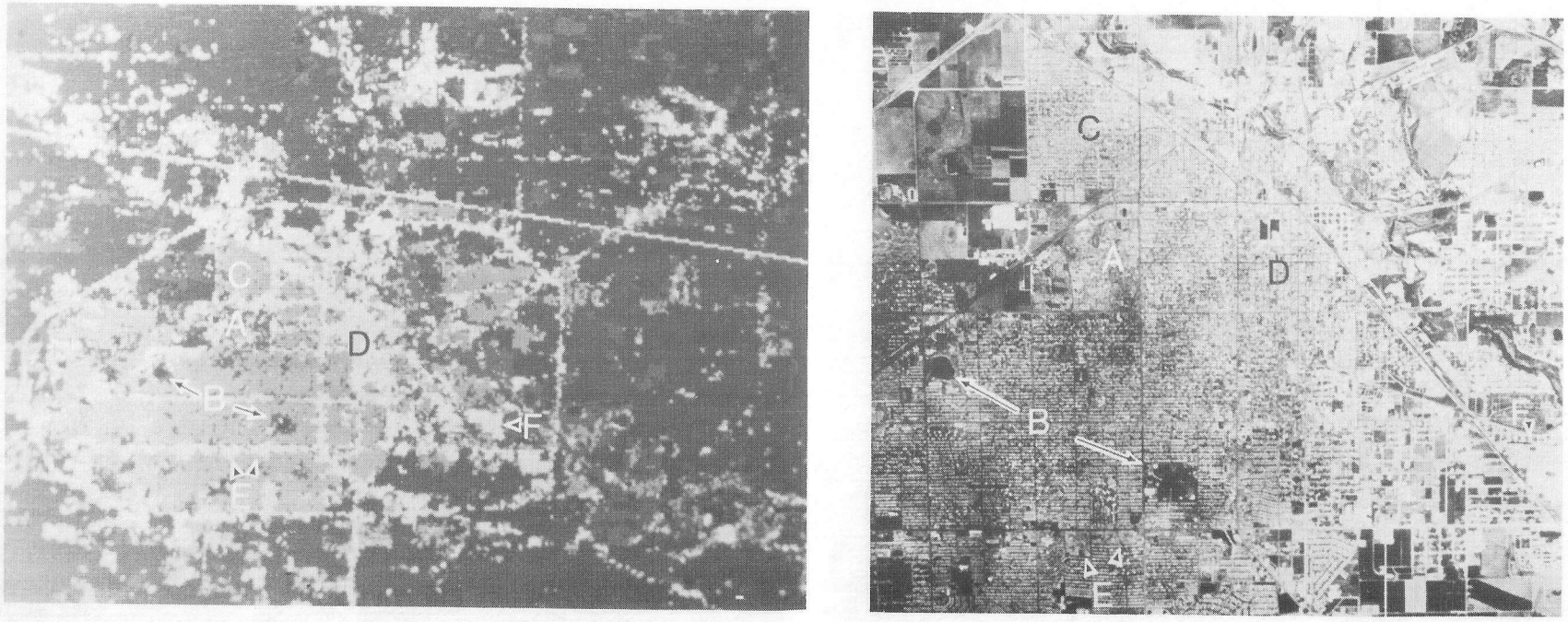

Figure 8. Comparison of classification of the City of Lubbock to a black and white copy of a color infrared photo.

A. Texas Tech University Campus
B. City Parks
C. Residential Areas
D. Commercial Areas
E. Shopping Centers along a major east-west street
F. Warehouse Complex

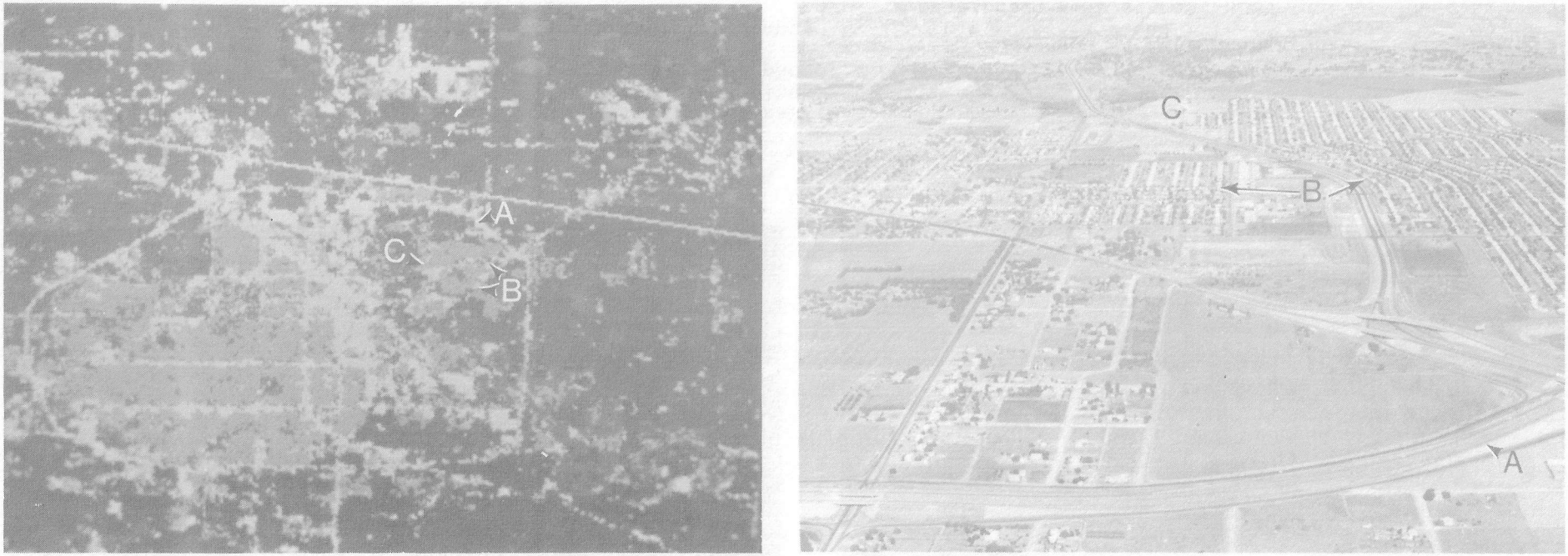

Figure 9. Comparison of classification of City of Lubbock to a black and white copy of a color photo.

A. Beltway
B. Residential Areas
C. Shopping Center

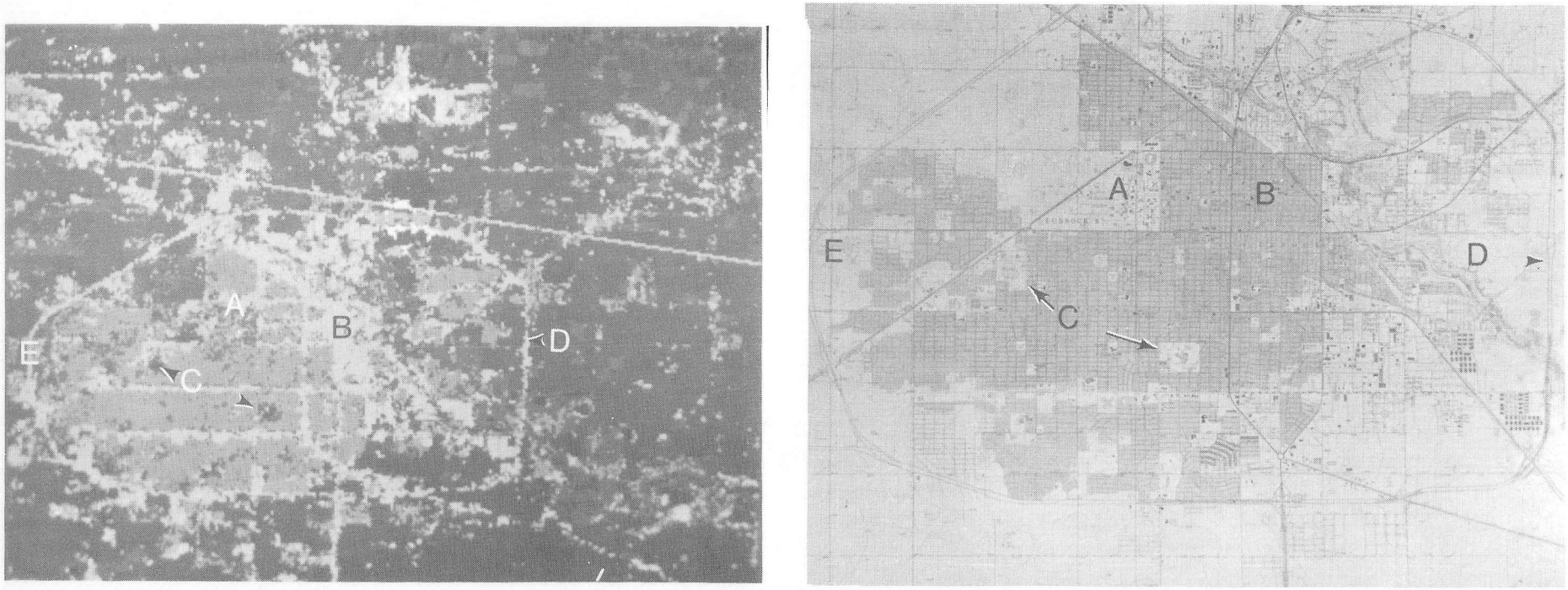

Figure 10. Comparison of classification of the City of Lubbock to the USGS Lubbock East and West Quadrangle maps.

A. Texas Tech University Campus
B. Central Business District
C. City Parks
D. Beltway
E. Areas of Growth since the photo-revision of the maps