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Techniques for Using Diazo Materials in Remote Sensor Data Analysis

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I. INTRODUCTION

The use of Landsat derived data is facilitated when special products or computer enhanced images can be analyzed. However, the capital investment and expertise needed to obtain and interpret such images tend to limit interest in taking full advantage of the Landsat system.

Diazo processing enables a researcher to make a specially designed product quickly at a modest price. There is a great savings in time since a useable image takes only a few minutes to produce as opposed to weeks for a special order product. The researcher can enhance pertinent features such as vegetation, lineations, or water by altering the band selection, color, and density range of the composite.

Diazo is a chemical term referring to a compound containing a pair of nitrogen atoms bonded to an organic molecule. A diazo-type film consists of a layer of diazo and coupler on a plastic film base. When allowed to react, the diazo and coupler combine to form a dye. To avert premature formation of the dye, the film emulsion contains a mild acid which prevents the reaction. Exposure to an ultraviolet light source causes the diazo to lose its nitrogen atoms and, thus, its ability to combine with the coupler.

Working with diazo materials is relatively simple and inexpensive. Since diazo is sensitive only to ultraviolet light, no darkness is needed. Exposure to incandescent or fluorescent light for short periods of time does not affect the film; however, care should be taken to avoid prolonged exposure of the film to direct sunlight.

II. EQUIPMENT

The equipment needed to process diazo film consists of an ultraviolet light source and a container able to hold ammonia vapor required for development.

The simplest system for processing diazo film is composed of a frame to hold the film and original in place during exposure, the Sun or a sunlamp as an ultraviolet light source, and a large jar used as a developer. A more sophisticated system may consist of a "Diazo Printer Module" and "Diazo Developer Module" such as the Awkwright models 101 and 202. In the printer module, the master and the film are wrapped around a clear plastic roller with a central ultraviolet light source. The exposure time can be accurately controlled by a built-in timing device. The developer module subjects the exposed diazo film to an ammonia vapor environment to bring about the development process.

III. SUBTRACTIVE COLOR THEORY

An understanding of fundamental subtractive color theory is necessary before making false color composites or other special products. Table 1 indicates what happens when white light passes through a color filter.

TABLE 1. EXAMPLES OF SUBTRACTIVE COLOR THEORY

Source Light	Filter	Light Passing	Light Cut Out
White	Magenta	Blue Red	Green
White	Cyan	Blue Green	Red
White	Yellow	Green Red	Blue
White	Magenta Yellow	Red	Green Blue
White	Magenta Cyan	Blue	Red Green
White	Cyan Yellow	Green	Red Blue
White	Magenta Cyan Yellow	None	Red Green Blue

IV. FILM DENSITY

Film density is a measure of the opaqueness of a film. It can be measured quantitatively and compared to a standard gray scale. Each Landsat image has a unique range of film densities. Since each of the film transparencies from each Landsat spectral band is exposed by different wavelengths of energy, those transparencies representing higher reflectance values will be lighter in tone. Realization of this simple fact is a considerable aid when computing exposure times for diazo film. It should be remembered that the more ultraviolet light striking the film, the lighter the color will be. Therefore, if the image is light, it should be exposed for a short time.

V. PROCEDURE

A. Frame-Jar System

Place the diazo film emulsion side up (film is usually notched in the upper right-hand corner) on the printing frame. Position a Landsat transparency on the film such that there is emulsion-to-emulsion contact. Expose the frame to the ultraviolet light source with the transparency nearest the light source, and time the length of exposure. After exposure, remove the film from the frame. Pour some 28 to 29.4 percent aqueous ammonia solution onto a sponge and place it on the bottom of a large glass container. Position the diazo film in the container so that the film is subjected to the aqueous ammonia vapor but not in contact with the sponge. Avoid inhaling the ammonia fumes. Close the lid and observe the developing process through the glass. After complete development, remove the film.

B. Modular System

Place the diazo film emulsion side up on the printer contact belt. Place the Landsat transparency on the film such that there is emulsion-to-emulsion contact. Allow the printer contact belt to retract into its housing. Set the automatic timer for the exposure time. After exposure, remove the film. Pump ammonia vapor into the developing chamber and feed the exposed film into the developer module. The machine will slowly return the film to the operator. It is usually necessary to run the film two or more times through the developer.

A tabular description of the two diazo processing techniques is presented in Table 2.

TABLE 2. DIAZO PROCESSING PROCEDURES

<table>
<tr><th>Modular System</th><th>Frame-Jar System</th></tr>
<tr><td>Place diazo emulsion side up on printer contact belt.</td><td>Place diazo emulsion side up on printing frame.</td></tr>
<tr><td colspan="2">Place the Landsat transparency on the film such that there is emulsion-to-emulsion contact.</td></tr>
<tr><td>Allow the printer contact belt to retract into its housing.</td><td></td></tr>
<tr><td>Set automatic timer for exposure time.</td><td>Use a second hand to time the length of exposure to the ultraviolet light source.</td></tr>
<tr><td colspan="2">Remove after exposure.</td></tr>
<tr><td colspan="2">The film develops in an aqueous ammonia vapor.</td></tr>
<tr><td>Pump ammonia vapor into the developing chamber.</td><td>Pour some 28 to 29.4 percent ammonia solution onto a sponge.</td></tr>
<tr><td></td><td>Place the sponge on the bottom of a large glass container.</td></tr>
<tr><td>Feed the exposed film into the developer.</td><td>Place the film in the container so that the film is subjected only to the ammonia vapor.</td></tr>
<tr><td></td><td>Close the lid.</td></tr>
<tr><td></td><td>Observe the developing process through the glass.</td></tr>
<tr><td>The machine will slowly return the film to the operator.</td><td>After complete development, remove the film.</td></tr>
<tr><td>It is usually necessary to run the film two or more times through the developer.</td><td>Avoid inhaling the ammonia fumes.</td></tr>
</table>

Note: One cannot overdevelop a diazo film. The length of exposure determines the density of the print.

VI. DIAZO FILM

Diazo film is available in a wide range of colors including magenta, cyan, yellow, green, brown, blue, red, black, orange, and violet. The film is available in 8 in. × 10 in., 8.5 in. × 11 in., and 10 in. × 10 in. sizes. Each size is suitable for making 1:1 000 000 scale Landsat composites. Commonly used brands of diazo films are Diazochrome, Escochrome, and Teledyne. Packages of 25 or 100 sheets may be purchased. Best results are obtained with the thinner films (0.003 in.). Some diazo films may tend to stretch during development when run through a belt system.

VII. DIAZO COMPOSITE IMAGES

When one sets out to produce a diazo composite using Landsat transparencies, it is necessary to consider the following points:

a. The relative spectral response of the target on each band (example: water is dark on bands 6 and 7, light on bands 4 and 5).

b. The contrast between the target of interest and adjacent targets (Are the boundaries well defined or gradual transitions?).

c. The overall film density of the Landsat transparency (relates to exposure time).

d. The number of images used to make a composite (more than six images in a composite usually leads to registration problems).

e. The subtractive color theory (a magenta, cyan, and yellow combination transmits no light).

With trial and error procedures, a set of "key" exposure values can be developed quickly for whatever equipment is available.

VIII. STANDARD FALSE COLOR COMPOSITES

To produce false color composites similar to those available from the U.S. Geological Survey, the following Landsat transparencies are needed:

Band	Scale	Format
4	1:1 000 000	Black and white — film positive
5	1:1 000 000	Black and white — film positive
7	1:1 000 000	Black and white — film positive

Yellow diazo film should be exposed with band 4, magenta with band 5, and cyan with band 7. After the films have been processed, they should be placed one on top of another using bordering registration marks and alphanumeric notation to aid in proper alignment. The order of the film is not important. Registration is easier with the use of a light table to illuminate the images. Registered images can be joined using cellophane tape. A schematic illustrating this standard procedure is presented in Figure 1.

IX. FALSE NATURAL COLOR COMPOSITES

Producing a pseudo-color composite is as easy as producing a standard false color composite. Landsat images in the following bands are needed for the area being studied:

Band	Scale	Format
5	1:1 000 000	Black and white — film positive
7	1:1 000 000	Black and white — film positive

Green diazo film is exposed with band 5 and cyan with band 7. With careful control of exposure time, an image exhibiting green vegetation, blue water, white clouds, and white bare soil is produced. A combination of a cyan and a yellow image of band 5 can be substituted for a green dizao image.

X. MASKED COMPOSITE IMAGE

The term "masked image" describes a composite containing both a negative and a positive transparency of the same band. Masking can be used to enhance particular targets. For example, to emphasize water, a band 7 image

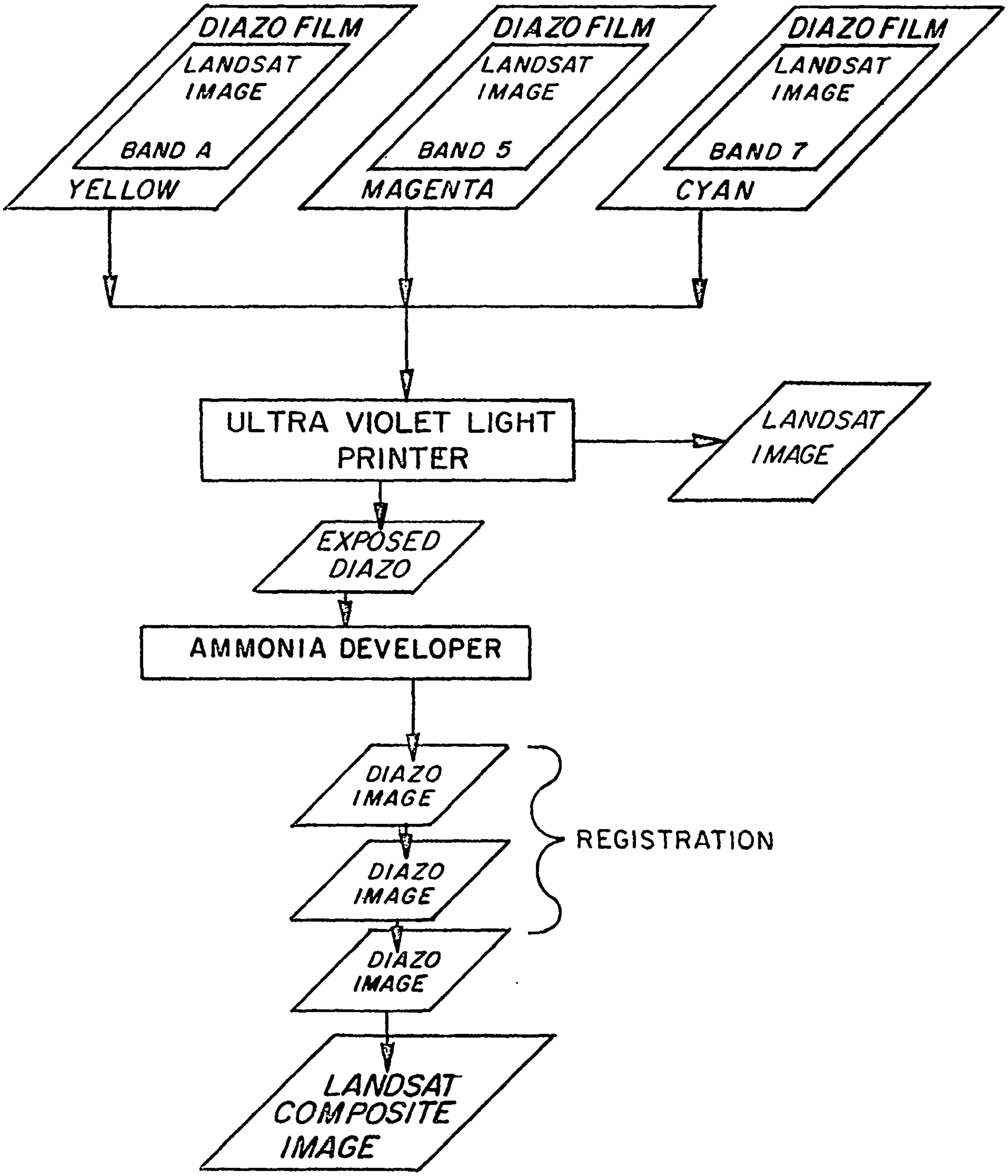


Figure 1. Schematic of standard procedure for making a Landsat false color composite.

in cyan registered with a negative band 7 image in magenta can be used. By controlling the exposure times, it is possible to produce an image in which only water and other objects of equal film density, such as cloud shadows, are blue.

No rules dictate which positive and negative bands should include a composite nor which colors should be used. These variables are best evaluated by the interpreter. Examples of false color diazo composites and masked composites are illustrated in Figures 2, 3, and 4.

XI. STORAGE OF DIAZO PRODUCTS

Diazo film should be stored at temperatures below 70°F and at a relative humidity of 50 percent or lower. Shelf life is increased from six months at 70°F to a year or more at 50°F. Low temperatures do not harm diazo products. However, excessive heat during storage can cause the diazo and coupler to react prematurely, forming a dye.

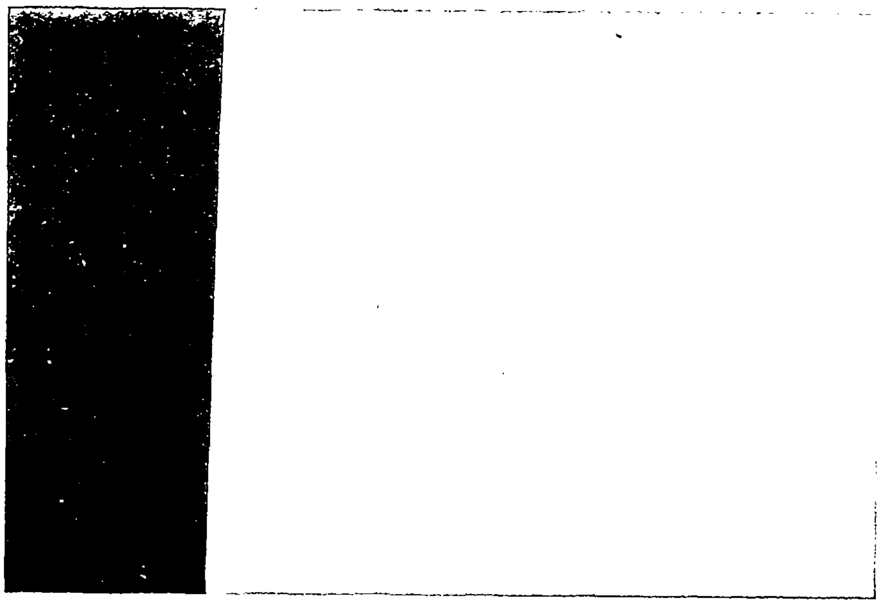
XII. STORAGE OF COMPOSITE IMAGES

Diazo prints have a life of 25 years or longer if stored in darkness. Long-term exposure to light causes discoloration. Also, rapid fading occurs if prints are subjected to an intense light source such as a projection lamp. Therefore, color slides should be made of those composites for which projection is anticipated.

To obtain a strong color contrast between targets, it may be necessary occasionally to expose two diazo films of the same band in the same color. Because film density is additive, the color of that particular band is correspondingly increased or darkened. The contrast between bands is augmented without altering the information content or color format of the original composite.

XIII. INTERPRETATION OF DIAZO COMPOSITES FOR LAND USE MAPPING – AN EXAMPLE OF UTILIZATION

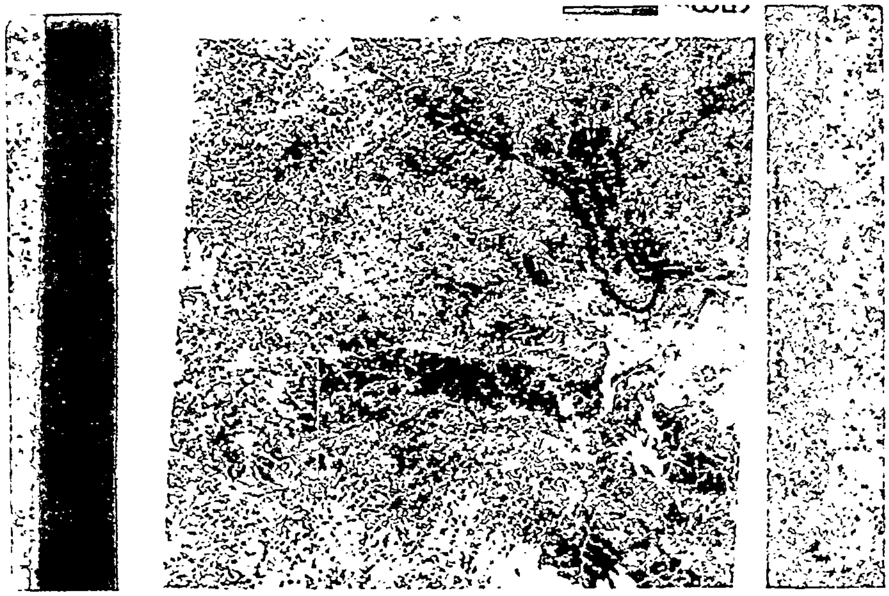
The first step in preparing a land use map is to produce a diazo composite following the procedures previously described. A 35 mm color slide should be made of that part of the image to be mapped by taping the composite to a vertically positioned light table. Dark paper should be placed around the position of the



ST. LOUIS – CENTRAL ILLINOIS (NOTE ENHANCEMENT OF WATER BODIES)
POSITIVE BAND 7 – GREEN
NEGATIVE BAND 7 – RED

SOUTHWESTERN ILLINOIS – COAL STRIP MINE
POSITIVE BAND 7 – CYAN
NEGATIVE BAND 7 – YELLOW
POSITIVE BAND 5 – MAGENTA
NOTE: WATER – 1, INACTIVE MINE WITH LONG NARROW LAKES – 2, ACTIVE MINE SITE – 3

Figure 2. Masked images.



STANDARD FALSE COLOR
EAST CENTRAL MISSOURI
BAND 4 – YELLOW
BAND 5 – MAGENTA
BAND 7 – CYAN

NATURAL FALSE COLOR
FLATRIVER, MISSOURI TAILINGS AND CHAT PILES FROM
LANDSAT BANDS 5 (GREEN) AND 7 (CYAN)

Figure 3. Standard false color and natural false color.

Figure 4. Diazo composite of Mississippi Delta using band 5 (green and cyan) and band 7 (magenta).

image being photographed to block out excess light. A 50 or 55 mm lens is best for full shots, and a bellows unit with close-up lens works best for close-up shots.

After developing the slide, place it in a "Post Micro-Film Viewer" or similar enlarging device. Position a sheet of acetate directly on the micro-viewer screen. Areas of forest, water, urban, disturbed, or agricultural land use can then be identified and outlined using generally accepted image interpretation procedures. Examples of land use maps interpreted from diazo Landsat composites are illustrated in Figures 5, 6, and 7.

XIV. ADVANTAGES AND LIMITATIONS OF OF DIAZO TECHNIQUES

As in any process, the use of diazo Landsat images in mapping has both advantages and disadvantages. Problems encountered in the process include the tendency of a microfilm enlarging device to magnify the 35 mm slide of a diazo composite to the limit of resolution. However, it is possible to produce

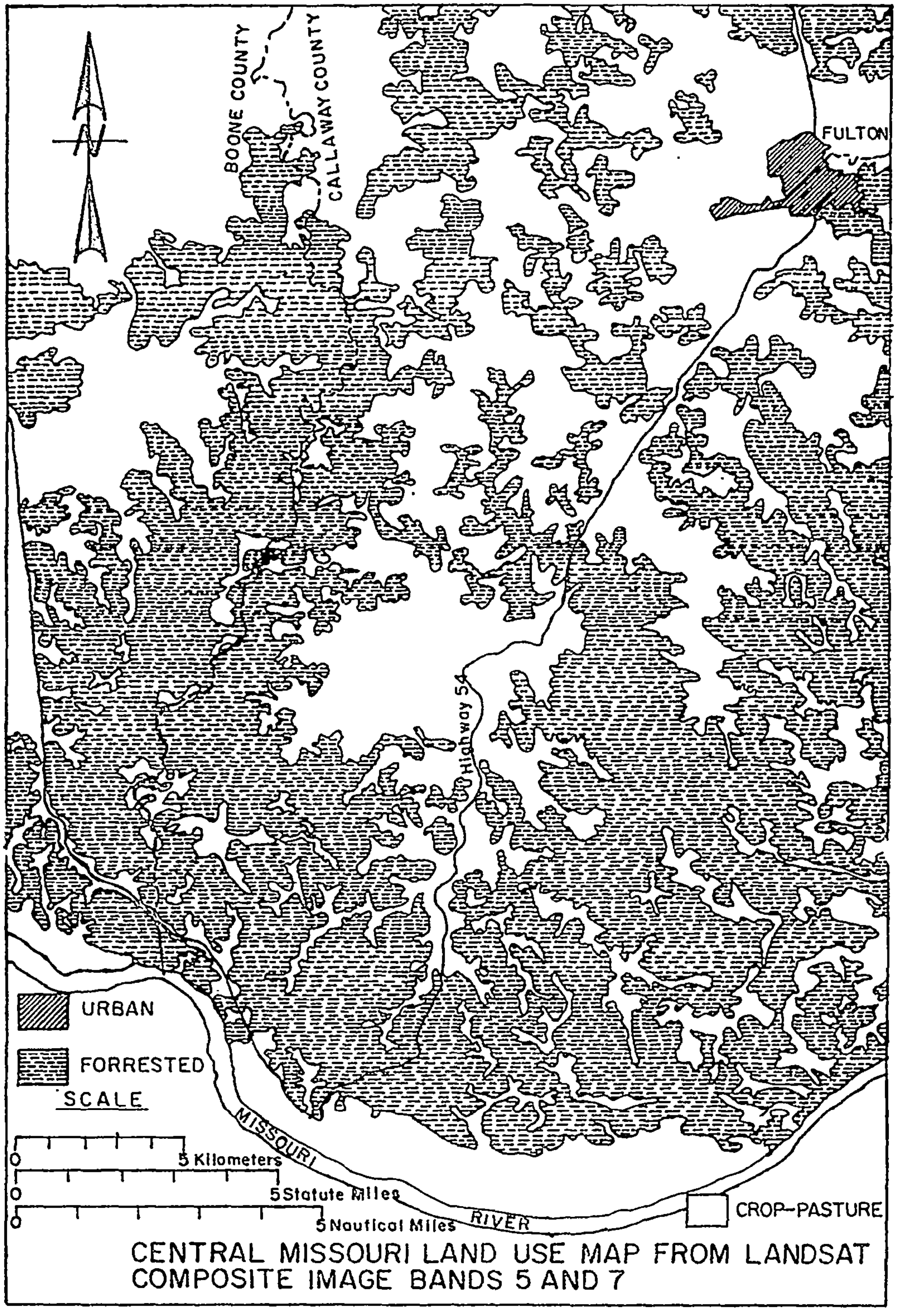


Figure 5. Land use map of central Missouri from Landsat composite image bands 5 and 7 using natural false color scheme.

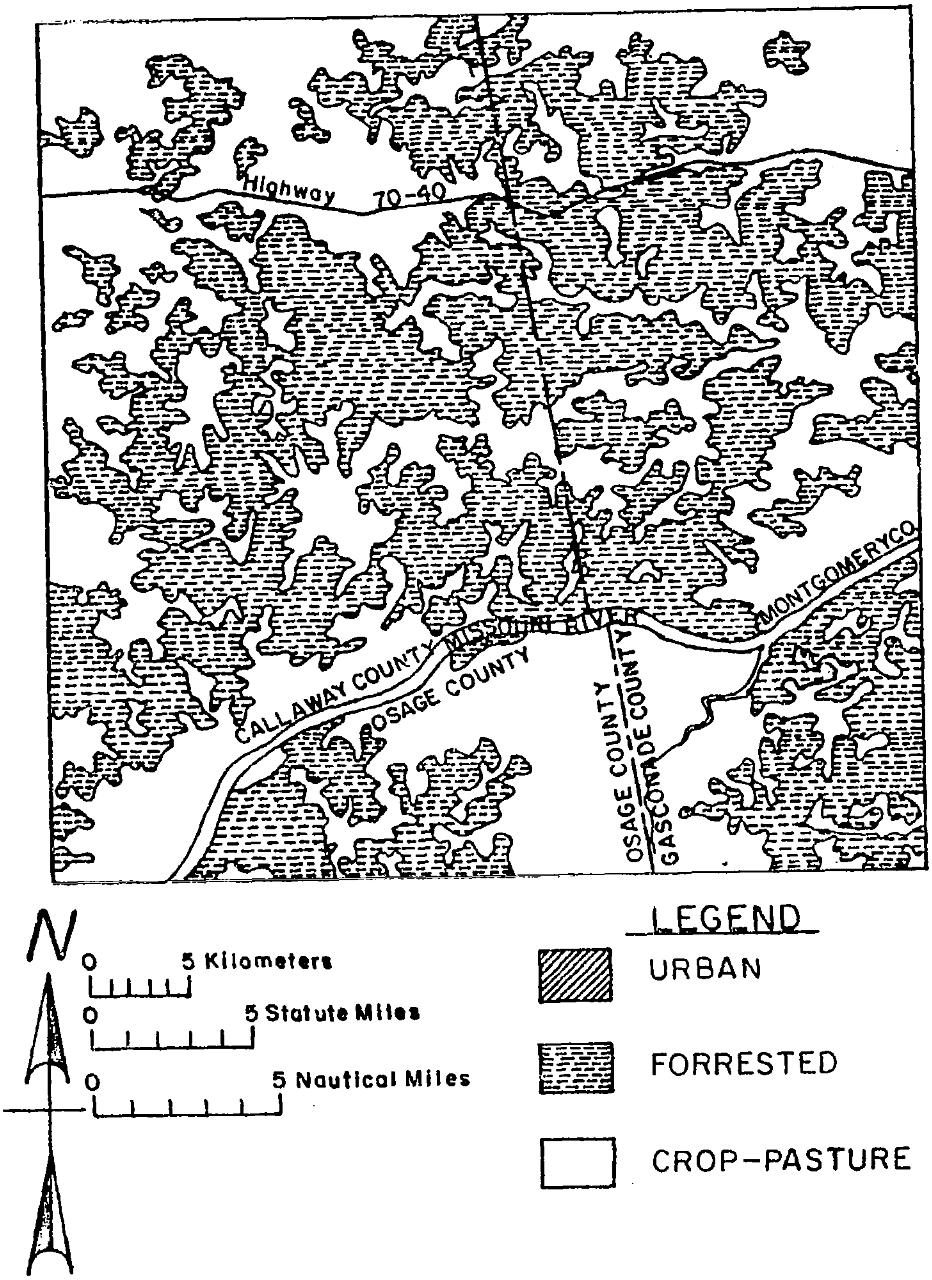


Figure 6. Land use map in central Missouri from Landsat composite image bands 4, 5, and 7 using normal false color scheme.

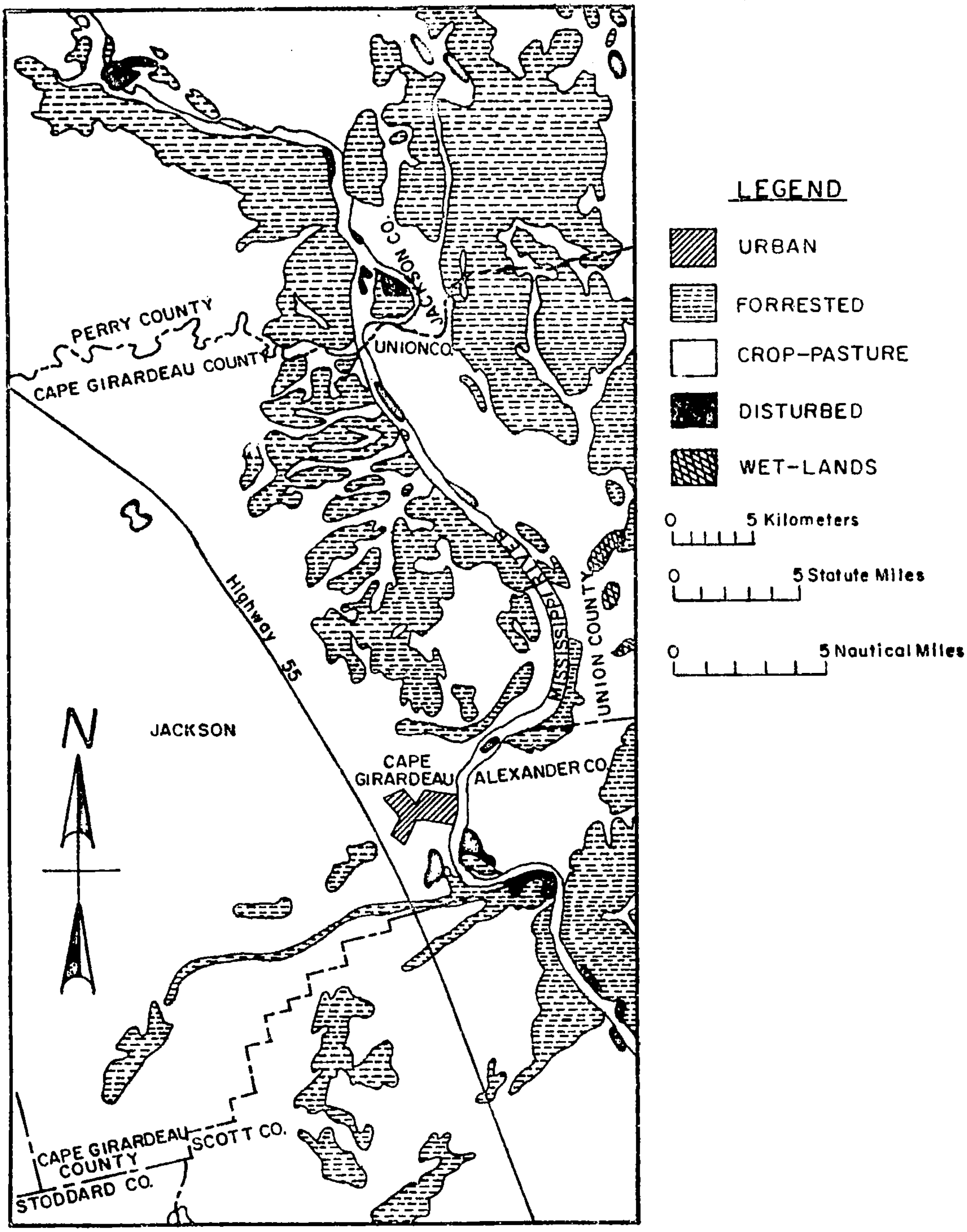


Figure 7. Southeast Missouri–southwest Illinois land use map from Landsat composite image bands 5 and 7 using natural false color scheme.

fairly accurate maps using the microviewer. When interpreting land use, discrimination between row crops and pasture and between wet bare soil and urban areas is difficult. Wise choice of season of the imagery combined with a knowledge of the crops in the area and their growing characteristics can partially alleviate this problem. Difficulties encountered in judging the correct exposure times will be greatly reduced with experience.

Advantages of the system include low cost, short production time, and the capability of producing images of any band combination, color, or density range. An investigator who is familiar with the spectral characteristics of the targets of interest can produce an image of maximum contrast by choosing the appropriate Landsat bands and varying the color contrast and density range. Economic advantages include a low initial cost of building a diazo printer-developer system and the continuing savings of doing one's own "special order" products quickly and at low cost.

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16. ABSTRACT

The use of data derived from Landsat is facilitated when special products or computer enhanced images can be analyzed. However, the facilities required to produce and analyze such products prevent many users from taking full advantage of the Landsat data. This report presents a simple, low-cost method by which users can make their own specially enhanced composite images from the four band black and white Landsat images by using the diazo process. The diazo process is described and a detailed procedure for making various color composites, such as color infrared, false natural color, and false color, is provided. The advantages and limitations of the diazo process are discussed. A brief discussion interpretation of diazo composites for land use mapping with some typical examples is included.

Note 1. The original of this report contained color illustrations. Because of cost considerations, this report was issued with black and white illustrations. The information on the bands and filters used is provided even though the examples of the diazo composites are not in color.

Note 2. The use of trade names or names of manufacturers in this report does not constitute an official endorsement of such products or manufacturers, either expressed or implied, by the National Aeronautics and Space Administration or any other agency of the United States Government.

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