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EVALUATION OF THREE TECHNIQUES FOR CLASSIFIED URBAN LAND COVER PATTERNS USING LANDSAT MSS DATA

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EVALUATION OF THREE TECHNIQUES FOR CLASSIFYING URBAN LAND COVER PATTERNS USING LANDSAT MSS DATA

by

PAUL R. BAUMANN

Associate Professor of Geography
State University College of New York at Oneonta
Visiting Scientist Under a
National Science Foundation Fellowship
Earth Resources Laboratory
National Space Technology Laboratories
NSTL Station, MS 39529

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SUMMARY

Three computer-quantitative techniques for determining urban land cover patterns are evaluated. The techniques examined deal with the selection of training samples by an automated process, the overlaying of two scenes from different seasons of the year, and the use of individual pixels as training points. Evaluation is based on the number and type of land cover classes generated and the marks obtained from an accuracy test. New Orleans, Louisiana and its environs form the study area.

INTRODUCTION

Ninety million Americans reside in thirty metropolitan areas. Millions more live in the thousands of towns and cities spread across the United States. To plan for the best possible growth and development of these communities it is imperative to have accurate, up-to-date information especially with regard to land use. NASA, through its earth resources programs, is attempting to fulfill this need. In July, 1972, NASA launched ERTS-1, later renamed Landsat-1, the first in a series of satellites with a mission to survey the earth on a systematic, repetitive basis. Landsat-2 and -3 were launched in 1975 and 1978, respectively. In general, multispectral scanner (MSS) data obtained by these satellites have been applied successfully to a variety of earth problems but new methods and techniques are being explored for the purpose of enhancing data interpretation accuracy, particularly in respect to urban areas where very complex land use patterns exist.

This report describes a study undertaken to evaluate the effectiveness of three computer-quantitative techniques used in conjunction with Landsat multispectral data in detecting urban land cover, especially any land use changes along the urban fringe. Specifically, these techniques are: (1) an automated process for obtaining training samples, (2) the overlaying of two scenes of data, and (3) the clustering of training points. The Earth Resources Laboratory (ERL) is conducting a series of land cover studies involving five predefined project areas. These project areas cover a variety of landscapes and one of them contains a large metropolitan area, New Orleans. Consequently, New Orleans and its environs form the test area for this study.

STUDY AREA

New Orleans, a typical large American city with over one million people, was selected as the study area because it is the only large metropolitan area within the five designated project areas. However, the city contains all the major urban land use patterns associated with any big city, and like all cities, it possesses its own unique features. Although such features, for example the meandering of the Mississippi River through the city, have influenced the location of land use activities, overall the spatial organization of these activities within the city corresponds closely to most major urban land use models. Consequently, with regard to land use, New Orleans is typical of most large cities making it a good test area for this study.

Land use constitutes only one factor to be considered in analyzing a study area. Due to the nature of the data employed in this study, it becomes important to examine some of the different types of reflectance surfaces found in large cities and to see how New Orleans, the study area, compares to other cities with respect to reflectance surfaces. Many large cities such as New York City, San Francisco, and Miami are coastal cities with major water bodies either surrounding or intersecting them. Located on the very flat Mississippi Delta, water bodies and wetlands lace New Orleans and its environs creating conditions comparable to those found in other coastal cities. Although water generally is easy to detect, some problems do exist in differentiating certain urban surfaces from water areas. For example, standing water on top of flat roofed buildings can form reflectances closely resembling those coming off of natural water and wetland surfaces. Flat roofs are not uncommon in large cities and are associated with a variety of activities.

Another reflectance surface to be considered is snow. Situated in a subtropical climate, New Orleans rarely receives snow and is never blanketed with snow throughout the winter like many northern cities are. This condition is not unique to New Orleans, since many large cities throughout the Sun Belt experience little or no snow. But due to the lack of snow the differentiation between winter and summer scenes often is not as pronounced in southern cities as in northern cities. Snow has a high level of reflectance making it easier to discriminate certain urban activities from the rural landscape. With the removal of snow from streets and parking lots and the melting of snow from roofs due to heat loss, an urban area stands out against a snow covered rural scene. Such a condition might make it easy to detect urban expansion.

Many people fail to realize the high degree of tree coverage occurring in large cities. From a high observation point one readily can see the large green surface of tree crowns spreading over a city. In this respect New Orleans is typical of most cities with its tree coverage. Since many trees stand taller at maturity than single level dwelling units, the reflectance being detected might be more representative of tree coverage than residential land use. Such conditions make it difficult to distinguish between certain non-urban areas and old, established residential areas or semi-open areas as for example parks, golf courses, and cemeteries. In addition to coverage, type of trees becomes important. Most trees can be classified as either being evergreen or deciduous. In New Orleans many large trees of the live oak species, with huge, spread out crowns, line the streets in the older residential areas such as the Garden District. These trees are evergreen; thus, trying to use a winter scene, when trees supposedly lack foliage, to classify urban activities is not always rewarding. This situation is not limited to New Orleans since other cities also have large stands of evergreen trees.

In addition to the three major surface types already mentioned, an urban area displays many smaller reflectance surfaces. Some examples are: roofs of various materials and colors, concrete and asphalt pavements, and grasses and weeds in different stages of growth. Often individual materials do not form large enough, homogeneous surfaces to be detected, especially with the basic Landsat MSS data unit being 1.1 acres in size. The types of urban reflectance surfaces and the problems associated with interpreting them are universal to most cities. Although, New Orleans possesses some unique reflectance surfaces, overall its surfaces are typical of those found in many other cities. Thus, any findings produced by this study should apply to other urban areas.

DELIMITING STUDY AREA

The U.S. Bureau of the Census uses three standard definitions for delimiting urban areas. Since practically all comparative urban socioeconomic data are collected based on these definitions, most urban planners, urban geographers, and other urban specialists find it necessary to employ them in their work. Due to the resolution and gridded nature of Landsat data, any one of these three definitions may be used to delimit the study area. In other words Landsat data can conform easily to any area delimited by one of these definitions. At this point a brief review of these definitions is needed to determine how they relate to the goals of this study. The three definitions are called: incorporated city, urbanized area, and Standard Metropolitan Statistical Area (SMSA).

An incorporated city, sometimes referred to as the political city, is a legal entity established by procedures developed by the state in which the city is located. Generally, before granting a charter, a state requires a minimum population, usually around 2500, and a constitution outlining an acceptable governmental structure for running the city. Boundaries for a city are determined at the time of incorporation. They may be changed later to meet the growth conditions within a city but annexation is often a difficult and tedious task. Today many large cities are not able to expand because smaller incorporated cities block their paths of growth. Thus, a large incorporated city often occupies only a small portion of its actual urban area. New Orleans finds itself in such a condition.

The urbanized area definition was developed by the Bureau of the Census. It's main criteria are population density and housing density. These densities must be at a certain level before an area can be considered to be an urbanized area. Also, an urbanized area must have a central city (an incorporated city) with a minimum population of 50,000. However, an urbanized area is not a legal entity and its boundaries do not correspond necessarily with any existing political boundaries. Although in many respects this definition comes the closest to outlining the actual city, the urbanized area lacks any political significance, and therefore, is used less often by urban specialists.

The SMSA is another definition developed by the Bureau of the Census. It also requires a central city with a population of 50,000 or higher. In order to relate to political unit other than a hemmed in incorporated central city, a SMSA has a county ("parish" in the case of Louisiana) as its basic areal unit. Although a SMSA starts with a single county containing a central city, other counties may be added if a certain amount of economic interaction occurs between the counties and the central city. Because of the size and shape of counties, often large portions of a SMSA consist of open rural areas. The New Orleans SMSA includes the following parishes: Orleans, St. Bernard, Jefferson, and St. Charles.

To base the study area on the incorporated city of New Orleans would exclude a sizeable portion of the urban area especially many of the suburbs. The urbanized area outlines the actual built up section of New Orleans but to use it as the study area would remove the opportunity to note changes on the urban fringe. The New Orleans SMSA covers a very large area, most of which contains undeveloped marsh and wetlands. This area extends far beyond any possible urban fringe development. None of the three definitions produces a desirable study area making it necessary to create one. Because the urbanized area covers the built up portion of the city, it was used as the basis for establishing a study area. To include urban fringe areas falling outside the urbanized area and those areas generally referred to as exurbia, the study area was extended a reasonable distance beyond the urbanized area (See Figure 1). Both the incorporated city and the urbanized area are nested within this

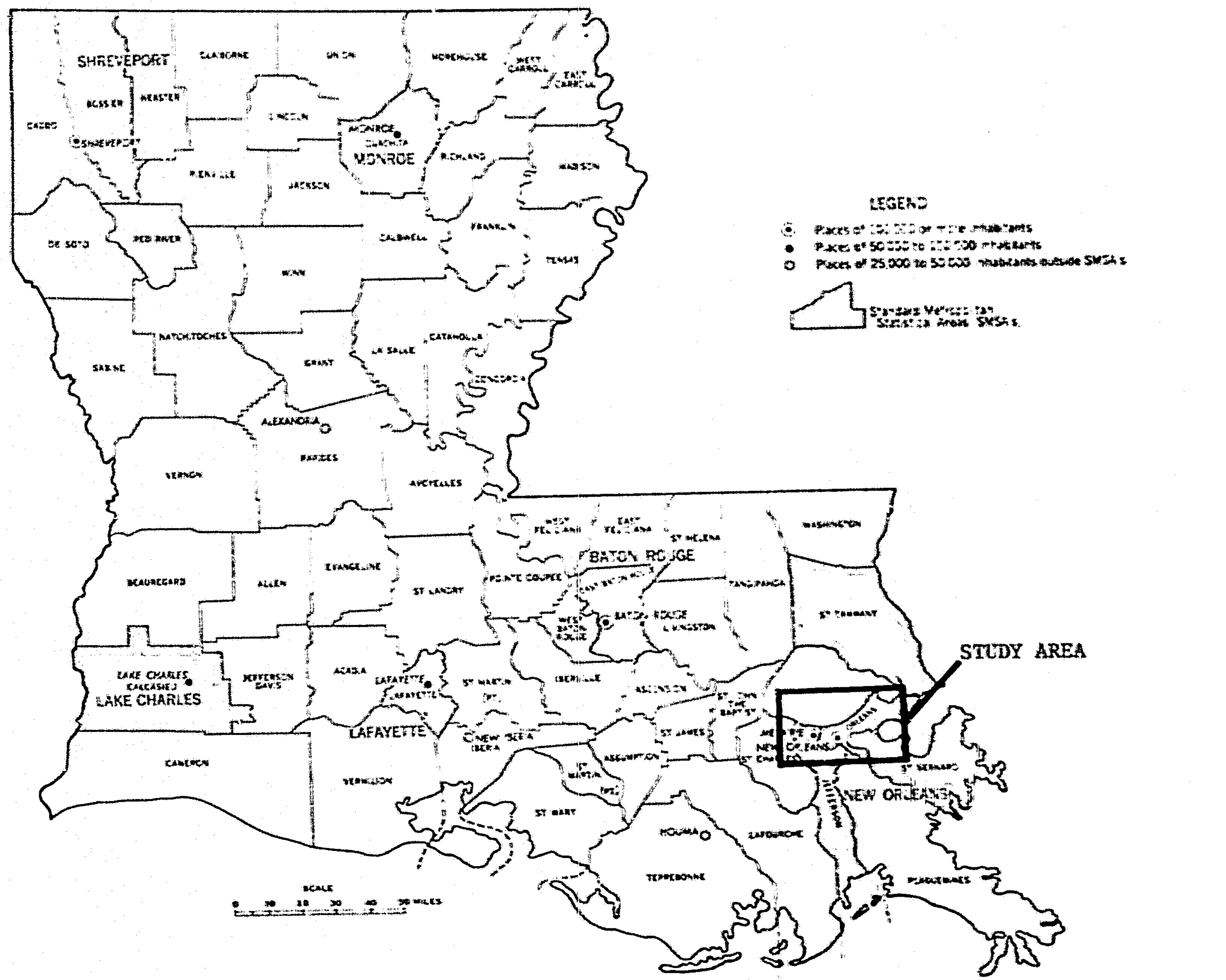

FIGURE 1 - STUDY AREA

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study area and can be extracted from it if desired. To simplify Landsat data processing procedures, the study area was made rectangular in shape.

PREVIOUS WORK

Shortly after the launch of Landsat-1, NASA sponsored a series of conferences emphasizing the application of Landsat data to various earth resources problems. These conferences generated many land use reports, several of which dealt with urban areas. Also, at this time a number of articles on urban land use detection using Landsat data appeared in professional journals and proceedings. These reports and articles discussed the use of a variety of analytical approaches, ranging from conventional air photo-interpretation procedures to sophisticated computer hardware and software techniques, for classifying urban land patterns. In general, these studies produced between seven and nine land cover classes of which two or three might be considered non-urban. Table 1 lists the classes developed in five separate studies. In recent years little work has been published and most of it has corroborated the findings of earlier works.

By looking at Table 1 it is evident that no standard set of class names exists for designating urban land use patterns. Although some names appear to have the same meaning, a considerable difference in meaning does exist between them making it difficult to draw comparison between studies. These differ-

TABLE 1. LIST OF CLASSES DEVELOPED IN FIVE SEPARATE STUDIES

MINNEAPOLIS[1]	HOUSTON[2]	MILWAUKEE[3]	LOS ANGELES[4]	ORLANDO[5]
Commercial Core Industrial Core Commercial/ Industrial Strip	Commercial/ Industrial/ Transportation	Commerce/ Industry	Commercial/ Industrial/ Institutional	Commercial Industrial/ New Construction
High Density Single Family Res. Low Density Single Family Res. Mixed Single Multiple Family Res.	Residential Residential (New) Mixed Residential	Inner City Wooded Suburbs New Suburbs Other Suburbs	Med./High Density Residential Low Density Residential	Residential Wooded Residential
Urban Open Extractive			Undeveloped Urban Green Space Flood Channels & Extractive	Undeveloped
	Woody Veg. Non Woody Veg.	Trees Grassy Rural	Chapparal Grassland Agricultural	Trees Marsh
	Water	Water	Water	Water

[1]Source: Brown and Sizer, 1973
[2]Source: Dornbach and McKain, 1973
[3]Source: Mausel, Todd, and Baumgardner, 1974
[4]Source: Bryant, 1976
[5]Source: Hannah, Thomas, and Esparza, 1975

ences are due probably to the particular interests and backgrounds of the various investigators and/or the type of technique and the quality and nature of data used. Also, no accepted set of standard terms or definitions has been established for urban land use classes except for some vague, broad terms. Thus, investigators do not have any clear guidelines to assist them in selecting class names.

A few studies give accuracy results. Little or nothing is stated in these studies on how accuracy measurements were determined. Accuracy results range from 50 to 100 percent for particular classes. Most often urban classes especially residential classes record low levels of accuracy; whereas, non-urban classes such as water and vegetation have high accuracy marks. In some studies only the average accuracy for all classes is given which can be misleading due to the differences between low urban classes and high non-urban classes. In these cases accuracy results are generally in the 75 to 80 percent range.

TECHNIQUE NO. 1 - SEARCH

ERL has developed an automated process for obtaining training samples which are used to produce the statistics needed to classify multispectral data. Under this process a scan window is moved systematically across a data set searching out homogeneous surfaces. A window is either 6 by 6 elements or 3 by 3 elements in size. Certain parameters are used to determine the homogeneity of the area within the window. These parameters are: a lower standard deviation limit, an upper standard deviation limit, and a coefficient of variation factor. A homogeneous area becomes a training sample. Since many training samples are very similar spectrally, they are grouped together into classes. To determine the separability of two samples either a divergence or scaled distance factor is used. Either the divergence or scaled distance measure can be used when the 6 x 6 window option is employed, but only the scaled distance measure can be employed with the 3 x 3 window option. If two samples cannot be separated by using one of these factors, they are considered similar and grouped together into one spectral class. After the search window crosses over the entire data set, a number of spectral classes will exist, each made up of a number of training samples. The computer program used to ascertain training samples under this process and to group them into spectral classes is entitled SEARCH. Statistics generated from these spectral classes are used in a maximum likelihood classifier program which analyzes each element within the data set and assigns it to the class it best fits. At this point an investigator names each spectral class based on its spatial relationship to certain land cover features.

An automated process possesses certain advantages over the normal manual approaches for selecting training samples. First, the entire data set under study is scanned which generally allows many training samples to be found for the development of spectral classes and produces classes based on a universal examination of the data. In comparison, under a manual approach often only a few samples are obtained for a spectral class and the samples might be selected from only certain areas within the data set. Secondly, the same criteria are used in determining each training sample, thereby, eliminating any arbitrary decisions in picking certain areas in relationship to others. Also, by using standard criteria two or more data sets can be compared since they can be studied under identical conditions. Finally, investigators are free to deal with other tasks rather than spending considerable amounts of time searching out training samples. This factor becomes especially important in a situation where a large number of data sets might be handled.

To test the application of an automated process on the problem of detecting urban land cover classes, two data sets covering the previously defined study area of New Orleans were analyzed using the program SEARCH. One data set came from the Landsat-2 MSS scene of June 2, 1976, a summer coverage, while the other came from the Landsat-2 MSS scene of February 9, 1977, a winter period. The two data sets are subscenes of their respective Landsat MSS scenes. Covering the same area each data set is 800 elements wide and 515 scan lines long, roughly 718 square miles in size. Basically both data sets are free of atmospheric interference. The summer scene has a few small clouds over Lake Pontchartrain and one over the Mississippi River. It also has some haze. The winter scene is clear of haze and cloud free.

The following parameter values were used as input to SEARCH to obtain training fields for both data sets:

Standard deviation lower limit	=	.5
Standard deviation upper limit	=	1.0
Coefficient of variation/100	=	.05
Scaled distance	=	2.0
Window size	=	3 x 3

These values were ascertained by testing several parameter combinations to determine which one gave the greatest number of urban spectral classes. A 3 x 3 search window was used because most homogeneous surfaces within urban areas are too small to be detected by the larger 6 x 6 window.

SEARCH generated thirty six spectral classes from the summer data set. From these classes eleven land cover classes were identified as seen in Figure 3. The winter data set produced twenty one spectral classes from which eight land cover classes were noted. See Figure 2. Based on these land cover classes, three major urban categories are discernable. They are: commercial-industrial, residential, and open space. Both the winter and summer data sets contain a general commercial-industrial class but the summer data set also has a second, more detailed class named "Central Business District (CBD) and Docks". No previous urban study based on a single Landsat scene has recorded a class at this level of detail within the commercial-industrial category. Two residential classes named "Residential 1" and "Residential 2" are found in both data sets, "Residential 1" corresponds to the older, inner city residential areas; whereas,

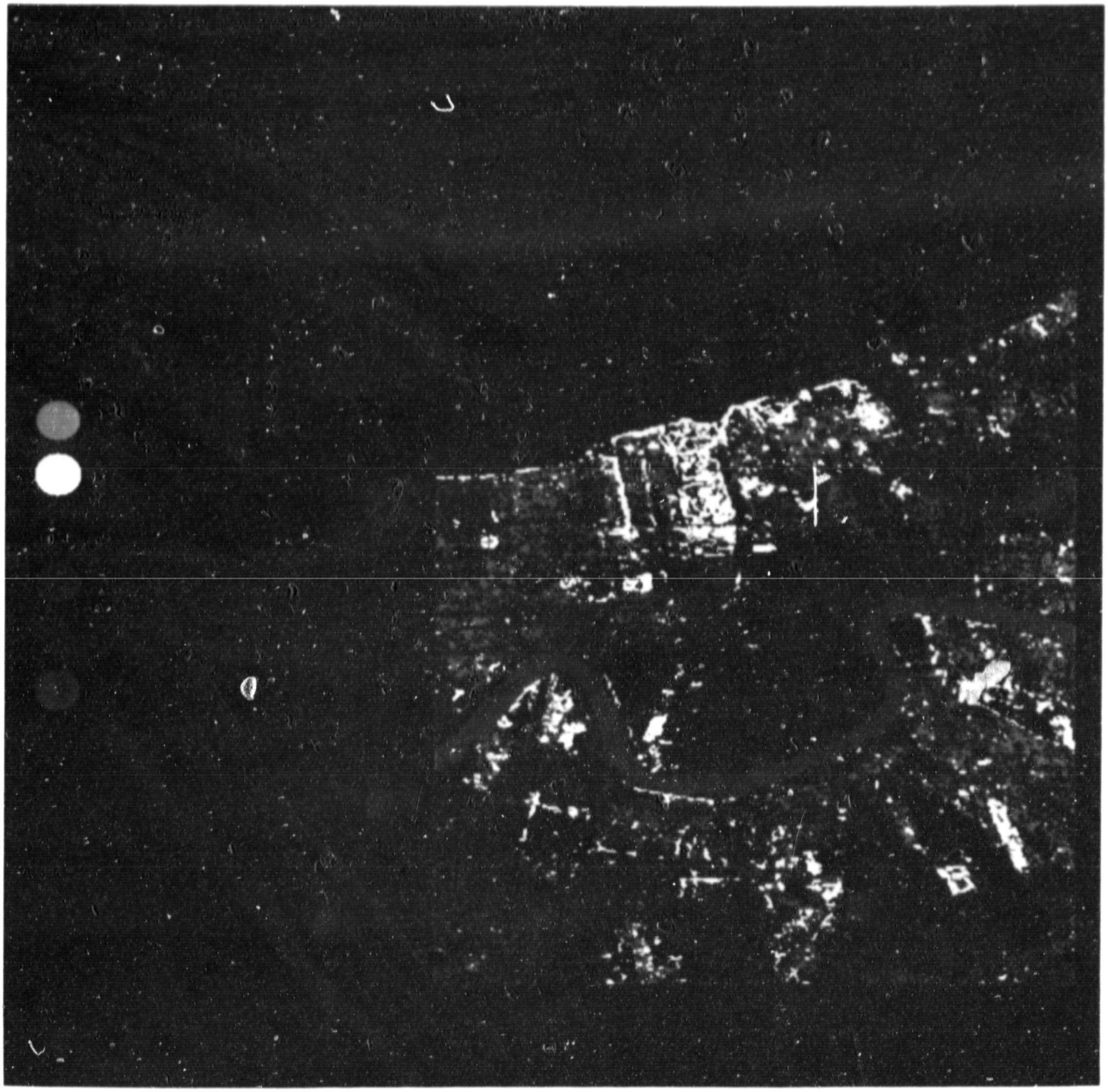

Figure 2

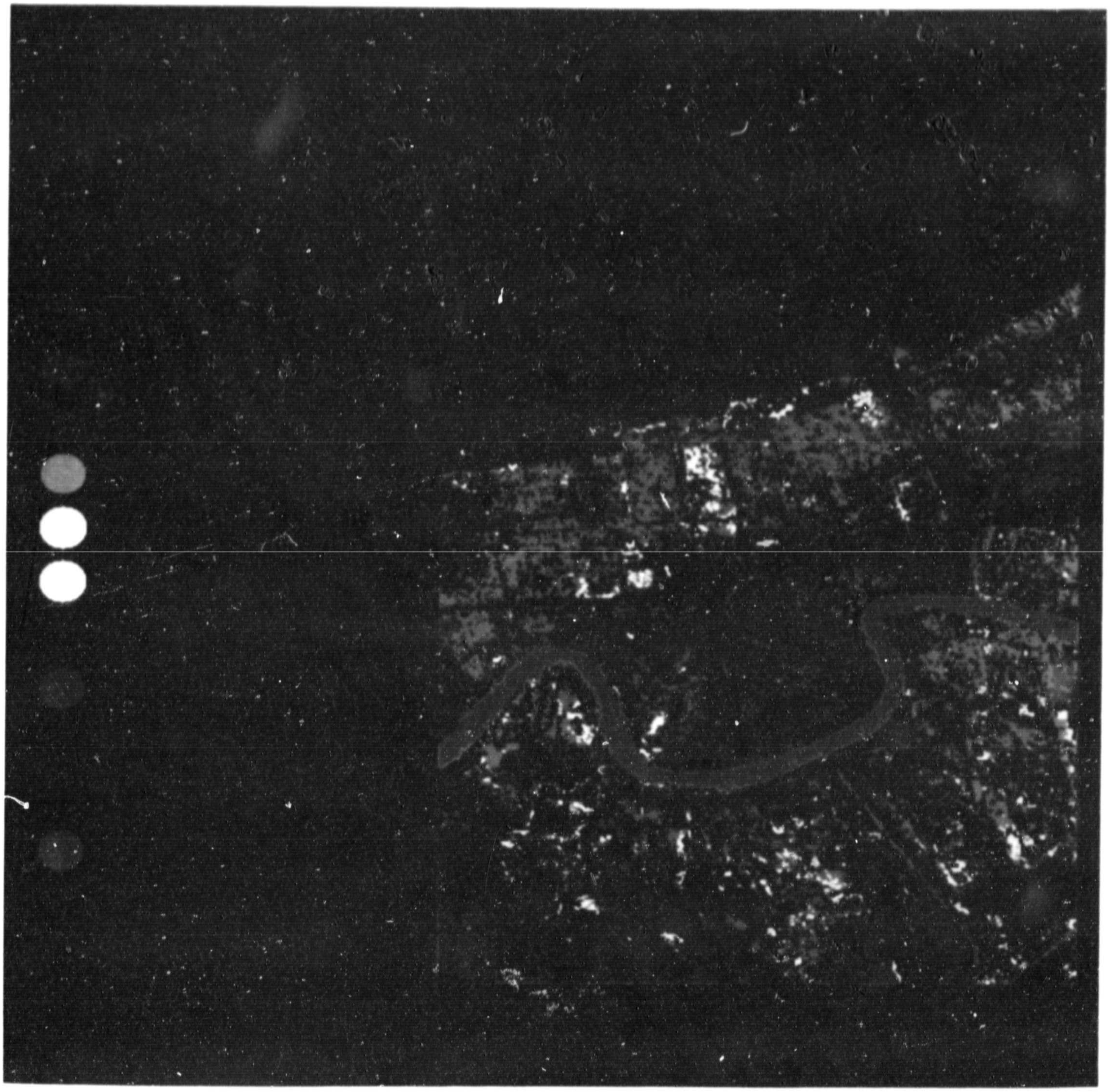

Figure 3

"Residential 2" relates to the newer, suburban area.* Two residential classes, one generally associated with the older parts of a city and the other with the newer areas, represent the normal findings recorded in most other studies. A few studies have produced as many as three or four residential classes. The open urban area category deals with intensively used open land such as urban parks, cemeteries, and zoos. The summer data set has a class for golf courses, a more detailed level of the open urban area class. With respect to the number and type of urban classes both data sets produced conditions equivalent to those created in other studies. The summer data set generated above average results but this condition may be due to the nature of the data. Of the other land cover classes the ones depicting vegetation might be categorized as non-urban classes. The two water classes also might be grouped as non-urban but in the case of New Orleans, the Mississippi River and canals are integral parts of the city's commerce and industry.

As a further evaluation of SEARCH a comparison between the classified image and high altitude aerial photography was

*To label these classes with descriptive names such as high density residential, inner city, or suburban can imply certain socioeconomic and demographic characteristics not inherent in the data. To name these classes with respect to vegetation coverage such as wooded residential might be more accurate in relationship to the data but such terms convey little, if any, pertinent information to most urban specialists. Until accurate, meaningful terms can be established and accepted, it is best to use non descriptive terms.

made to determine the relative accuracy of the classified land cover. The aerial photography was color IR taken in October 1976, half way in time between the two data sets. The scale of the photography was about 1:120,000. The test consisted of choosing twenty randomly selected points associated with a particular land cover class and comparing them to the photography. To make the test complete the same procedures were repeated except the random points were taken first from the photography and related to the classified image. Consequently, for each land cover class forty different points were checked. Since the study area was established to include urban fringe development, each data set was divided into two geographic areas for testing purposes. The one test area incorporated everything within the urbanized area as defined by the Bureau of the Census, while the other test area comprised the remaining sections outside the urbanized area.

Table 2 shows the results of the test. It is not possible to compare these findings with other studies since, as pointed out before, previous works provided either no or only sketchy results with respect to accuracy test. As Table 2 illustrates, urban land cover classes generally did well within the urbanized area with marks of 80 percent or higher. Outside the urbanized area marks drop to approximately 50 percent, an unacceptable level. Trying to separate urban fringe development from agricultural land or low marsh is extremely difficult as these results indicated. Non-urban land cover classes did well both inside and outside the urbanized area except for the high marsh land which

TABLE 2. RELATIVE ACCURACY RESULTS FOR TWO DATA SETS

	JUNE 2, 1976			FEBRUARY 9, 1977		
	Percent Inside Urbanized Area	Percent Outside Urbanized Area	Combined Percent	Percent Inside Urbanized Area	Percent Outside Urbanized Area	Combined Percent
Com/Ind Areas	100.00	75.00	87.00	80.00	55.00	67.00
CBD & Docks	80.00	NR[1]	80.00	NA[2]	NA	NA
Residential 1	85.00	NR	85.00	80.00	NR	80.00
Residential 2	92.50	55.00	61.25	90.00	67.50	78.75
Open Urban Area	65.00	57.50	61.25	85.00	47.50	66.25
Golf Courses	82.50	90.00	86.25	NA	NA	NA
Forested Wetland	80.00	85.00	82.50	75.00	70.00	72.00
High Marsh[3]	67.50	85.00	76.25	62.50	87.50	75.00
Lakes & Canals	100.00	95.00	95.00	100.00	95.00	97.00
River	95.00	90.00	95.00	87.50	65.00	76.25

1 NR = No Recordings

2 NA = Not Applicable

3 February data set has only one marsh class encompassing both high marsh and low marsh.

often conflicted with open urban areas. River water also had problems because it did not separate always from lake and canal water. Also, the famous New Orleans' French Quarter is classified as river water particularly within the Bourbon Street area.

In respect to these two data sets, SEARCH, as an automated process for obtaining training samples, did as well as, if not slightly better than the normal manual approaches used in other studies. However, making a comparison between an automated process and a manual approach is very difficult because the latter permits an investigator to make certain arbitrary decisions which cannot be duplicated from one data set to another.

TECHNIQUE NO. 2 - OVERLAY

ERL has developed a simple and efficient method for overlaying two sets of Landsat data. The method employs a bilinear interpolation technique based on Landsat scan lines and elements. Stable points which can be detected on each of the two Landsat scenes to be overlaid are used as control points. For each control point a scan line and element reading are taken from each Landsat scene. A recommended minimum of five to seven control points are picked from the two scenes. More can be picked if desired. These points are used to generate a larger set of control points which, in turn, are used to compute the mathematical constants needed to place a pixel from one scene with its corresponding pixel in another scene. Because an interpolation technique is being applied, a certain degree of error can be expected. Generally, 60 meters, the approximate size of one pixel, or less is considered an acceptable error level. Rather than overlaying four channels from one scene with four channels from another, thus, creating an eight channel data set, only two channels from each scene are used. Data in channels 1 and 2 and in channels 3 and 4 often display a high degree of correlation. Consequently, two channels from a particular scene might produce results as good as four. Using two channels from each scene decreases the computation time in producing an overlay, and more importantly, in analyzing the new data set.

Channels 2 and 4 from both the June 2, 1976 and the February 9, 1977 data sets were overlaid to form a new four channel data set. The two independent data sets are the same ones employed in the automated training sample experiment. Forty control points, more than necessary for the size of the study area, were used to compute the constants required to make the overlay. The rms (root-mean-square) error was 39.56 meters. The new data set was analyzed employing the identical procedures used to classify the two independent data sets.

The SEARCH program created thirty-eight spectral classes which were aggragated into eleven identifiable land cover classes. Figure 4 illustrates these results.* Several names assigned to the land cover classes are different from the names

*The map product, enclosed in a pocket inside the back cover, was created from the overlaid data set and was corrected geometrically and referenced to UTM coordinates.

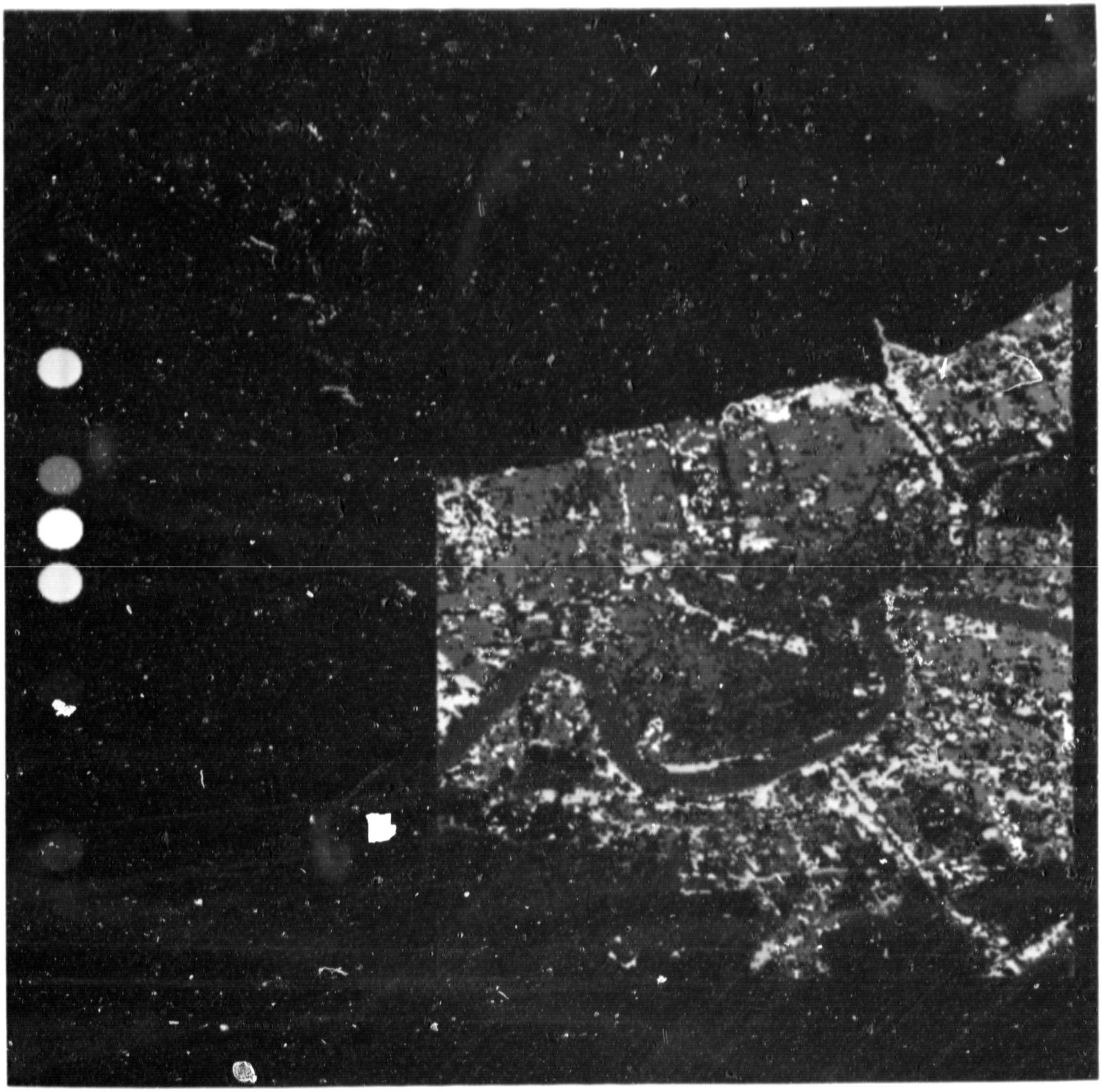

Figure 4

used in Figures 2 and 3. Based on the spectral classes generated, it was not possible to maintain the same land cover classes developed from the two independent data sets. The major differences occurred with the separation of commercial and industrial activities into two classes and the appearance of a new class named "Mixed Urban Areas." To be able to differentiate between commercial and industrial areas represents a significant improvement. Urban specialists concerned with land use problems find it difficult to rationalize lumping a commercial function such as a shopping center with an industrial activity like an oil refinery. The areas classified as mixed urban areas are made up of a variety of land use patterns with no one activity dominating. Many areas within a city are either by nature a mixture of land use activities or going through a state of transition. It is very desirable from a planning perspective to detect these areas especially those in transition.

The land cover classification produced by the overlay technique might be considered to be better than the classification developed from the two independent data sets. The classes in general are at an equivalent level of detail making it possible to develop comparisons. No specialized classes dealing with some minute land cover exist. The occurance of a class covering transitional areas creates a more realistic condition with respect to an urban landscape than to have always clear, sharp breaks between classes.

The relative accuracy test applied to this classification is the same one as used on the first two classifications. Table 3

TABLE 3. RELATIVE ACCURACY RESULTS FROM OVERLAID DATA SET

	Percent Inside Urbanized Area	Percent Outside Urbanized Area	Combined Percent
Commercial	72.5	55.0	63.75
Industrial	80.0	65.0	72.50
Residential 1	65.0	NA	65.00
Residential 2	72.5	70.0	71.25
Open Urban Area	80.0	62.5	71.25
Mixed Urban Area	85.0	65.0	75.00
Forested Wetland	80.0	82.5	81.25
High Marsh	67.5	85.0	76.25
Low Marsh	85.0	85.0	85.00
Lakes & Canals	92.5	95.0	93.75
River	90.0	90.0	90.00

NA = Not Applicable

shows the marks. The marks for the urban land cover classes inside the urbanized area are not as high as those produced from the two independent data sets. Only half of the classes have marks above 80 percent, an acceptable level of accuracy. No significant change occurred in the other classes.

Overall the overlay approach created better classes for application type work but did not score as high as might be desired on the relative accuracy test. The only published work on the overlaying of two Landsat scenes covering an urban area is the Washington, D.C. study done by Gaydos and Wray. This study used eight channels to produce a classification. It also generated eleven classes but two classes dealt with cloud conditions. No accuracy marks were given for this study. Consequently, to draw any comparisons between the studies is difficult. Actually, more overlay studies are needed before any patterns might be observed.

TECHNIQUE NO. 3 - POINT CLUSTERING

The final technique that was evaluated involved selecting individual pixels as training points and grouping similar ones into spectral classes. This technique is known as point clustering. It eliminates the use of large training samples based on homogeneous surfaces. Instead, it employs pixels, the basic data unit, as training points which should help in analyzing environments with complex, variable surfaces such as urban areas. ERL has developed a computer program which allows training points to be picked systematically over a small data set. To test for separability of training points into spectral classes, a divergence factor is used. The statistics produced for each spectral class are used in a maximum likelihood classifier program to classify each pixel within the data set.

To analyze this technique the June 2, 1976 data set was used since it generated the best classification results with the SEARCH program. To reduce computation time only channels 2 and 4 were processed. Every fifth element on every fifth scan line was used as a training point and a divergence factor of 2 was employed to cluster points into spectral classes.

With these parameters forty-eight spectral classes were generated from which nine land cover classes were identified. See Figure 5. Although the number and type of land cover classes do not represent any major improvement over the results created by the other techniques, the number of spectral classes associated with urban land cover classes is much greater as shown in Table 4. With so many more spectral classes, an investigator has greater flexibility in grouping them into appropriate land cover classes. This flexibility made it possible to obtain a high level of classification accuracy as illustrated in Table 5. The area of greatest relative accuracy improvement was the urban land cover classes within the urbanized area. The overall average for those classes was 89.06, approximately a 5 percent improvement over the same group of classes with the

TABLE 4. NUMBER OF SPECTRAL CLASSES BY TECHNIQUE IN RELATIONSHIP TO URBAN AND NON-URBAN LAND COVER CLASSES

	Urban Classes	Non-Urban Classes
SEARCH (Feb., 1977 Data)	8 (38)	13 (62)
SEARCH (June, 1976 Data)	11 (30)	25 (70)
OVERLAY (Combined Data	7 (18)	31 (82)
POINT CLUSTER (June, 1976 Data)	21 (44)	27 (56)

Percentage Values Inside Parentheses

TABLE 5. RELATIVE ACCURACY RESULTS FROM POINT CLUSTER TECHNIQUE

	Percent Inside Urbanized Area	Percent Outside Urbanized Area	Combined Percent
Com./Ind. Areas	95.00	55.00	75.00
Residential 1	90.00	NA	90.00
Residential 2	88.75	87.50	88.12
Open Urban Areas	82.50	63.75	73.12
Forested Wetland	86.75	90.00	88.37
High Marsh	67.50	85.00	76.25
Low Marsh	NR	83.75	83.75
Lakes & Canals	95.00	95.00	95.00
River	96.25	93.75	95.00

NR = No Record
NA = Not Applicable

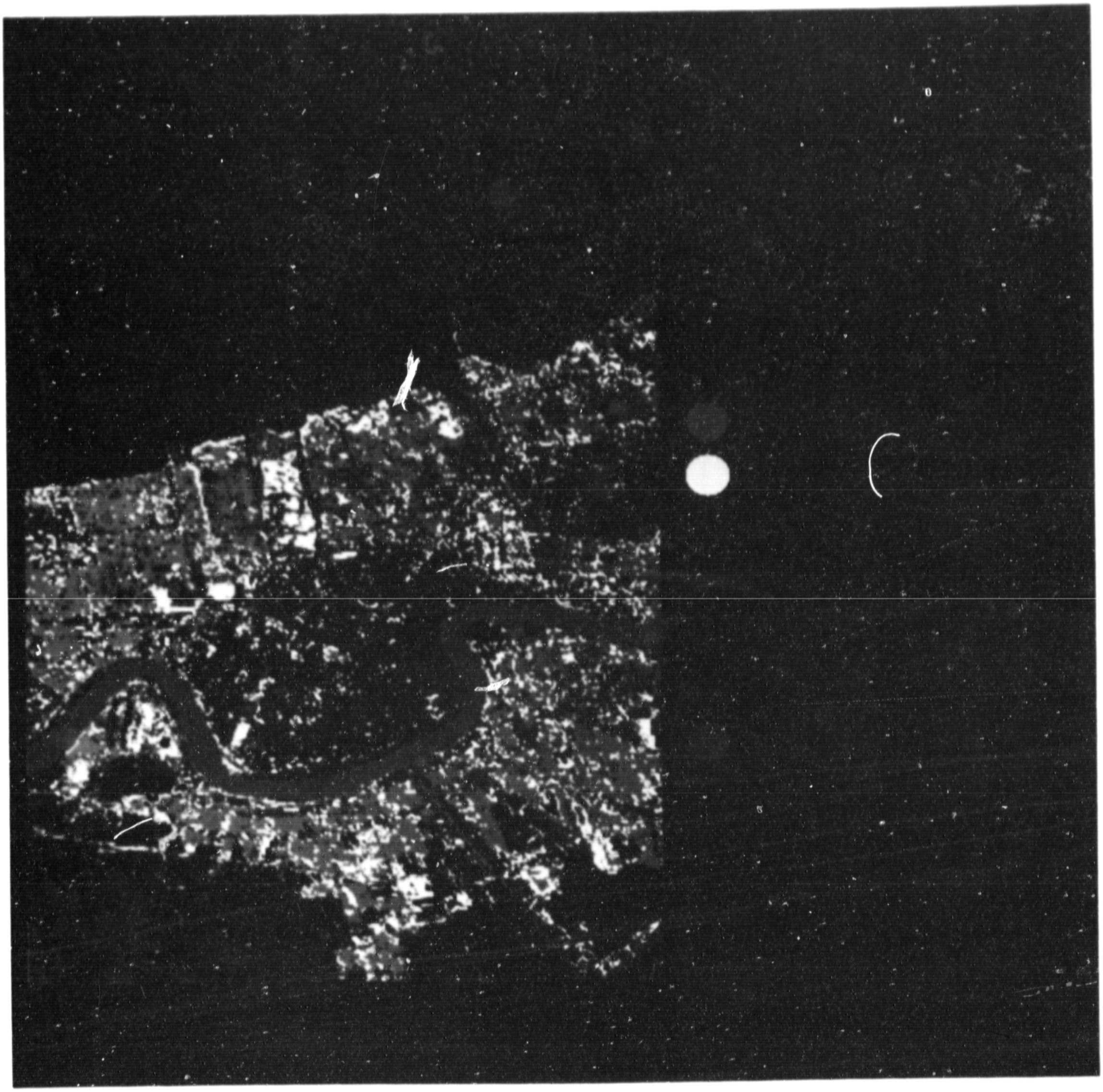

Figure 5

second best overall mark. The urban classes outside the urbanized area did not classify with any greater accuracy than they did under other techniques. However, it should be noted that the residential class improved drastically with an relative accuracy mark of 87.5. The second highest mark for this class was 70 percent produced by the overlay technique. Agricultural and marsh areas separated well from the residential class indicating that the point cluster technique might be a good approach for detecting changes on the urban fringe.

In summary, no improvement occurs in the number and type of classes but relative accuracy marks are higher in the urban land cover classes. This technique possesses potential for urban fringe detection.

CONCLUDING REMARKS

Each of the three techniques evaluated display certain strong points as well as weak ones in classifying urban land cover patterns. The automated process for obtaining training samples produced results comparable to, if not better than, classifications developed under the normal manual approaches. In terms of the number and type of classes, the two data sets used to evaluate this technique generated fairly good classes in comparison to earlier studies. Relative accuracy marks for classes were generally at an acceptable level of 80 percent or higher except for urban classes outside the urbanized area. Because of the low relative accuracy marks for these urban classes it was not possible to detect land use changes along the urban fringe. The overlay technique also created a good classification with respect to the type of urban land cover classes. In general the classes formed were at the same level of detail allowing comparisons to be made between them. Also, one class covered areas with mixed land use such as transitional zones. Due to the complex land use patterns found in cities, this type of class is needed since it is not feasible to pigeonhole every area into a single function class. Relative accuracy marks were low for this technique in relationship to marks obtained under the other techniques. The final technique, point clustering, produced a classification that was not different from the other two techniques with regard to the number and type of classes. However, the relative accuracy marks for urban land cover classes within the urbanized area were very high. Also, the residential class covering suburban areas separated well on the urban fringe.

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90°10'
05

FOLDOUT FRAME 2

LAND COVER MAP FROM LANDSAT, 1976-77

By Paul R. Baumann

This map was created by computer-quantitative techniques using Landsat multispectral data from February 9, 1977 and June 2, 1976. First, channels 2 and 4 from each of the two Landsat scenes were overlaid to form a new four channel data set. Next, an automated process for obtaining training fields was used to produce the statistics needed to classify each pixel. Under this process a scan window (3 x 3 elements in size) was moved systematically across the data searching out homogeneous surfaces based on certain statistical parameters. Training fields which were similar spectrally were grouped together into spectral classes. Thirty-eight spectral classes were generated from the overlaid four channel data set. Statistics produced from these spectral classes were used by a maximum likelihood classifier program to assign each pixel within the data set to a spectral class. The thirty-eight spectral classes were combined into eleven land cover classes by using high altitude infrared aerial photography taken in October, 1976. Finally, the classified data set was rotated and scaled geometrically to correspond to a regular map. Software used to produce and to classify the data and the accompanying map was developed by the Earth Resources Laboratory.

With the data classified, electro-static printer plots were generated for each major land cover category. The plots were converted photographically into transparencies. Using the CROMALIN process developed by Du Pont[1], the transparencies were used to create a multi-color map. This map was photographed. Four separation negatives were derived from the photograph to be used in the printing of the map.

[1]The use of brand names in this report is for descriptive purposes only and does not constitute endorsement by NASA.

FOLDOUT FRAME

LAND COVER CLASSES

COMMERCIAL

INDUSTRIAL

RESIDENTIAL, OLDER

RESIDENTIAL, NEWER

URBAN OPEN SPACE

MIXED URBAN

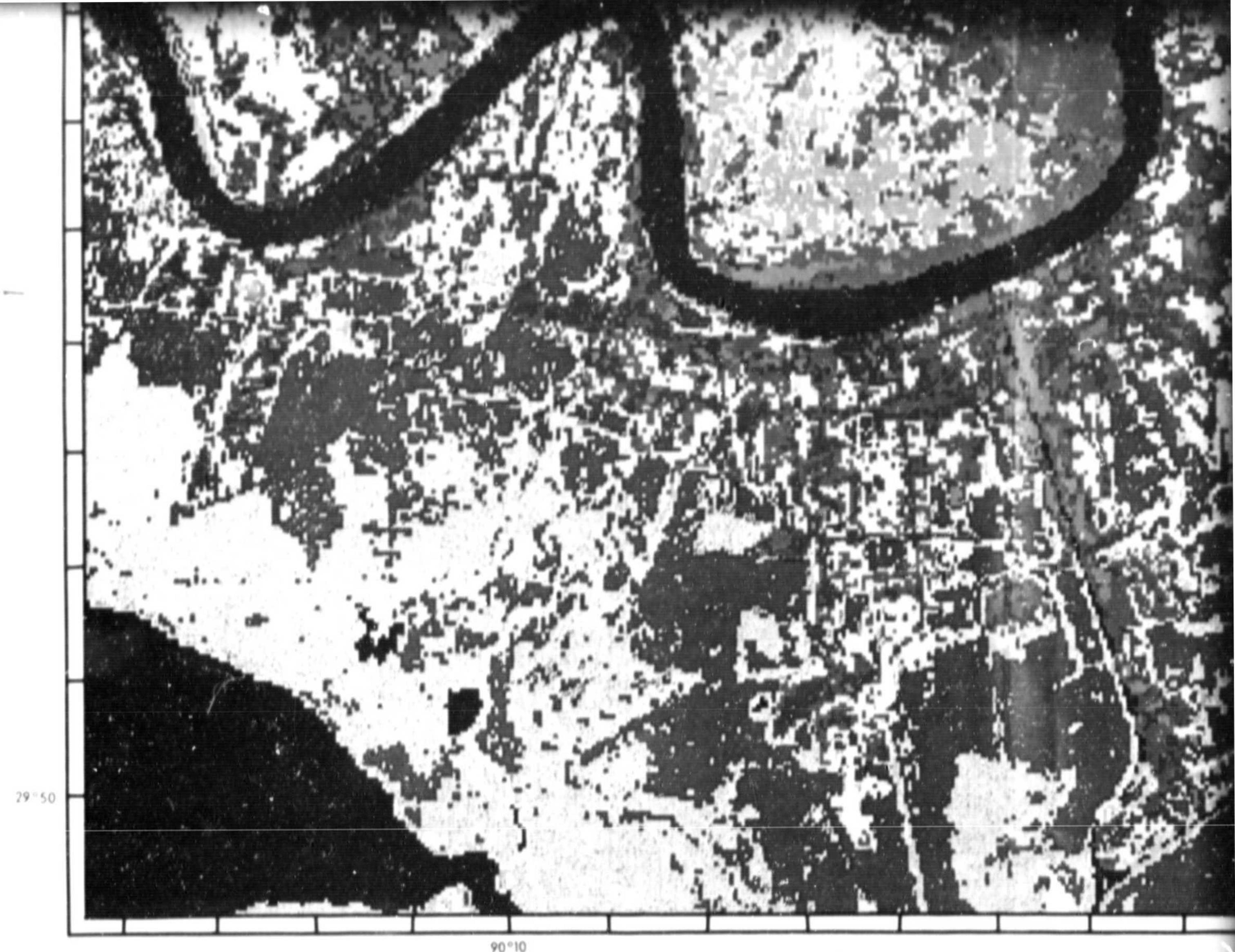
FORESTED WETLAND

HIGH MARSH LAND

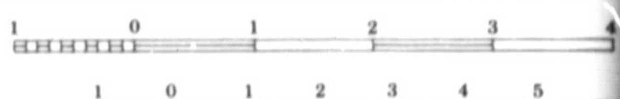
LOW MARSH LAND

RIVER AND CANALS

LAKES



QUADRANGLE LOCATION

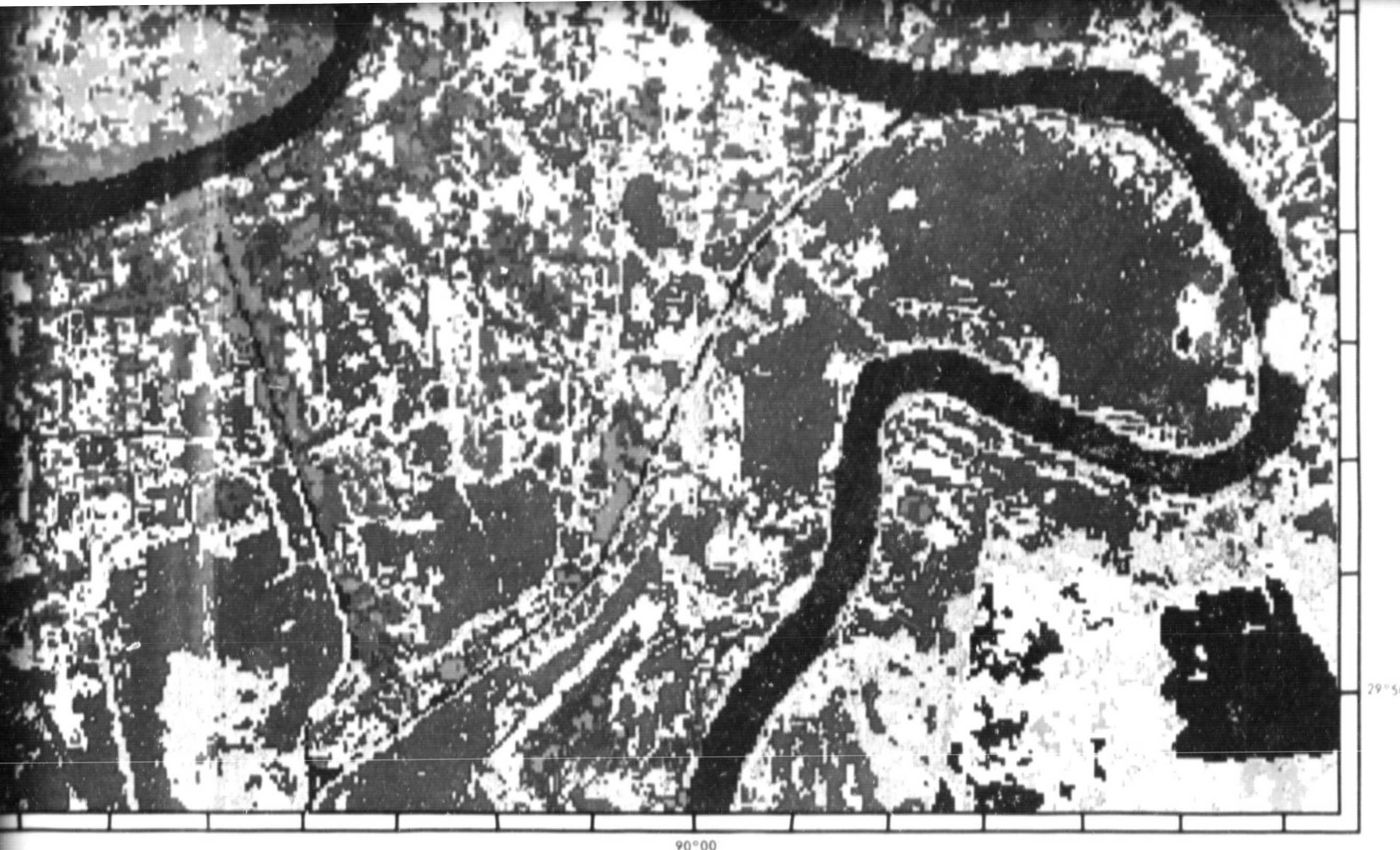


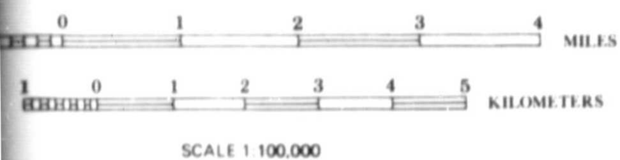
SCALE 1:100,000

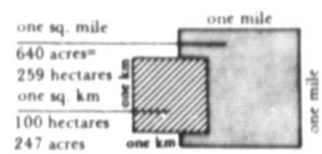
LAND COVER MAP DERIVED FR

FOLDOUT FRAME 4

NEW ORLEANS, LA AND ENVI







MAP DERIVED FROM LANDSAT DATA

W ORLEANS, LA AND ENVIRONS, 1976-1977

URBAN OPEN SPACE

MIXED URBAN

FORESTED WETLAND

HIGH MARSH LAND

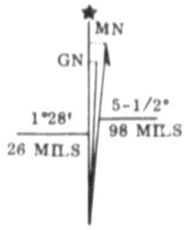
LOW MARSH LAND

RIVER AND CANALS

LAKES

CLOUD APPEARS OVER RIVER WITH A REFLECTANCE
SIMILAR TO SOME URBAN CLASSES

29°50



UTM GRID AND 1966 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

NATIONAL SPACE TECHNOLOGY LABORATORIES
EARTH RESOURCES LABORATORY