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APPLICATION OF LANDSAT DATA IN DISTRICT WATER RESOURCES INVESTIGATIONS AND MANAGEMENT

By

Harold A. Wilkening, III
Division of Engineering
Department of Water Resources

St. Johns River Water Management District
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ABSTRACT

The purpose of this study was to establish the operational use of Landsat satellite data in the District program. A Landsat digital data processing system has been established. The benefits of Landsat data include low cost, historical archive of data, repetitive coverage over the District and digital format which allows for computer automation. The primary applications of Landsat data in the District program are providing landcover, wetlands and surface water mapping over large areas on a timely and economical basis.

Two projects were carried out to demonstrate the use of Landsat data. Up-to-date landcover information was developed from Landsat data and merged with other digitized data to determine runoff curve numbers for the Econlockhatchee River Basin. This is a highly automated procedure which can be applied to other river basin studies to reduce manpower needs. The geographic data base which resulted from this analysis can be updated and assessed for basin management planning and regulatory permitting.

Landsat data was also used to inventory wetland areas in Duval County, Florida. The results can be utilized for planning and permitting programs until a more detailed mapping program can be completed.

INTRODUCTION

Since the early 1970's, this country has operated a land remote sensing program which has proven to be valuable to earth resource management on a regional scale. The primary data acquisition during this period has been a series of Landsat satellites operated by NASA. Since 1977 the St. Johns River Water Management District (District) has supported several investigations carried out by universities and other state agencies to test the feasibility of utilizing Landsat digital data in support of water management in Florida. These investigations have indicated that Landsat data could potentially be used to provide information necessary for water management within the District.

The purpose of the current District study was to establish the operational use of Landsat digital data in District programs on a routine basis. The specific objectives of the study were the following:

1. Review of Landsat data and potential applications in District studies and programs.
2. Establish an operational Landsat digital data processing system.
3. Utilize the Landsat data processing system in several pilot studies.
4. Document the procedures used to process Landsat data and derive useful information.

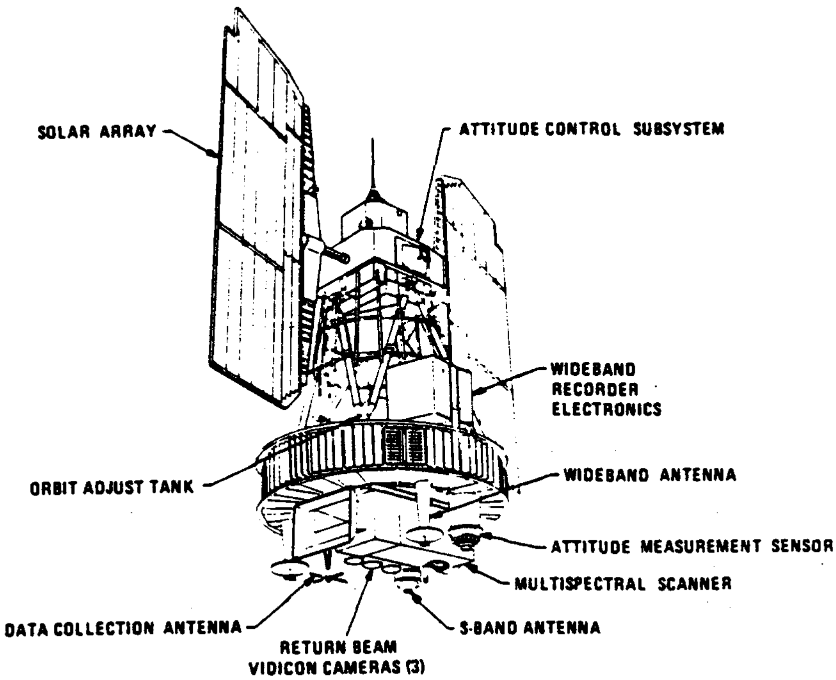
Each of these objectives will be discussed in this report.

REVIEW OF THE LANDSAT SATELLITE

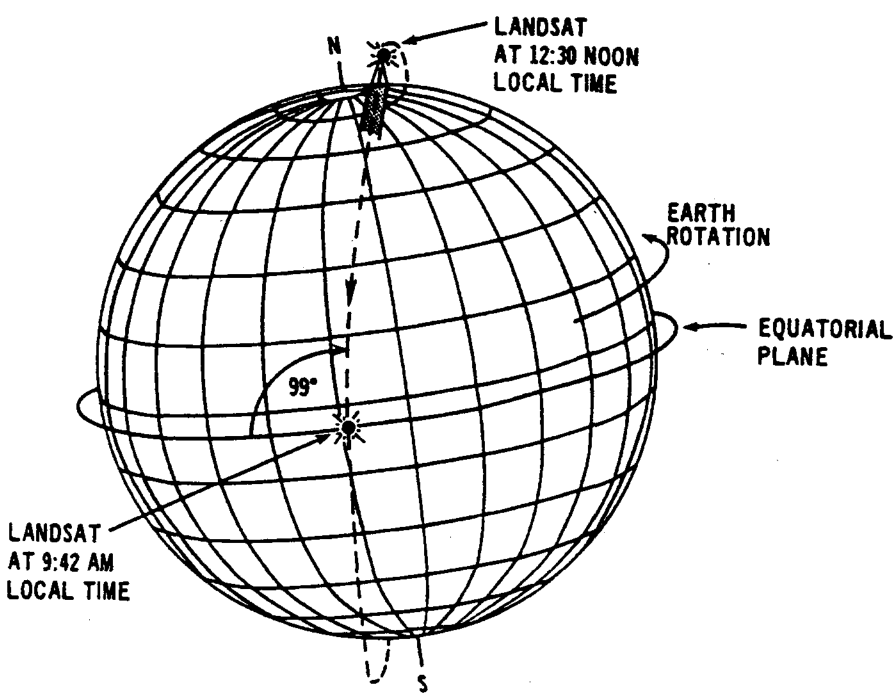
History and Operation

The Landsat program (formerly known as the Earth Resources Technology Satellite, or ERTS program) was begun in the late 1960's. In 1972, the first Landsat satellite was launched into a near polar sun-synchronous orbit at an altitude of 570 miles (Figure 1). Since that time, four additional Landsat satellites have been launched to provide continuous remote sensing of the earth's surface. Each of these satellites has been similar in design and orbit although Landsat 4 and Landsat 5 orbit at a lower altitude of 440 miles and have an additional sensor, known as the thematic mapper, not on the previous satellites. Currently, Landsat 5, which was launched in April 1984, is collecting data continuously and Landsat 4 is collecting data only on a limited basis due to equipment malfunction. All of the previous satellites are no longer operational. The orbit of Landsat 4 and 5 allows each satellite to cover the entire earth every 16 days; with one of the satellites covering a given location every 8 days.

The digital data collected by the satellite is constantly being transmitted by radio signals to ground stations throughout the world. Computers are then utilized to reconstruct the data into various formats available to the user. Data processing and distribution are currently performed by the National Oceanic and Atmospheric Administration (NOAA).



(A) SATELLITE



(B) NEAR-POLAR SUN-SYNCHRONOUS ORBIT

FIGURE 1. LANDSAT SATELLITE AND ORBIT

The current administration has directed that the operation of the entire earth remote sensing program, including Landsat, be transferred to the private sector. Currently, plans are underway to make this transition. At the present time, there are no plans to launch any new Landsat satellites in the near future.

Characteristics of Data

Multispectral Scanner. Landsat 1, 2, and 3 carried two sensors to collect data: the Return Beam Vidicon Camera (RBV) and the Multispectral Scanner (MSS). Although the RBV was originally planned to be the primary data collection device, data from the MSS proved to be more valuable and the RBV had several malfunctions causing the MSS to become the primary data collection device. The MSS measures the total level of reflectance from the earth's surface within four different bands of the electromagnetic spectrum: two bands in the visible range (red and green) and two bands within the near infrared portion of the spectrum not visible to the human eye. The reflectance level within each of the four bands provides different information that can be utilized to characterize conditions on the earth's surface. A summary of the MSS scanner data is given in Table 1.

As the satellite continues through its orbit, the MSS scanner rotates back and forth across a swath of 115 miles in width. As the scanner rotates across the swath, the reflectance of the earth surface in each of the four bands is measured for discrete picture elements, known as pixels. Each pixel is 60 meters by 80 meters, covering about 1.1 acres on the earth surface. Figure 2

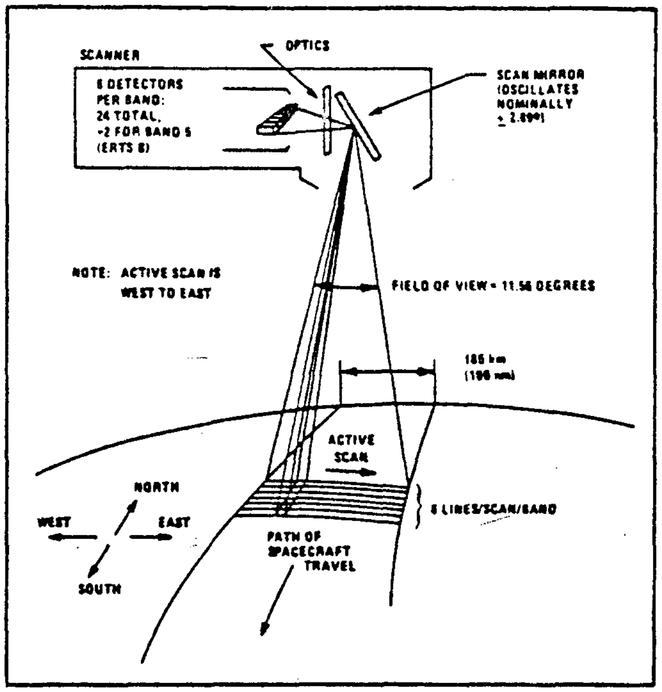
TABLE 1. SUMMARY OF LANDSAT MSS DATA

CHANNEL	RESOLUTION (METERS)	SPECTRAL BAND µm	DESCRIPTION	EARTH FEATURES/APPLICATIONS
1	80	0.5-0.6	Visable Green	Sediment loads in water. Cultural features.
2	80	0.6-0.7	Visable Blue	Cultural features.
3	80	0.7-0.8	Near Infrared	Vegetation health and vigor, land/water delineation.
4	80	0.8-1.1	Near Infrared	Vegetation health and vigor, land/water delineation.

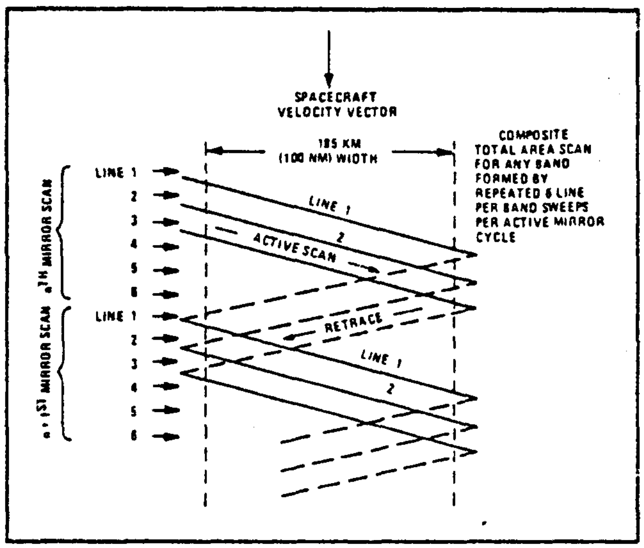
shows the operation of the MSS scanner. The MSS measures an aggregate reflectance of the earth surface within each pixel in each of the four bands. The data is then transmitted to ground receiving stations where it is reconstructed into Landsat scenes, each scene being about 115 miles (one swath) by 106 miles of ground coverage. Each particular scene is identified by a path and row number. Path and row identification of scenes within SJRWMD is given in Figure 3 for Landsat 1, 2, and 3 and Figure 4 for Landsat 4 and 5. Pixels within each scene are identified by scan line (row) and pixel element (column) numbers. The pixel in the northwest corner of the scene is line 1 and element 1; the scene contains 3,548 pixel elements and 2,983 scan lines.

Thematic Mapper. A second generation scanner known as the Thematic Mapper (TM) was included on the Landsat 4 and 5. This scanner operates similar to the MSS. The TM, however, provides two major improvements over the MSS. First, the pixel elements are reduced from 80 meter to 30 meter, yielding a resolution of approximately one quarter of an acre. Second, the spectral resolution is improved by the use of seven discrete bands for data collection. These bands cover a wider range of the spectrum and have been optimized to provide useful information on the earth surface. Table 2 gives a summary of the TM scanner.

Currently, the TM scanner is in an experimental rather than operational mode. Practically, this means that data collection is not continuous like the MSS, but only selected scenes are collected by the satellite based on ground control direction from NASA. Data collection is limited due to the current capacity of



Scanning arrangement of the MSS. From <u>NASA Landsat Data Users Handbook</u>. PAO Number: E-6327-35.



Scanning pattern of the MSS on the Earth's surface. <u>NASA Landsat Data Users Handbook</u>. PAO Number: E-6328-35.

FIGURE 2. OPERATION OF MSS SCANNER

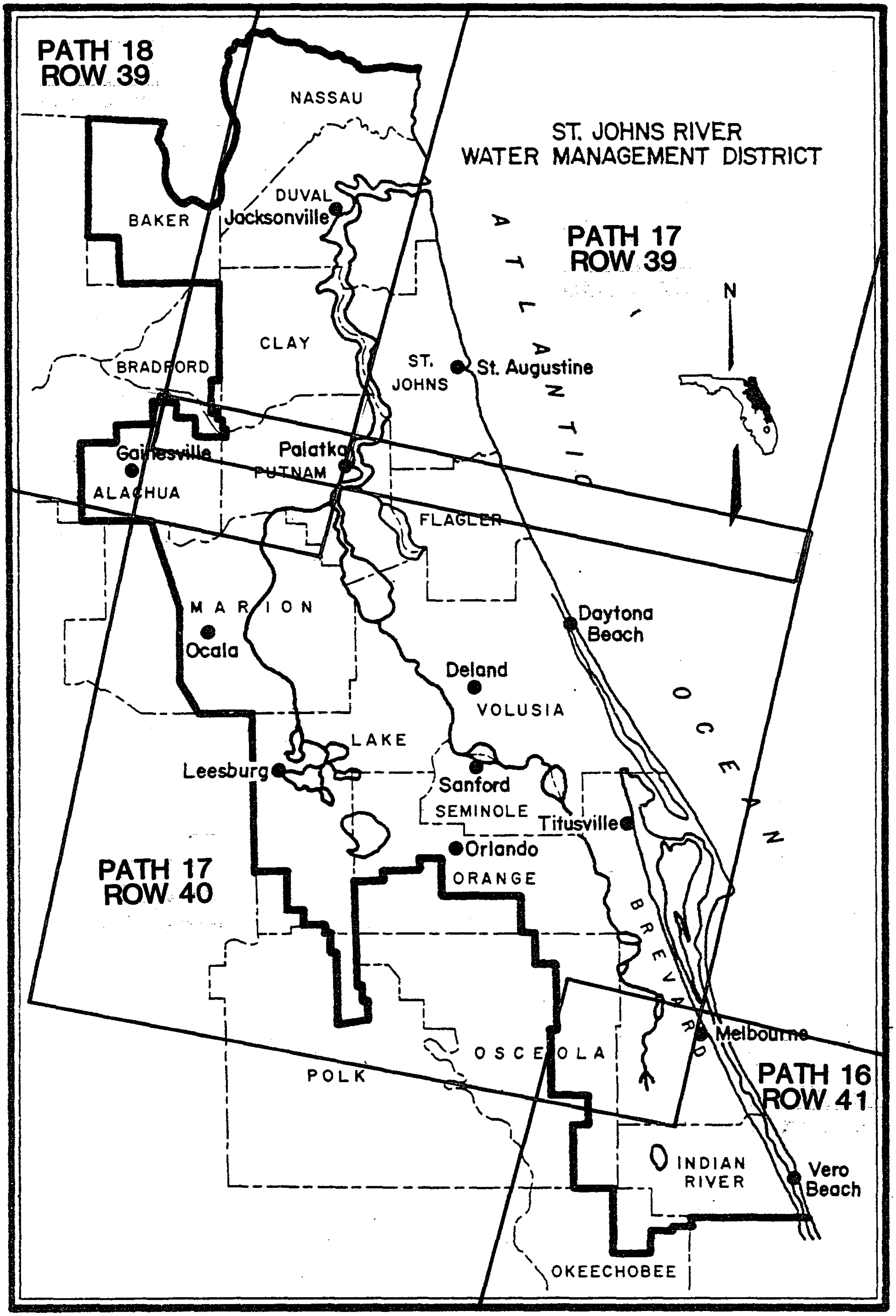


FIGURE 3. APPROXIMATE COVERAGE OF LANDSAT 1, 2, and 3 SCENES

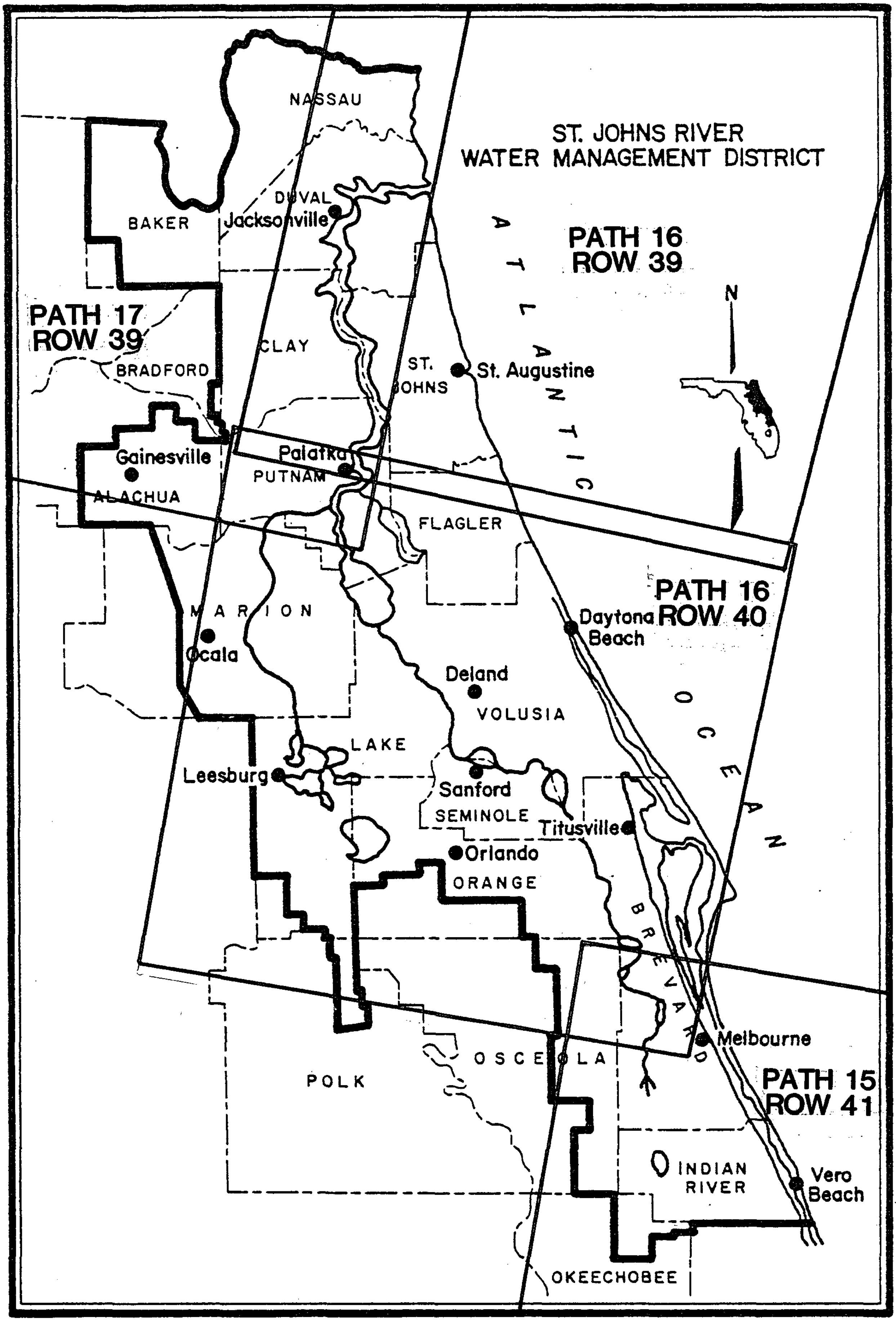


FIGURE 4. APPROXIMATE COVERAGE OF LANDSAT 4 and 5 SCENES

TABLE 2. SUMMARY OF LANDSAT TM DATA

CHANNEL	RESOLUTION (METERS)	SPECTRAL BAND µm	DESCRIPTION	PRINCIPAL APPLICATIONS
1	30	0.45-0.52	Blue Green	Coastal water mapping, soil/vegetation differentiation, deciduous/coniferous differentiation.
2	30	0.52-0.60	Green	Green reflectance by health vegetation.
3	30	0.63-0.69	Red	Chlorophyll absorption for plant species differentiation.
4	30	0.76-0.90	Near IR	Biomass surveys, water body delineation.
5	30	1.55-1.75	Mid IR	Vegetation moisture measurement.
6	30	10.4-12.5	Thermal IR	Plant heat stress management, other thermal mapping.
7	30	2.08-2.35	Mid IR	Hydrothermal mapping.

ground processing facilities. The limited TM data is primarily being used by research teams investigating the potential benefits for resource management. TM data is available for the same scenes as MSS (Figure 4); however, it can also be purchased in quarter scenes.

Data Format. Both TM and MSS data are reconstructed by computer into two basic formats: photographic and digital on computer compatible tapes (CCT).

The data can be converted to images similar to photographs useful for visual interpretation. Black and white images of the reflectance data in each spectral band can be obtained. In these images, low reflectance will appear dark while high reflectance appear light. In addition, any three of these images can be combined to form color images known as false color composites because they do not necessarily portray the earth in "natural tones". Such a composite is formed by passing each of the three color images through one of the primary color filters and then combining them. These photograph products can be obtained at different scales from USGS at a very reasonable cost (see Appendix A for details). Landsat data can be utilized in this format when visual inspection and interpretation on a regional scale is all that is necessary for the analysis. Typical applications are in geologic studies to determine linear features, general assessment of crop health and vigor and sediment load in water bodies.

The other format for MSS and TM data is computer compatible tapes (CCT) which contain the digital reflectance values collected by the sensor. The advantage of the data in this format is that computer processing can be utilized to classify the data into particular thematic classes based on the spectral characteristics of each pixel. In addition, Landsat data in digital format can be easily entered into a geographic information system (GIS) in which computer processing is used to merge digital data sets and access the data to derive information for resource management decisions within specific geographic boundaries. The GIS is a very powerful tool and Landsat digital data is an excellent source of data.

POTENTIAL APPLICATIONS FOR LANDSAT DIGITAL DATA IN DISTRICT STUDIES

This section presents a review of potential applications for Landsat data in SJRWMD studies and programs based on a review of the literature; only those applications documented as being successful and considered operational are discussed in detail. In general, most of the applications of Landsat occurring on an operational basis (i.e. no further research and development of methodology required) are limited to MSS data. Applications for TM data are still in some phase of development and evaluation. However, it should be noted that the TM data will provide improved applications in the future because of the improved spectral and spatial resolution. Applications of MSS data are discussed in three general areas: landcover mapping, surface water mapping, and other potential applications.

Landcover Mapping

Overview. This is the most widely demonstrated application of MSS digital data. Anderson, et al (1979) presented a landcover classification system having three levels of detail that can be established with different remote sensing platforms. Table 3 shows the general Level 1 and the more detailed Level 2 categories. Level 1 categories can be mapped routinely using MSS data while mapping of some Level 2 categories is also possible (Anderson et al, 1979; Middleton and Munday, 1979). Historical

TABLE 3. USGS LAND USE AND LAND COVER CATEGORIES

1 Urban or Built-up Land 11 Residential 12 Commercial 13 Industrial 14 Transportation, Communications, and Utilities	2 Agricultural Land 21 Cropland and pasture 22 Orchards, Groves, Vineyards and Ornamentals 23 Confined feeding ops 24 Other ag land
3 Rangeland 31 Herbaceous rangeland 32 Shrub and brush rangeland 33 Mixed rangeland	4 Forestland 41 Deciduous forest land 42 Evergreen forest land 43 Mixed forest land
5 Water 51 Streams and canals 52 Lakes 53 Reservoirs 54 Bays and estuaries	6 Wetlands 61 Forested wetlands 62 Nonforested wetlands
7 Barrenland 72 Beaches 73 Sandy areas other than beaches 74 Bare exposed rock 75 Strip mines, quarries gravel pits	

and up-to-date landcover information over large areas is typically needed by the District for hydrologic studies; wetland and vegetative mapping, and the regulatory permitting program.

Basin Surface Water Hydrologic Studies. Many studies have documented that MSS data can be computer processed to obtain landcover data necessary for input to basin runoff models. A cooperative demonstration project between NASA and the U.S. Army Corps of Engineers (Corps) compared the use of conventional landcover information (derived manually from aerial photography) with Landsat derived landcover information in several basin studies throughout the country (Rango et al, 1983). In each of these river basins, the Corps HEC-1 runoff model was used to generate discharge frequency curves. This model uses the Soil Conservation Service (SCS) approach. Differences in the discharge frequency curves were insignificant for sub-basins as small as 1.0 sq. miles. For basins larger than 10.0 sq. miles, Landsat derived landcover was determined to be more cost effective with costs typically 50% less than the conventional procedures. The study also points out that the value of Landsat data for hydrologic modeling is further enhanced as it is merged with other digitized data into a geographic information system for use by regional planning agencies such as the SJRWMD.

Several other studies have documented the use of Landsat derived landcover to develop runoff curve numbers (CN) for the SCS approach in models other than HEC-1. Ragan and Jackson (1980) documented the use of MSS data to derive CN values in the use of SCS TR-20 model. Additional procedures and studies are given by Slack et al (1980), Jackson and Bondelid (1983). Still and Shih (1984) found that the basin-wide CN value derived from Landsat and USGS LUDA data for the Econ River Basin were found to be very similar.

Landsat MSS data has been demonstrated to provide acceptable information on the degree of impervious areas in urban areas necessary for use in some hydrologic models. Jackson, et al (1977) used Landsat data to derive the percent impervious area within the 19.5 sq. mile Four Mile Run River Basin in Virginia. This information was input to the Corps' Storage, Treatment, Overland Flow Model (STORM) to test various basin management alternatives. Differences between impervious area estimates from Landsat and manual interpretation of aerial photographs was found to be acceptable for planning purposes.

The feasibility of using Landsat derived landcover information as an input to the Hydrologic Simulation Program - Fortran (HSPF) was investigated by Franz, et al (1981). HSPF is a comprehensive water quality and quantity model used for continuous event simulation. Comparison of the HSPF simulations for the 580 sq. mile Occoquan watershed in Virginia indicated that Landsat derived data performed as well as conventional data set while offering an estimated saving of at least 30% in the cost of model input preparation. Landsat data was recommended for modeling agricultural and natural areas while more detailed information was recommended for urban and water areas.

Allord (1979) used Level I landcover from Landsat in a step forward regression analysis to develop relations for low flows and flood flows. In basins where landuse was a significant predictor, standard error of estimate for regression equations was lowered when Landsat derived data was used instead of landcover data derived from USGS 7 1/2' quad maps.

In summary, MSS data can be used to develop the landcover data needed for the following models used by the District in basin management planning: HEC-1, TR-20, STORM and HSPF.

Detailed Wetland Mapping. An excellent overview of the applications of Landsat and other remote sensing platforms is given by Carter (1982). In general, the spectral and spatial resolution of the MSS data is not sufficient to derive detailed vegetative maps. The spatial resolution makes it difficult to identify linear wetland fringes and to place wetland boundaries with an accuracy necessary for wetlands regulatory programs. In addition, vegetative communities are often highly interspersed leading to a spectral value for a pixel that is not distinct but more of an average of several vegetation types. The spectral resolution of the MSS is not sufficient to differentiate between many vegetative types.

Given these constraints, MSS data can be utilized to map wetland/non-wetland areas and to classify wetlands into general categories based on major vegetative differences. While aerial photography is necessary for detailed mapping, Landsat data is available on a repetitive and cost effective basis and can be used to supplement analysis from aerial photography.

Mapping Irrigated Acreages. Several studies have demonstrated the use of MSS data in inventory of irrigated crop acreage on a repetitive basis. Williams et al (1979) and Thelin et al (1979) reported that MSS data was useful for periodic mapping of cropland in western states. Webster et al (1979) used MSS data to inventory two irrigated crops, corn and rye, at selected sites within the Suwannee River Water Management District. Estimates from Landsat were 20-30% higher than actual acreages. The Landsat estimates were, however, judged to be suitable for regional planning purposes. Based on these studies, MSS data could be used to periodically inventory irrigated acreages within the District to support the consumptive use permitting program. Ground truthing for selected areas would be necessary to evaluate if acreage estimates were consistantly biased.

Detection of Landcover Changes. Landsat data is being collected on a repetitive basis and is available for large areas on a cost effective basis. Thus, an ever growing set of data dating back to 1972 is available for use in comparing historic landuse and landcover changes. This information can be used for assessing historical water management practices and current changes that may go otherwise unnoticed. Presently, the District operates an active aerial surveillance program to identify unpermitted water management activities. With this program in operation, the role of Landsat data in the regulatory program would be only supplementary.

Landsat MSS data can be used to establish historical landuse and water management practices during the 1970's that might not otherwise be available. In addition to general landcover, floodplain features such as natural and artificial levee systems, agricultural patterns and features, and channel configurations can often be determined by visual inspection of MSS data.

A very powerful tool in detecting landcover changes is to georeference two data sets from different time periods and automatically locate pixels that have changed. Williams (1979) investigated the potential use of automatic change detection techniques to assist in the U. S. Army Corps of Engineers dredge and fill permit responsibilities. He concluded that this technique is of limited value with MSS data because the classification accuracy of single pixels can be quite low due to the various features within the pixel that contribute to the overall composite reflectance value. The conclusion was that in using MSS data to determine change detection, visual interpretation must be relied upon more than automated techniques. Automated change detection on a pixel by pixel basis may become more useful with TM data. In the interim, MSS data can be computer processed to periodically estimate the total change in landuse/landcover within larger areas of regional interest.

Surface Water Inventory

Landsat MSS data can be computer processed to locate surface water and survey its extent. This information can be used by the District to establish stage-storage-area relationships for water bodies and survey surface water areas on an economical basis.

Lake Stage - Storage Relationships. Shih (1982) demonstrated that lake stage-storage relationships could be developed using historical MSS data to determine lake surface areas corresponding to a range of measured lake stages. The procedure, which was successfully applied to Lake Washington and Lake Harris, can be used to establish the change in lake stage or lake storage. Due to the pixel resolution, however, this procedure is limited to larger lakes of at least several hundred acres in size.

Extension of Historical Stage Records. Landsat data collected on a continuous basis since 1972 can be utilized to estimate lake stage records that may not otherwise be available. After a lake stage-area relationship has been established, Landsat data can be used to derive surface water areas and corresponding lake stages from the known stage-area relationship. Thus, this technique may be used to estimate historic low stages occurring during several drought periods throughout the 1970's on larger lakes that were not included in data collection program. Such information could be used in the District's program to establish minimum lake levels and flows.

Flooded Area Mapping. Landsat data collected immediately after a major flood event can be used to inventory flooded areas over large areas. Floodplain maps of the spring 1973 flood on the Mississippi River near St. Louis were developed from Landsat and found to be in good agreement with flood hazard maps produced from aerial photography (Middleton and Munday, 1979). Kruus et al (1979) presented techniques for using Landsat and other remote sensing platforms to map flooded areas and durations. Although the resolution of MSS data precludes mapping flooded areas in sufficient detail for zoning and flood insurance studies

(Middleton and Mundy, 1979), it is sufficient for mapping large flooded areas throughout the District. Such information would be useful in rapidly locating specific areas requiring inspection and detailed aerial reconnaissance as well as documenting flood damages on a regional scale.

NOAA has implemented the Landsat Emergency Access and Products Program (LEAP) for the purpose of providing Landsat data, in a minimum time frame, to federal, state and local government and agencies having the responsibility for protecting lives and property during a civil emergency. Upon receiving a request, NOAA activates Landsat 4 so that coverage over the area of interest is every 8 days. As soon as an acceptable scene is collected, a CCT is sent within 24 hours and within 5 days, another CCT with the normal geometric and radiometric preprocessing is sent. The total cost of the service is $1,000. Early in 1984 the Florida Department of Transportation utilized this service successfully to obtain data on the Suwannee River immediately after flood stages (Tullos, 1984).

Other Potential Applications

Water Quality. Several studies have investigated the use of Landsat MSS data for water quality monitoring. Scarpace et al (1978) used Landsat to conduct a statewide inventory of the trophic status of lakes greater than 20 acres in size. The study concluded that MSS data is capable of monitoring lake trophic conditions; however, multi-temporal data sets are required. The measurement of turbidity using MSS data is the most widely accepted application in the area of water quality. Two common indicators of turbidity which correlate with Landsat data are secchi disc depth and suspended sediment concentration (Middleton and Munday, 1979). The potential benefit of Landsat digital data in District studies would be the opportunity to extrapolate surface water measurements at a point to develop distribution over the entire surface water body. The first step toward such an application would be correlation of MSS data and water quality measurements.

DISTRICT LANDSAT DIGITAL DATA PROCESSING SYSTEM

Background

During the 1982 and 1983 fiscal years, the District purchased the necessary equipment to computer process Landsat digital data. The system was purchased based on the conclusion that computer processed Landsat data would be a valuable data source for District studies. This was based on cooperative demonstration projects carried out with IFAS and NASA (ERL, 1981; Wilhelm, 1979; Shih, 1982). Although the computer processing could be contracted out, it became apparent that a relatively inexpensive system could be set up in-house which would prove to be more economical if Landsat was utilized on a routine basis. In addition, several advantages to having such a system were identified: staff familiarity with the data potential and limitations, quicker turn around time, multiple use of the data for several project applications, and compatibility with the District geographic information system.

Overview of System

An overview of the processing system is given in Figure 5. The system is relatively low cost compared to typical costs for stand-alone dedicated digital image processing systems. The reason for this is that most of the system utilizes existing computer equipment with the only significant cost being the addition of an image display microprocessor and high resolution color monitor. While economical, this approach does have some limitations not found in more expensive stand-alone systems for data

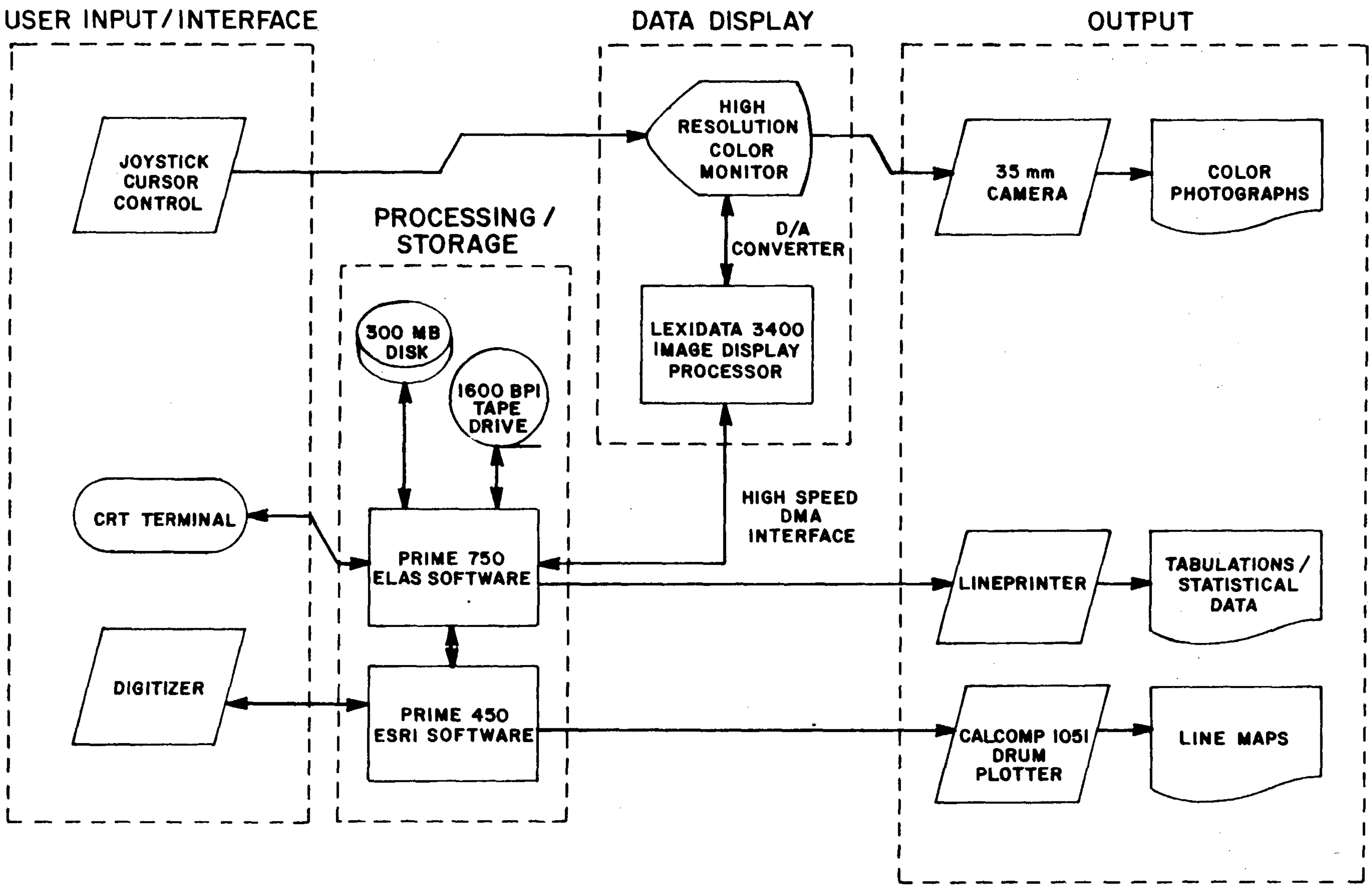


FIGURE 5. DISTRICT LANDSAT DIGITAL DATA PROCESSING SYSTEM

processing and storage. However, the system does represent a good compromise between cost and utility. Digital processing of Landsat requires four capabilities: data processing/storage, user interface, data display, and data output. The District Landsat data processing system is discussed below.

Processing/Storage Subsystem. All processing of the Landsat data is carried out by use of the Earth Resources Laboratory Software (ELAS) run on the PRIME 750. This software package was developed and is maintained by the National Space Technology Laboratory of NASA. ELAS is a comprehensive software package including capability for the following data processing: reading and reformatting various types of digital data off computer tape (such as Landsat MSS and TM, NCIC topographic data, digitized aerial photography); display of the raw data; classifications; georeferencing; merging ancillary digital data; multitemporal registration of two Landsat scenes; multispectral storage of digital data in a grid cell data base; and calculations using data base information. An introduction to the capabilities of ELAS are given in the orientation manual (ERL, 1981). A detailed discussion is given in the users manual (Graham et al, 1984). Appendix B gives a summary of the numerous application modules in ELAS.

In addition to ELAS, the ESRI software package, which is currently running on the PRIME 400, is used to digitize ancillary data such as base maps, soils, hydrologic boundaries, etc. that are to be merged with the classified Landsat data. The ESRI package is already used extensively in District studies.

Extensive disk storage is required in using the system for many steps of the processing application. Projects discussed in this report each required about 1/3 of a 300 megabyte disk drive. Currently, this amount of storage is not available during normal working hours, but can be accessed during off hours when a separate disk pack can be loaded.

The 1600 bpi tape drive is used to load and read Landsat CCTS, transfer large volumes of digital data from the Prime 400 to the Prime 750, and storage of final map products in digital format for future use.

User_Input_and_Interface_Subsystem. Successful processing of Landsat data requires that the user or analyst interface with the data at various stages in the process, thus making it an interactive process rather than a batch mode. The most basic user input is through the use of ELAS software, which is set-up in menu-oriented interactive mode which can be run from any terminal.

The joystick cursor control allows the user to interact with the data as it is displayed on the monitor. The joystick controls the position of the cursor on the screen and is used for several operations on specific portions of the data such as writing polygons, reading specific data values, graphics overlay, and control of the black and white transform functions. The joystick control is a useful feature; use is further discussed in the guidelines section.

The user can input additional digitized data, such as soils, roads, water courses, or hydrologic boundaries through the use of the digitizer and the ESRI software.

Data Display Subsystem. The display of the digital data is an important component and is accomplished by the Lexidata 3400 Image Display Processor. The processor is a microcomputer with a refresh memory buffer which stores a digital image, and a display controller transforms the stored data into a black and white or color image on the monitor. The refresh memory buffer is a 512 by 640 array of pixels each with 8 bits of data storage. Practically, 8 bits means that digital values of 0 to 256 (2^8) can be stored for the array. The refresh memory can be divided for image storage and graphics overlay. For example, since Landsat data can have up to 64 values (0 to 64), the 8 refresh memory bits are often divided as follows: 6 bits for data which gives 64 values (2^6) and the remaining two bits for graphic overlay (i.e. titles, tables, boundaries, etc.).

The digital data is transferred from the PRIME to the Lexidata 3400 memory buffer through a high-speed direct memory access (DMA) interface. Once the data is in the buffer, the display controller converts the digital values to a analog signal which drives the color monitor. Black and white images are displayed as the digital data is converted to a grey scale level intensity through a particular transformation function set up by the user. Color images are made as the digital data is converted to a particular color combination through the use of a color "look-up" table. The look-up table, which is set up by the user, indexes each digital value to a particular color combination specified by particular intensity levels in blue, red and green color guns which drive the monitor. All commands to drive the Lexidata 3400 are made through the ELAS software which contains a software driver for this particular display device.

Output Subsystem. Three devices are currently used for output. Statistical data and tabulations from ELAS can be output on the lineprinter. Digitized data can be output in polygon (line) format with the Calcomp drum plotter. Landsat and other digital data that has been digitized and converted to raster (pixel or grid) format and input to ELAS can be displayed on the color monitor and photographed. It is also possible to convert the Landsat or other raster data to polygon format and output on the Calcomp plotter using ESRI software.

Procedures for Computer Processing Landsat Data.

This section presents the basic steps required in processing Landsat or any other digital data on the District computer. This discussion is meant to serve as an introduction and therefore refers to supporting documents for additional information.

Step 1. Selection of Appropriate Landsat Data.

The selection of the particular Landsat CCT to be processed should be based on a careful review of the objectives of the study. The following factors should be considered:

A. Size of study area.

Landsat may not be practical for small areas. Determine the path/row of the required scene or scenes from Figure 3 for Landsat 1, 2, 3 and Figure 4 for Landsat 4 and 5.

B. Objective of analysis.

The detail of classification categories may require data from a particular period of the year or even multitemporal analysis (classification using data from different periods of the year). Eventually when TM data becomes available on an operational basis, a decision must be made regarding whether to use MSS or TM.

Step 2. Obtain Landsat CCT for Processing.

Once the required scene or scenes has been identified by path and row and by the period, a search must be made of available CCT tapes. Appendix C gives a list of CCTs that the District currently owns. Additional CCT tapes that are currently owned by IFAS or other state agencies are given in Appendix D. Arrangements can be made to borrow any CCT listed in this appendix. If none of the CCTs listed in these appendices are acceptable, a CCT can be purchased from NOAA for $730. A complete listing of all CCTs covering the District from 1972 through 1985 is available for staff use in selecting CCTs for purchase. In selection of particular scenes, the critical factor, in addition to the date of collection, is the cloud cover conditions. Cloud cover is rated on the computer listing by 10% increments. Cloud cover over the study area is generally unacceptable because clouds completely eliminate the spectral signature from the earth surface.

Step 3. Reformat Data and View Raw Data File.

The CCT is loaded on the tape drive and a portion of the tape can be read into a ELAS data file using modules NCCT or REFO (depending on the tape format). The subscene is selected by specifying initial and last lines (rows) and elements (columns). These can be estimated by relating the position of the study area to the total scene (Figures 3 and 4). Since this is an approximation, a larger subscene is specified than the study area. The data file normally will contain the four channels of Landsat data. Using ELAS, any one channel of the data file can be displayed on the monitor in black and white. In viewing the raw data, it is necessary to dynamically alter the function that converts digital data to grey scale intensity on the monitor. Figure 6 shows how this transfer function is set so that the maximum tonal contrast available on the monitor is used for the

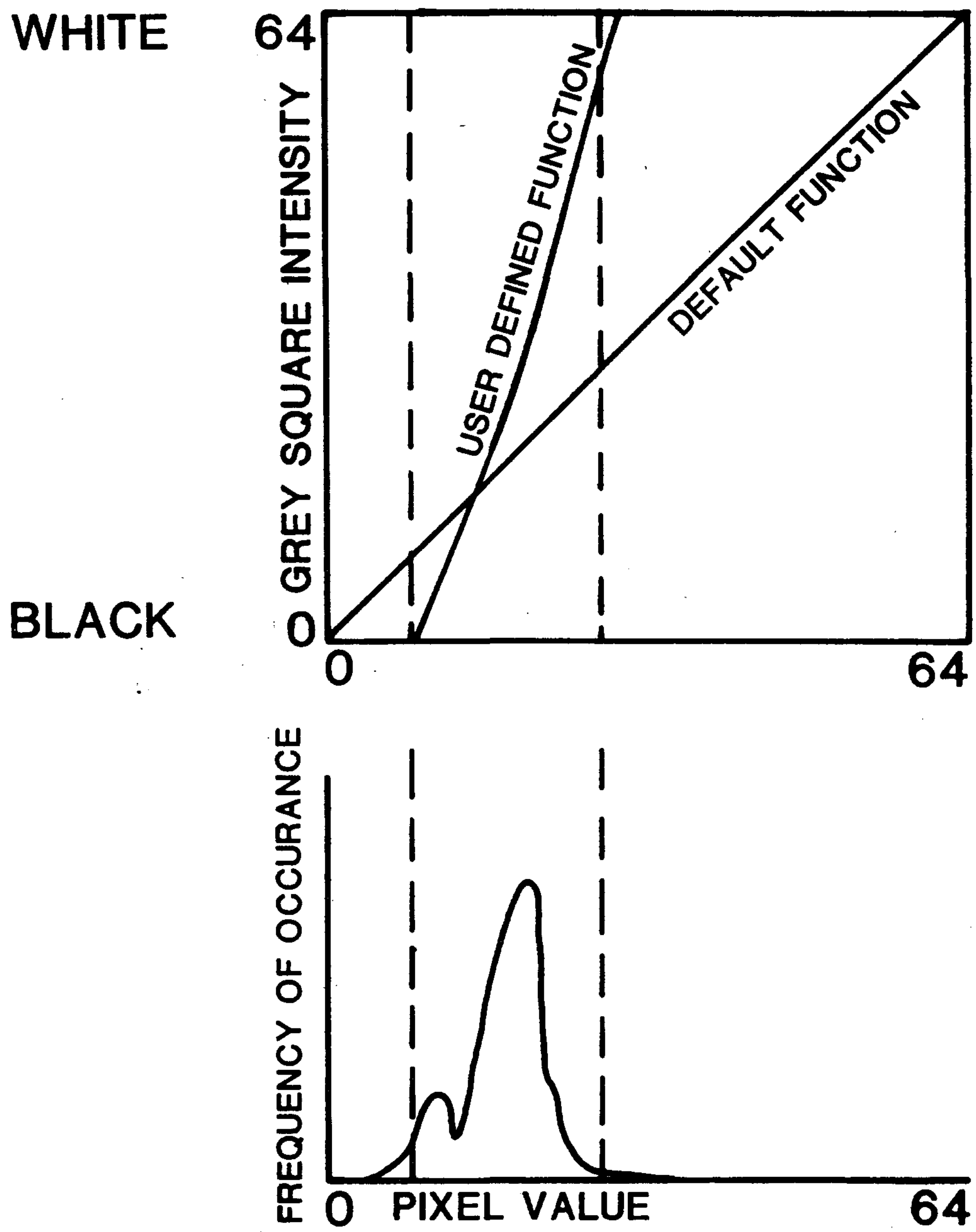


FIGURE 6. IMAGE DISPLAY CONTRAST STRETCH FUNCTION

range of data shown in the histogram for a particular channel. After viewing the raw data in one channel, the line and elements of the study area can be defined with detail using the cursor.

Often it is very helpful to view the data at this stage using a pseudocolor transformation. This is really a color composite with three of the four Landsat data channels, each assigned to one color gun. By assigning Channel 1 to blue, Channel 2 to green, and Channel 4 to red, a color image results which resembles an infrared photograph. Displaying the data in this format is very useful for visual inspection and analysis.

Step 4. Selection of Training Sites and Collection of Ground Truth

Except in those cases where only visual inspection of the data is required, appropriate ground truth data must be collected to support classification of Landsat data into thematic classes of interest. The ground truth could include any or all of the following: USGS 7 1/2 minute quad maps; detailed black and white, color or infrared (IR) photography; ground surveys; and previous landcover/landuse inventories. The detail and extent of ground truth required depends on the desired detail of the classification. For instance, a Level 1 classification might only require limited black and white photography while a Level III vegetative mapping may require color IR photography and/or extensive field surveys. The basic principle is that the resulting Landsat classification can never be more detailed or accurate than the ground truth that is used. However, ground truth is only required for a small portion fairly representative of the entire study area. In addition, ground truth does not necessarily have to coincide with the date of Landsat data. Thus, one set of ground truth may be useful for several different classification efforts. The particular method for using ground truth depends on the approach used in developing spectral signatures (Steps 5, 6, and 7).

Step 5. Develop Multispectral Signatures.

A set of spectral or "training" signatures (characteristics) for each desired thematic category (class) must be developed before the raw Landsat data can be classified. Two approaches can be used: supervised and unsupervised. Both can be performed using ELAS.

In the supervised approach, the analyst "supervises" the collection of signatures by using ground truth to identify training sites of a known map category. These training sites are isolated on the image display device with polygons using the joystick. Sufficient training sites must be identified for each category so that a sufficient number of pixels exists for meaningful statistics to be developed to represent the class signature. The spectral signature of a particular map category consists of statistics used to characterize the data in each of the four spectral bands. This includes the mean reference value in all four channels, the variance in each channel and the covariance between all channels. The primary advantage of this approach is that signatures are developed for the particular mapping categories of interest. However, the supervised approach is time consuming because many training sites have to be identified manually. Also, the analyst must be careful to develop a set of signatures that represents all possible map categories because in the classification process, every pixel will be classified as one of the categories.

In the unsupervised approach, the computer develops spectral signatures based on a statistical analysis. The data set is automatically searched for acceptable training sites which are then combined to form class signatures. The user sets parameters to define the statistical criteria for training sites and the criteria for combining training signatures into one class. By varying these parameters, the analyst can control, to some degree, the total number of class signatures that are developed. The more detailed a classification is to be, the class signatures are generally developed. However, several class signatures may in reality be developed from the same landcover.

Step 6. Multispectral Classification.

After class signatures are developed, one of several classification algorithms is used to assign a class value to each pixel in the data set. A simple classification algorithm is a minimum distance classifier, which assigns each pixel to the class which has the mean values in each channel that are closest to those of the particular pixel. A more sophisticated classifier is the maximum likelihood classifier which assigns each pixel to the class that has the greatest statistical probability of containing the pixel. This classifier utilizes not only the mean values of each class, but also the variance of the class signature. ELAS utilizes these and several other classifiers. The maximum likelihood classifier (MAXL) is most commonly used.

Step 7. Verification of Thematic Classes.

After a classified data set has been established, it is necessary to utilize ground truth to verify or assign thematic map categories. When the classification results from a supervised approach, class signatures already correspond to known thematic categories (known training sites). In this case, ground truth should be used to certify that correct classification results in areas other than the actual training sites. Systematic errors in classification are then corrected by returning to Step 6 and adding or revising training signatures and repeating the classification of the data set.

When an unsupervised approach is used, the classified data set contains classes that must be assigned to thematic categories. This is done by viewing the data set for the area and assigning each class the appropriate map category by comparing the displayed data set with ground truth data.

Step 8. Georeference Data.

The raw Landsat data is skewed due to the orbit and operational characteristics of the MSS scanner. ELAS can be used to correct the geometric distortions and fit the data to the Universal Transverse Mercator (UTM) coordinates. The data is actually resampled using mapping coefficients developed from a series of control points established by the analyst. Approximately 3 control points are required for each 7 1/2 minute quad sheet. For each control point, the UTM northing and easting coordinates are determined from the USGS 7 1/2 minute quads and the corresponding line and element of point within the data file are determined using the cursor. Both the raw data and the classified data can be georeferenced; however, any data classification should be made using the raw data before being georeferenced.

Step 9. Accuracy Assessment.

This step is an optional extension of verification using ground truth (Step 7). Accuracy assessment is usually a labor intensive process and may or may not be necessary, depending on the study objectives. For example, when developing a Level I landcover map using standard procedures, it may be sufficient to reference accuracies documented in the literature for similar studies. When performing more detailed classifications or when the study objective requires an assessment of the classification accuracy, the general procedure is to digitize the ground truth source using ESRI, convert it to a pixel format with cell size identical to the georeferenced Landsat classified data file, overlay the two data sets, and then do a pixel by pixel comparison using the data-base routines in ELAS.

Step 10. Digitize and Merge Other Relevant Data into Data Base.

Often the use of Landsat classified data is enhanced by merging it with other digital data into a geographic information system (GIS). Data such as soils classifications or hydrologic boundaries can be digitized and then converted to a grid cell (raster format) using ESRI. The grid cell size should be the same as that used in the georeferenced Landsat data file. A utility module in ELAS can then be used to convert the ESRI data file to an ELAS data file. If the maximum and minimum UTM coordinates of this new data file coincide with the georeferenced Landsat data, then it can be copied directly as another channel of the GIS file; otherwise it must be offset to match UTM coordinates when it is copied into the GIS file. Another method for merging digitized data is to digitize polygons from base maps directly using an ELAS module. Given reference UTM coordinates, these polygons can be overlayed as a graphics overlay within georeferenced data file. Data within the polygon can then be extracted for further analysis.

Step 11. Data Base Modeling.

After a georeferenced data file has been established with several layers of data, a programmable function can be used to calculate a new layer of useful information based on the existing data layers. Examples include calculating runoff curve numbers, soil erosion potential or changes in landcover. In each case, a new parameter is estimated as a function of the existing data on a pixel by pixel basis. Information within the new data file can then be tabulated for any geographic boundary digitized from a base map or from the displayed data.

PILOT STUDY - DETERMINATION OF RUNOFF CURVE NUMBERS FOR ECONLOCKHATCHEE RIVER BASIN

Introduction and Objectives

One of the primary applications of Landsat digital data for the District is in deriving information needed to utilize hydrologic models for basin studies. This demonstration project was carried out to show how Landsat data can be computer processed and merged with other digital data to determine SCS runoff curve numbers (CN) used in the U. S. Army Corps of Engineers HEC-1 model. HEC-1, which is commonly used in District basin studies, is being used to determine flood discharges in the Econlockhatchee (Econ) River. The CN value represents the runoff potential and is determined as a function of the landcover and hydrologic soil grouping (SCS, 1972). An average CN value must be determined for each hydrologic sub-basin being included in HEC-1. Typically, this is a labor-intensive process of manually compiling the total acreage of each landcover/SCS soil type combination and then calculating a weighted average CN value for each sub-basin. The objectives were as follows:

(A) Calculate SCS CN value for hydrologic sub-basins using up-to-date landcover information from Landsat and a highly automated process to reduce manpower.

(B) Establish a GIS for the Econ Basin containing all relevant digital data for continued use in basin management planning and regulatory permitting.

Description of Study Area

The Econ River drains about a 275 square mile area east of Orlando. The river begins in an elongated swamp in northern Osceola County and flows north through Orange County and into Seminole County before draining into the St. Johns River south of Lake Harney (Figure 7). The Little Econlockhatchee (Little Econ) is the major tributary of the Econ and drains about 72 square miles in eastern Orlando metropolitan area. Extensive urbanization in the Little Econ has resulted in major drainage improvements within Orange County. A detailed study was completed by Orange County documenting the drainage system and flood elevations of the Little Econ basin within Orange County (Orange County, 1984). A recent District study documented water quality conditions and problems in the Econ Basin. A preliminary report on flood hazard information for the lower reaches of the Econ River (from St. Johns River to S.R. 528) was prepared by the U. S. Army Corps of Engineers as part of the Central and Southern Florida Flood Control Project (USACOE, 1970). Floodplain information presented in that report was based on aerial reconnaissance of historical events. The current study by SJRWMD will determine detailed flood elevations and floodway limits based on hydrologic and hydraulic modeling.

Methodology

Hydrologic sub-basins. Hydrologic sub-basins were delineated on USGS 7 1/2' quad maps. Each sub-basin represented an area of fairly uniform runoff characteristics to be modeled as

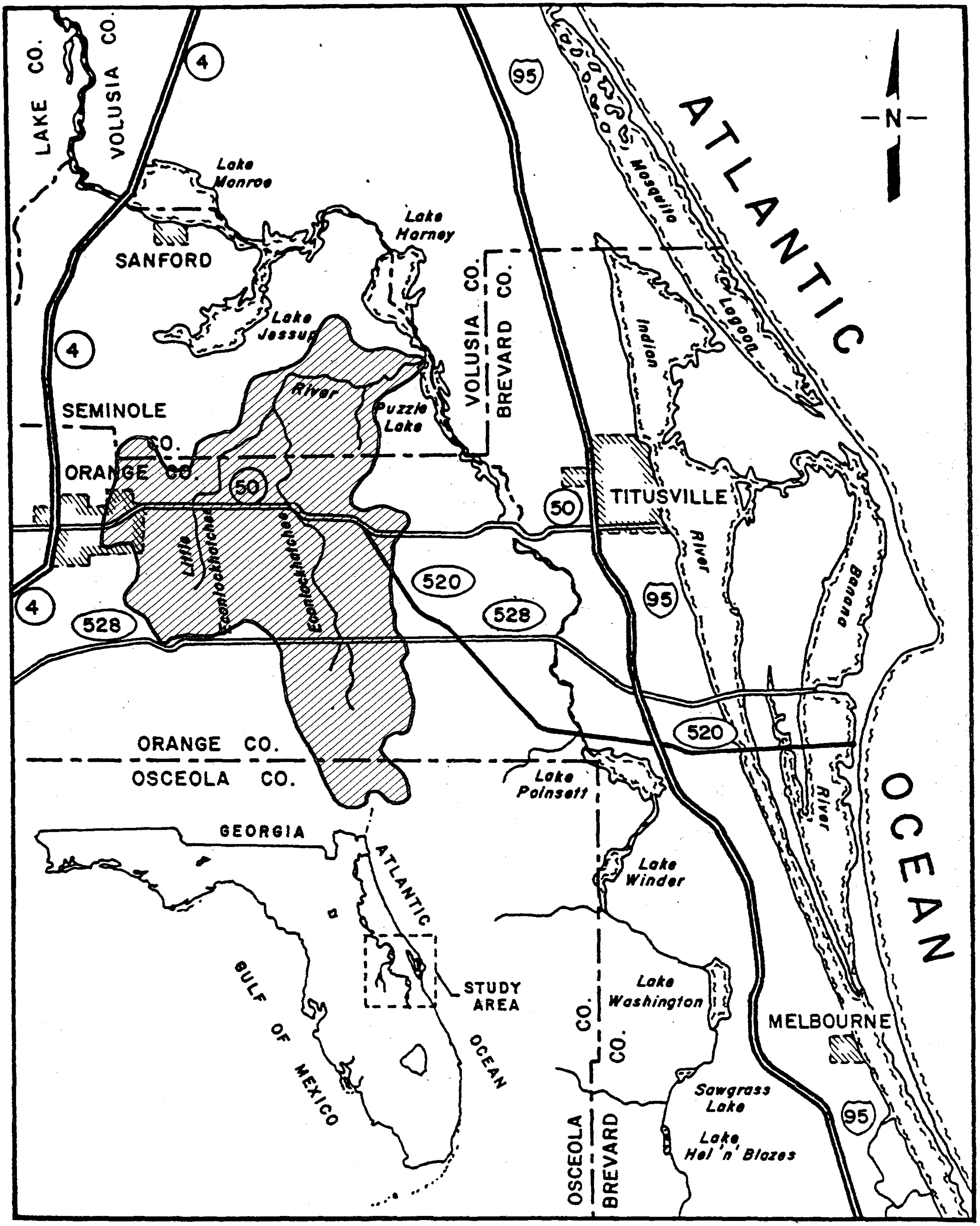


FIGURE 7.- Econlockhatchee River General Location Map.

one unit within HEC-1. Detailed sub-basin delineation was not made for the Little Econ drainage basin within Orange County which was studied in detail in a previous study (Orange County, 1984). Using the ESRI software, major roads and watercourses were digitized in line format and the 67 sub-basin boundaries were digitized in polygon format from the USGS quad maps. Once digitized, this data can be plotted at various map scales using the Calcomp plotter. Digitized sub-basin polygons are shown in Figure 8; all the digitized information is shown in Figure 9. The sub-basin boundary data was then converted from a polygon format to a grid cell (raster) format using the ESRI program. The grid cell size was selected as 60 meters square and the minimum and maximum UTM coordinates were calculated for use in overlaying this data with other data sets in later steps. The particular grid cell size was selected to adequately represent spatial variation for hydrologic modeling, coincide with Landsat pixel resolution, and facilitate the display of the entire Econ Basin data set effectively on the image display device. After the data was in raster format, ELAS was used to reformat the ESRI data file into an ELAS data file. The data could then be displayed on the monitor and manipulated in later steps using ELAS.

Hydrologic_Soils_Mapping. The four SCS hydrologic soil groupings were digitized based on detailed soil surveys in Seminole (SCS, 1966) and Orange (SCS, 1960) counties. It was determined that the generalized soil maps in these reports did not provide sufficient detail. Therefore, the detailed aerial photographs showing soil classifications were utilized by first

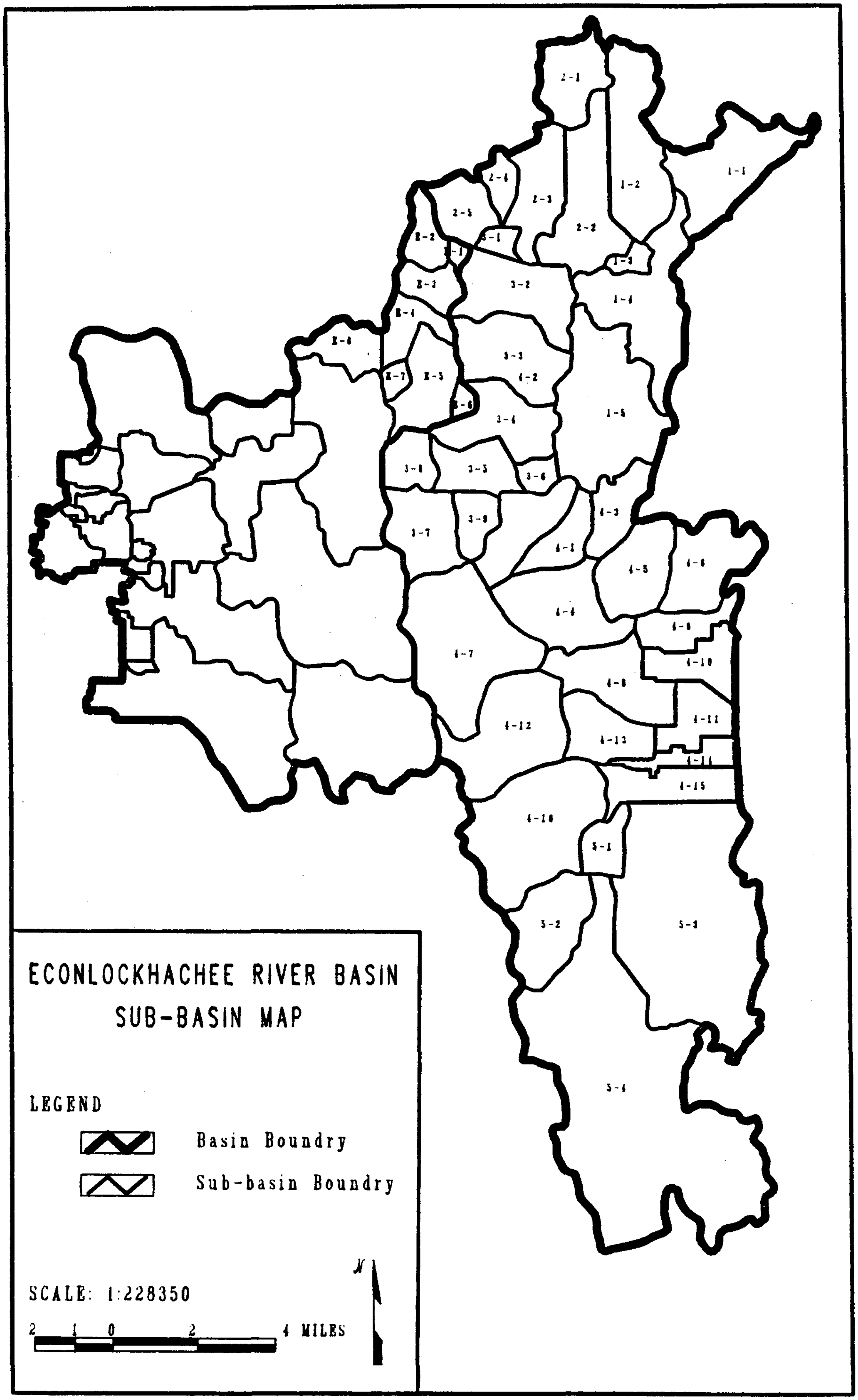


FIGURE 8. ECONLOCKHATCHEE RIVER HYDROLOGIC SUB-BASINS

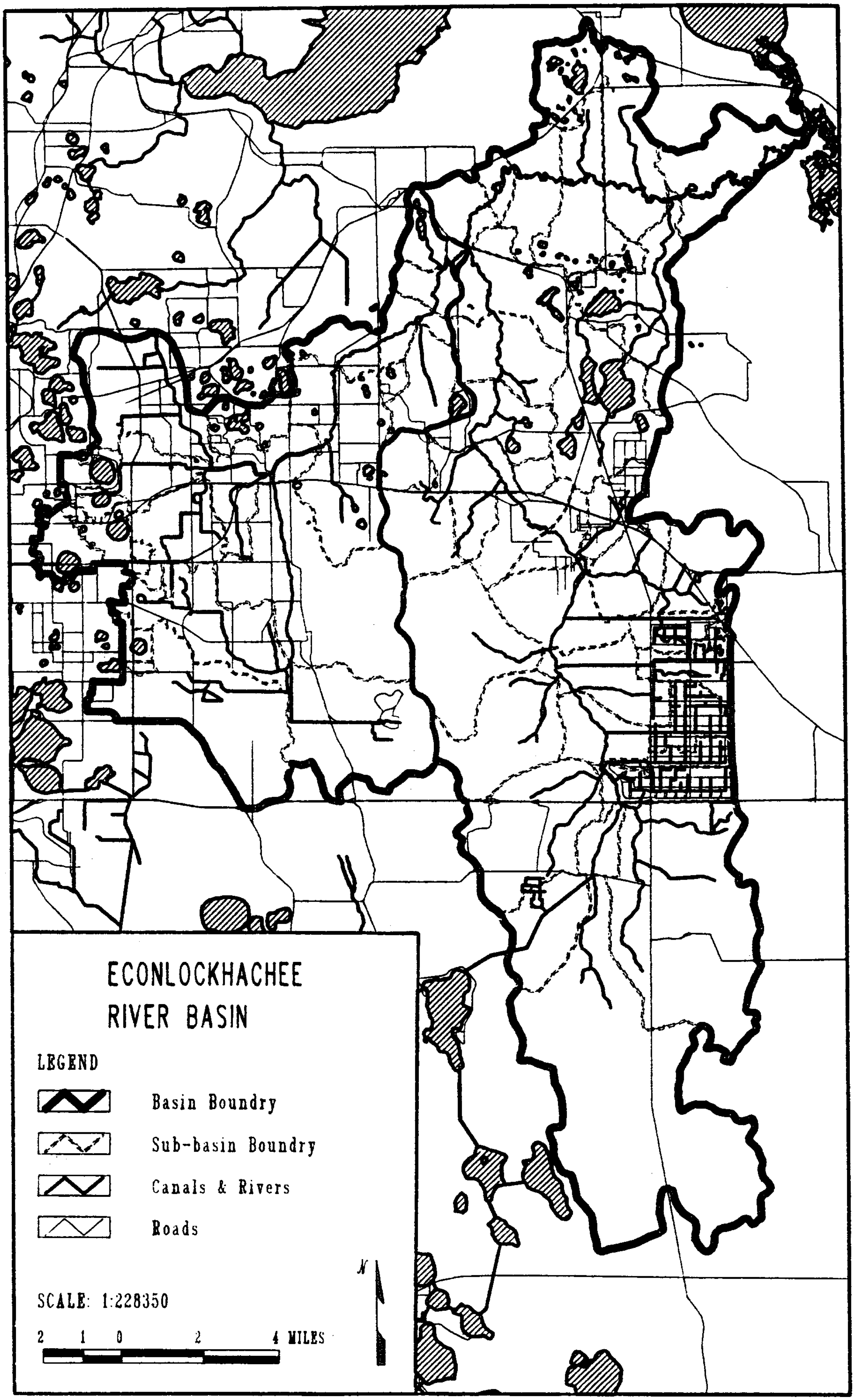


FIGURE 9. ECONLOCKHATCHEE RIVER BASIN DIGITIZED BASE MAP

color coding by hydrologic soil grouping and then digitizing using the ESRI software. A significant number of control points had to be established because of the distortion inherent in the aerial maps and the need to piece together many different photographs. After the data was digitized it could be plotted using the Calcomp drum plotter at any desired scale (Figure 10). The data was converted to grid cell format with 60 meter square cell size and reformatted to an ELAS data file using the same procedure as the sub-basin boundary data.

Landcover data. A Landsat MSS CCT collected on November 6, 1984 was computer processed to derive an up-to-date landcover map in digital format. The particular scene selected was the first cloud-free scene on Path 16/Row 40 collected by Landsat 5 since its launch in April 1984. The raw data was viewed on the image display device; a color composite resembling an infrared photograph was viewed using data Channel 1 (blue), Channel 2 (green), and Channel 4 (red) (Figure 11).

An unsupervised approach was used to classify the data. First, an ELAS routine was used to automatically search the data set and develop 26 distinct spectral signatures identified by statistical parameters of mean channel values and covariance matrices. In addition to these statistics, ELAS was used to generate a 2 channel plot of the mean values of each spectral class (Figure 12). The maximum likelihood classifier was used to classify the entire data set so that each pixel was assigned to 1 of the 26 classes. Each of the 26 classes was then assigned to one of the 10 thematic map categories shown in Figure 12. The

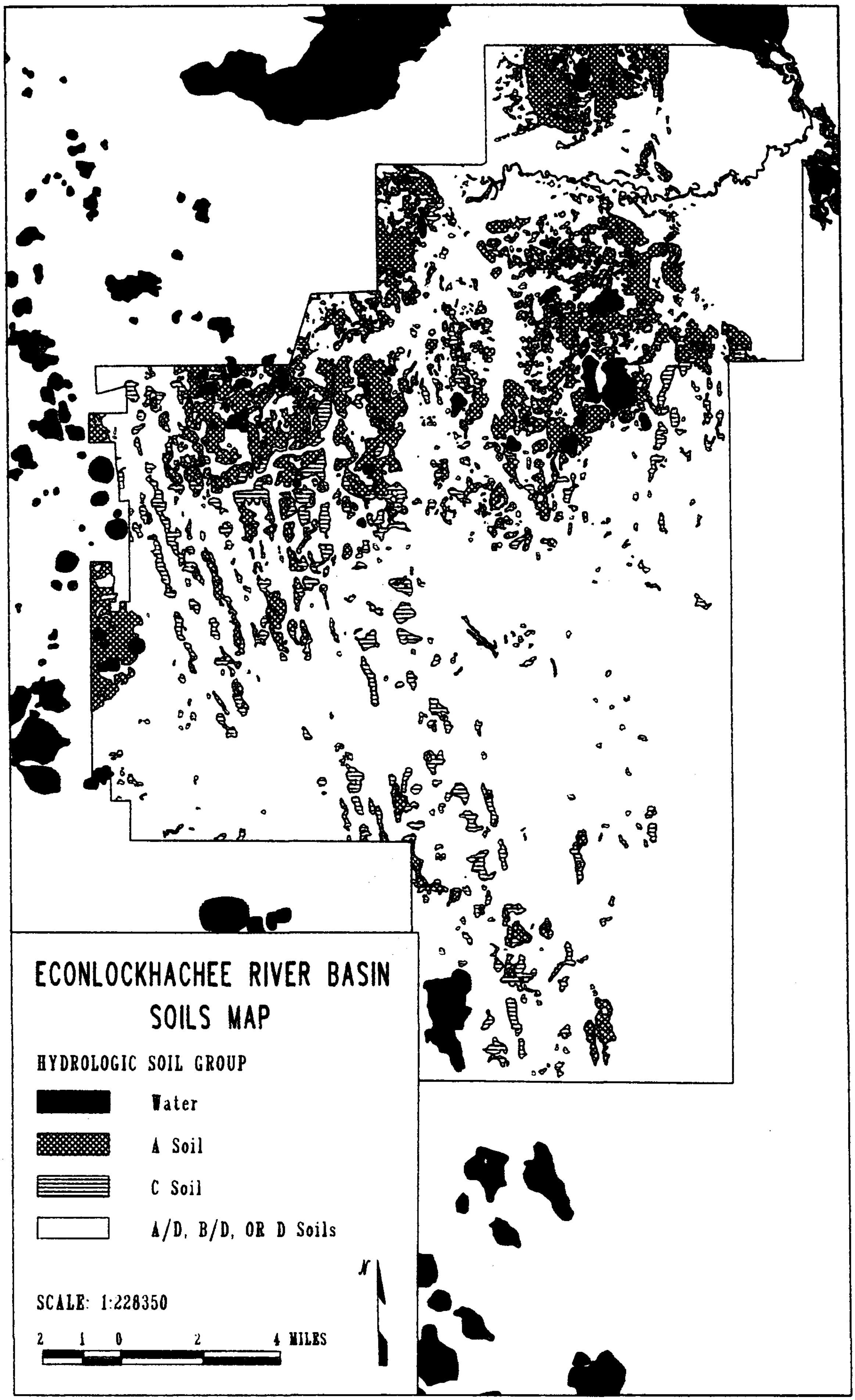


FIGURE 10. ECONLOCKHATCHEE RIVER BASIN SCS HYDROLOGIC SOILS

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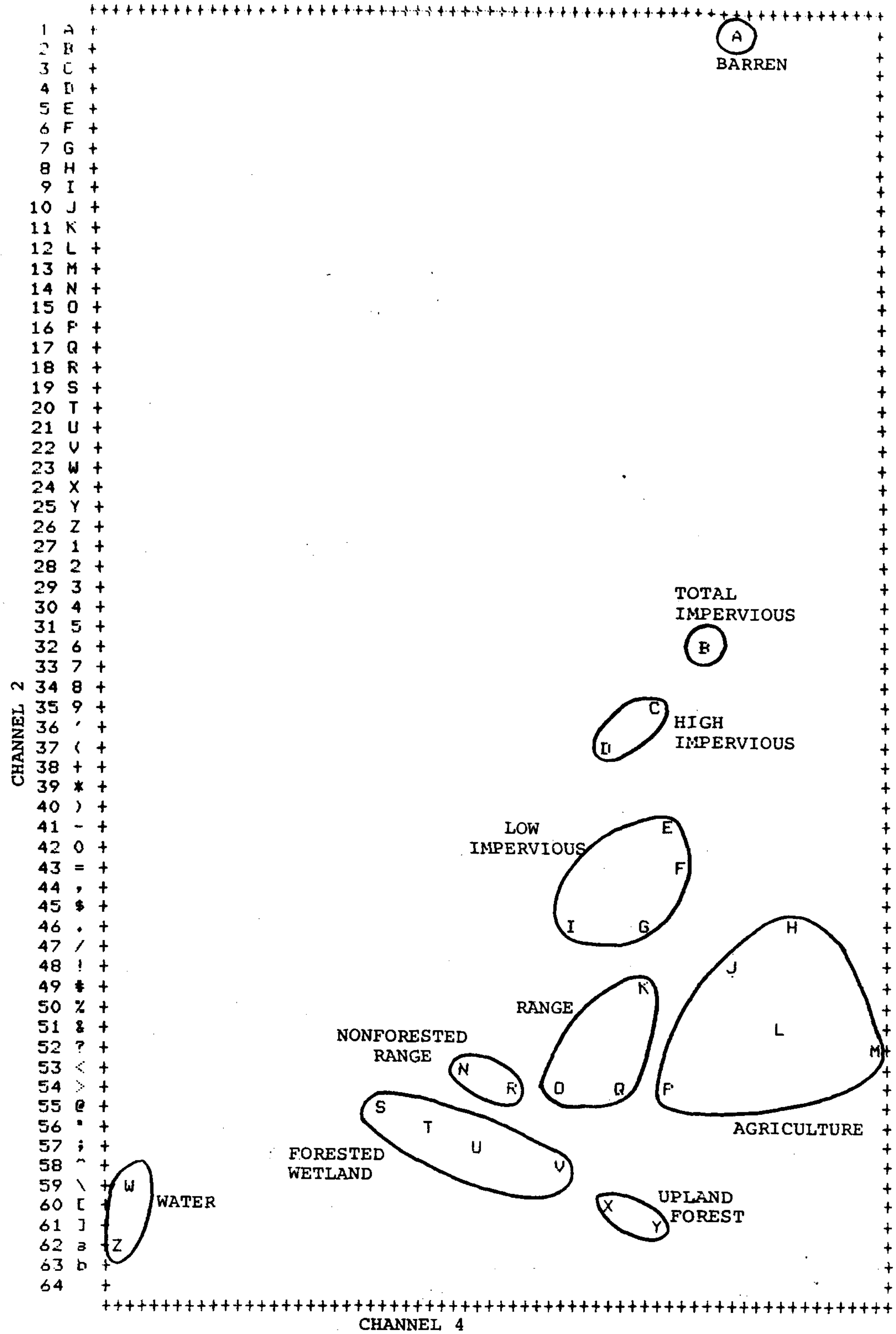

FIGURE 12. 2 CHANNEL PLOT OF CLASS MEANS FROM UNSUPERVISED CLASSIFICATION OF MSS DATA.

assignments were made based on a knowledge of the spectral characteristics of each class (summarized by Figure 12) and comparison of the classified image with several ground truth sources: 1973 and 1979 black and white aerial photographs (1:24,000); 1973 vegetation and landuse map (1:80,000). The process of assigning each class to a category was carried out by highlighting each individual spectral class on the image display device and the comparing it with ground truth.

The classified data set was then georeferenced into UTM format. UTM coordinates calculated from USGS 7 1/2' quad maps and the corresponding pixel line and element within the data file were read from the image display of the raw data. Mapping coefficients were developed using ELAS based on 30 control points. Control points were deleted one by one until a RMS error of 100 meters was achieved. The entire data set was then mapped using the mapping equations, a specified 60 meter square cell size and minimum and maximum UTM northing and easting coordinates to define the boundary. These coordinates were specified to set up a rectangular region that included the entire basin.

Merging Data into Data Base. After the classified Landsat data was georeferenced (resampled) into a new data file with minimum and maximum UTM coordinates, the sub-basin and soils data file were merged into the data base file as additional data layers. The data was offset, when necessary, such that the UTM coordinates for the corresponding cell in each data base layer were identical. With the landcover, soils and sub-basin data now in this data base format, several powerful data-base routines could be used to extract useful information. For instance, the Econ Econ basin boundary (in the sub-basin data layer) can be merged with the landcover data to yield the Econ Basin landcover map shown in Figure 13. This map display was supplemented using the graphics display capabilities of the image display device. The landcover data tabulated from this new data set is given in Table 4 along with estimates from a previous study (Still and Shih, 1984).

Comparison_of_Landcover_Data. Still and Shih (1984) developed landcover from 1976 Landsat data and compared it with USGS Landuse Data (LUDA) developed in 1973. The LUDA data, at a scale of 1:250,000, was developed from interpretation of aerial photography. The Landcover information from this study is similar to both the previous Landsat analysis and the LUDA data (Table 4). The similarity of the two Landsat estimates, peformed by different analysts, confirms the reliability of the method. The landcover derived from Landsat in this study compares well to the LUDA data developed using conventional techniques. The major difference was the increase in urban area which is to be expected. Because the Landsat data is in digital format, landcover could be tabulated for each sub-basin automatically. Estimates from both of the earlier data sets were only given for the entire basin and not for sub-basins.

Data_Base_Modeling. Data-base routines in ELAS can be utilized to generate new information layers based on existing database layers (Figure 14). This procedure was used to develop a CN value for each pixel. The CN values for each landcover/

TABLE 4. COMPARISON OF LANDSAT DERIVED LANDCOVER ESTIMATES FOR ECONLOCKHATCHEE RIVER BASIN WITH OTHER SOURCES.

LANDCOVER	USGS LUDA DATA (1973)	LANDSAT (1976)	LANDSAT (1984)
	LANDCOVER, PERCENT OF TOTAL ECON BASIN		
Urban		13.84	
Residential (Low Impervious)	7.30		10.57
Commercial (High Impervious)	1.54		4.87
Industrial	0.01		
Transportation	0.76		
Other	0.52		
Sub-total	10.10	13.84	15.44
Agricultural Lands		12.64	15.17
Crop and Pasture	12.90		
Orchards and Groves	4.08		
Sub-total	17.00	12.64	15.17
Rangeland		35.53	31.40
Herbaceous rangeland	32.40		
Sub-total	32.40	35.53	31.40
Forestland		14.74	13.69
Evergreen forest	14.20		
Sub-total	14.20	14.74	13.69
Water		2.06	1.53
Lakes	2.84		
Reservoirs	0.07		
Sub-total	2.91	2.06	1.53
Wetlands		18.63	
Forested wetlands	22.29		18.73
Non-forested wetlands	0.30		2.20
Sub-total	22.59	18.63	20.93
Barrenland (Barren, Total Impervious)		2.42	1.85
Strip mines; gravel pits	0.21		
Transitional areas	0.68		
Sub-total	0.90	2.42	1.85
Total	100.0	100.0	100.0

Note: Landcover categories in parentheses denote categories used in this study only.

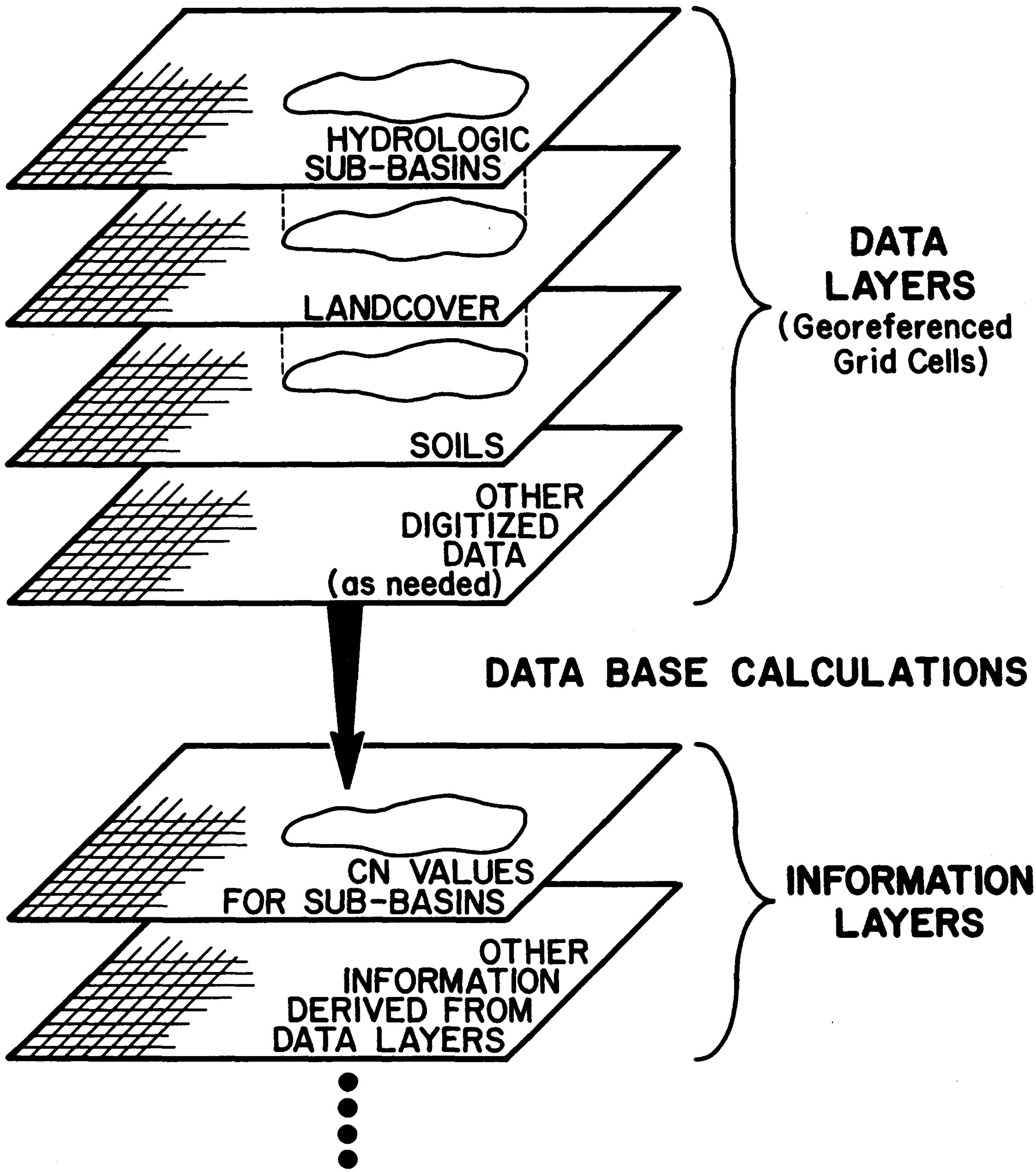

FIGURE 14. DATA BASE STRUCTURE AND MODELING.

hydrologic soil combination is given in Table 5. This information was stored within an indexed "look-up" table in ELAS which was used to automatically calculate a CN value for each pixel based on the landcover and soil type corresponding to that pixel. An average CN was calculated for each hydrologic sub-basin using data base calculations on the CN values and hydrologic sub-basin data layers. CN values calculated using this procedure are given in Table 6. CN values were not calculated for the Little Econ drainage basin within Orange County that has already been studied in detail (Orange County, 1984).

Utilization of Results

The sub-basin CN values calculated from Landsat are being used as input data in the HEC-1 model to estimate peak flows in the Econ Basin. The model results will be used to estimate floodway and floodplain boundaries on the Econ River (to be documented in a later study report). The automated procedures used in the Econ study can also be used in other river basin studies to determine CN values on an economical and efficient basis.

The landcover and soils data used to develop CN values can also be easily accessed for other resource management decisions in the Econ Basin. Maps and tabular data can be produced for any portion of the basin defined by digitizing the area of interest using ESRI and converting to an ELAS overlay in the data base.

The existing data base file can be easily updated with revisions or new data layers as the Econ Basin study progresses. For

TABLE 5. RUNOFF CURVE NUMBERS (CN) FOR LANDCOVER/HYDROLOGIC SOIL COMPLEX

LANDCOVER	USGS CATEGORY	SCS HYDROLOGIC SOILS A	B	C	D
Water	5	100	100	100	100
Forested Wetland[1]	61	94	94	94	94
Non-forested Wetland[1]	62	98	98	98	98
Upland Forest	4	32	58	72	79
Range	3	49	71	80	89
Agr/Cultivated	2	39	61	74	80
Residential/Low[2] Impervious	11	57	72	81	86
High Impervious[3] (Res./Urban)	11, 12, 13	82	88	92	93
Total Impervious		98	98	98	98
Barren/Extractive	7	74	82	87	89

Source of CN Values: SCS (1983) unless otherwise noted.

Notes:
1. Source: Suphunvorranop (1985)
2. Avg. CN for residential (lot size less than 1/8 ac.), commercial and industrial (avg. impervious area: 74%)
3. Avg. CN for residential with lots sizes 1/4, 1/3, and 1/2 acres. (avg. impervious area: 31%)

TABLE 6

ECON SUB-BASIN AREAS AND CN DETERMINED FROM DATA-BASE

Sub-basin No.	Polygon ID	Area sq.mi	CN	Sub-basin No.	Polygon ID	Area sq.mi	CN
1-1	5	5.86	86	4-6	46	4.28	88
1-2	3	6.10	78	4-7	50	9.01	88
1-3	13	0.64	74	4-8	57	4.23	87
1-4	10	6.67	77	4-9	53	2.14	88
1-5	17	8.62	84	4-10	56	2.55	88
2-1	2	3.17	74	4-11	61	2.42	90
2-2	4	5.36	77	4-12	60	6.64	88
2-3	6	3.47	81	4-13	62	2.96	85
2-4	7	1.11	84	4-14	63	1.44	89
2-5	8	2.24	84	4-15	65	3.12	88
3-1	11	0.66	75	4-16	64	8.87	86
3-2	14	4.61	80	5-1	67	1.58	82
3-3	18	4.61	78	5-2	68	4.26	84
3-4	25	3.84	75	5-3	66	18.58	88
3-5	30	2.47	81	5-4	69	28.52	89
3-6	33	0.79	78	E-1	12	0.31	85
3-7	40	3.59	84	E-2	9	1.59	80
3-8	28	1.82	84	E-3	15	1.57	82
3-9	42	1.52	83	E-4	16	1.86	82
4-1	39	1.98	83	E-5	20	3.21	83
4-2	35	3.24	78	E-6	24	0.45	87
4-3	34	2.37	85	E-7	23	0.55	83
4-4	49	5.03	86	E-9	19	2.16	80
4-5	47	3.78	84				

example, floodplain boundaries determined in the first phase of the study can be digitized as a new data layer and used to determine landuse in various portions of the existing floodplain. Topographic information which will become available from photogrammetric mapping could be digitized as a new data layer and used to automate the calculation of flood stage-flood damage estimates. Using procedures such as these, the data-base will continue to support the development of a surface water management plan for the Econ Basin.

PILOT STUDY: WETLANDS INVENTORY IN DUVAL COUNTY, FLORIDA

Introduction

Background. This study is the first phase of a study conducted by the District in cooperation with the City of Jacksonville, under the Regional Water Resources Assistance Program. The purpose of the overall study is to provide a detailed up-to-date mapping of wetlands throughout the county. The information is required for protection of existing wetlands. In addition, delineation of wetland areas providing stormwater drainage and beneficial water quality impacts is needed for implementation of surface water regulations at the City of Jacksonville and the District.

The first phase of the study is to derive an up-to-date inventory of wetland areas using computer processed Landsat MSS data. This information can be used for planning purposes in the interim period until a more detailed wetlands mapping can be developed in the second phase of the project. This detailed mapping is a more labor intensive process involving photo interpretation and digitization of 1:12,000 infrared photography flown in 1984. The detailed mapping is anticipated to be completed by 1986.

Study Area. Duval County is located in the northeastern portion of the District adjacent to the Atlantic Ocean. The county contains approximately 840 sq. mi. of which approximately 80 sq. mi. is covered by water.

The county contains three major drainage basins: St. Marys River, Nassau River and St. Johns River. In addition, the coastal areas are drained by numerous small streams that empty into the Intracoastal Waterway or the Atlantic Ocean. Drainage within the county is primarily controlled by ancient marine terraces that direct runoff so that streams flow parallel to ancient shorelines. In the flat marsh areas located in the northeast sections of the county, drainage is often sluggish and streams form a dendritic pattern. Because of the low relief over much of the county, drainage divides are often difficult to define.

Summary of Methodology

Digitized Sub-basin Boundaries. Major drainage basin boundaries described by Stone and Largen (1983) were digitized using ESRI software and converted to a raster format ELAS data file. The ELAS data file could then be displayed as shown in Figure 15.

Landsat-derived Landcover Data. Two landcover maps were developed from 1977 and 1984 data. Because the study area overlapped two Landsat scenes, a total of 4 CCTs were processed. The two CCTs used for the 1977 map were Scene ID 8288815003500 (Path 18/Row 39) collected on 28 June 1977 and Scene ID 8276115011500 (Path 17/Row 39) collected on 21 February 1977. The 1984 map was developed from Scene ID 85007415223X0 (Path 16/Row 39) collected on 14 May 1984 and Scene 85004915282X0 (Path 17/Row 39) collected on 19 April 1984. The study area was extracted from each CCT and processed using the same procedures as discussed on the previous pilot project. In the georeferencing procedure, the two respective classified data sets were merged into one file.

The spectral classes were assigned to 10 thematic classes based primarily on two sources of ground truth. A vegetation and landuse map (dated 1973) prepared for Duval County by the University of Florida Center for Wetlands Mapping contains some 48 categories and corresponds to a level 3 detail at scale 1:80,000. Although detailed, in many cases it is no longer up-to-date. Color infrared photographs (1:58,000) taken in 1983 as part of the USGS National High Altitude Program were also used. Primarily emphasis was on classification of forested and non-forested wetland categories.

The classified data sets were georeferenced using similar procedures as discussed for the Econ. In this case however, mapping coefficients had to be developed for each of the four sets of data. For both the 1977 and 1984 data, it was necessary to merge the two data sets together; this is accomplished by first georeferencing one data set in a new data file and then georeferencing the second data set into the same file. The data sets merged together very well for both of the maps.

Data Base Modeling. The data base structure included each of the classified maps and the major river basin boundaries. Data base modeling was utilized to extract total area and wetland area for each of the major river basins in Duval County (Table 7). Map displays were also generated for each landcover set; the 1984 landcover map is shown in Figure 16. The actual scale of this map on the display device is about 1:80,000.

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Utilization of Results

Tabulation of wetland acreages developed from 1984 Landsat data given in Table 7 represent an up-to-date inventory for Duval County. Overall, current wetland area (including open water) is estimated to be 30.2% of the area within the county. This information can be used to support city and District wetlands planning and permitting programs. Similar tabular data can be extracted from the data base for any geographic unit of interest digitized from a base map on the image display device. Map displays can be generated at scales of 1:80,000 and larger for planning purposes.

The estimate from the earlier 1977 data was 31.5%; the similarity of the two estimates confirms the reliability of Landsat estimates. The small difference in estimates indicate that the area of wetlands had decreased by 4% between 1977 and 1984. Due to the impact of continued development, wetland areas would be expected to be decreasing. Within each basin estimated wetland area decreased in eight basins, but increased in three. There are two explanations for an increase in total estimated wetland areas in several basins. First, is an increase in open water areas which may occur as a result of land development. Second, is the classification errors which occur as a result of limitations in spectral and spatial resolution of the MSS data. These errors tend to impact estimates more as the area of interest decreases in size. Some of these errors may be systematic and can be reduced through extensive field surveys. Such field surveys were not within the scope of this initial phase of study. Detailed mapping from photo interpretation of IR photography will

TABLE 7. **ESTIMATED WETLAND AREAS IN DUVAL COUNTY**
IN SQUARE MILES (PERCENT OF BASIN AREA)

		1977 DATA				1984 DATA				
BASIN (Portion in Duval Co.)	Area Sq.Mi.	Water	Non-Forested	Forested	Total	Water	Non-Forested	Forested	Total	Difference Total Wetland Area
Nassau	115.9	8.5	27.8	21.9	58.2(50)	14.7	19.1	20.1	53.9(46)	- 4.3(7)
St. Mary's	57.3	0.0	1.1	11.9	13.0(23)	0.1	0.7	8.9	9.7(17)	- 3.3(25)
St. Johns River										
- Dunn's Creek	22.2	0.4	1.0	4.8	6.2(28)	0.5	0.7	3.7	4.9(22)	- 1.3(21)
- Broward River	26.0	0.4	0.8	5.1	6.3(24)	0.8	0.5	4.6	6.0(23)	- 0.3(5)
- Trout River	94.8	1.7	2.0	15.9	19.6(21)	2.3	1.8	17.3	21.5(23)	+ 1.9(10)
- Arlington River	31.4	0.1	0.7	2.9	3.7(12)	0.4	0.5	4.8	5.8(18)	+ 2.1(57)
- Ortega River	95.5	0.9	1.0	13.5	15.4(16)	1.3	0.8	15.0	17.1(17)	+ 1.7(11)
- Black Creek	70.1	0.0	1.2	7.7	8.9(13)	0.0	2.9	6.0	8.9(13)	0 (0)
- Julington	68.0	0.4	0.8	22.4	23.6(34)	0.6	0.4	19.7	20.7(30)	- 2.9(12)
- Intercoastal (SJR)	92.0	1.6	8.2	19.7	29.5(32)	1.8	7.9	17.7	27.4(30)	- 2.1(7)
- St. Johns River	175.4	49.6	22.4	10.7	82.7(47)	53.9	16.6	11.1	81.6(46)	- 1.0(1)
Coastal & Intercoastal	2.5	0.3	0.0	0.3	0.6(24)	0	0	0.1	0.1(4)	- .5(83)
TOTAL	851.1	63.9	67.0	136.5	267.7 (31.5)	76.4	51.9	129.0	257.3 (30.2)	-10.4(4)

be conducted in the next phase of the study and can be used to verify and further refine, if necessary, the classification of the MSS data. After the MSS data set has been correlated with the detailed mapping, the potential exists for further updates in wetland areas (general categories) on an economical basis using Landsat.

SUMMARY AND CONCLUSIONS

1. District now has capability of computer processing Landsat MSS data for landcover and surface water area mapping of large areas on an economical basis. An archieve of historical data is available with new data continually being collected. Primary applications at present are: general landcover mapping for river basin studies, and District-wide surface water inventory during drought and flood conditions.
2. Maximum benefit of Landsat MSS data is achieved when the classified data set is merged into a data base structure with other digitized data for data base analysis. This approach is efficient and should be used whenever possible. It encourages the continued use of data developed initially for basin management studies.
3. Landsat TM data will provide significant improvements in both spectral and spatial resolution that will increase applications to include more detailed vegetative mapping and urban landuse analysis. TM data will be processed using the techniques presented in this report for MSS except data reduction techniques such as principal components analysis, or subsetting data channels may be necessary due to limited data storage.
4. The capabilities of the Landsat data processing system can be utilized to display and analyze other types of digital data in raster format such as other land remote sensing satellite

data (such as the French SPOT satellite) or data digitized manually using the ESRI software package.

5. Geographic data base was established for the Econ Basin using ELAS and ESRI software. The data base currently contains Landsat derived landcover, hydrologic soil groups, sub-basin boundaries, major roads and watercourses. Average SCS runoff curve number values were calculated automatically for each sub-basin for use in the HEC-1 model. This technique should be used in other studies in large river basins to reduce man-power requirements. The data base will be accessed and updated to support regulatory permitting and continued basin management planning.
6. An inventory of current wetland areas in Duval County was developed from 1984 Landsat data and compared with 1977 Landsat data. The classified data is in a data base format that can be accessed to develop tabulations for any specific geographic area; an example is tabulations of wetland areas given for each major river basin within Duval County. This information will be used to support Duval County and District wetlands planning and permitting programs until a more detailed mapping is completed using infrared aerial photography.
7. Continued use of the Landsat data processing system on an extensive basis will require consideration of the following maintenance and/or upgrades:
   a. Additional disk storage capacity
   b. Hard copy image display output device.

c. Software routines to reformat TM and other satellite data to ELAS format.

d. Software routine for improved interface between ELAS and ESRI software routines.

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APPENDICES

LANDSAT 4 & 5 STANDARD MSS PRODUCTS ORDER FORM

RETURN COMPLETED FORM TO: NOAA/NESDIS Landsat Customer Services • EROS Data Center Sioux Falls, SD 57198 • Comm: 605/594-6151 FTS: 784-7151 • TWX: 910-668-0310

SEE REVERSE SIDE FOR INSTRUCTIONS

DATE ____________

NAME ____________ COMPANY ____________

ADDRESS ____________ CITY/STATE ____________ ZIP ____________

PHONE(HOME) ____________ (BUSINESS) ____________ EROS ACCT. NO. ____________ REF. NO. ____________

SHIP TO: ____________

SCENE IDENTIFICATION	PRODUCT CODE	PHOTOGRAPHS ONLY: MSS BANDS 1	2	3	4	NO. OF EACH	CCT	QTY.	UNIT PRICE	TOTAL PRICE

PRICES SUBJECT TO CHANGE

TOTAL ABOVE A ____
TOTAL FROM PEVIOUS SHEET B ____
TOTAL COST C ____

STANDARD PRODUCTS TABLE

BLACK AND WHITE PRODUCTS

NOMINAL IMAGE SIZE	PRODUCT MATERIAL	CODE	PRICE
18.5cm (7.3 in.)	Paper	23	$ 35.00
18.5cm (7.3 in.)	Film Positive	13	35.00
18.5cm (7.3 in.)	Film Negative	03	40.00
37.1cm (14.6 in.)	Paper	24	85.00
74.2cm (29.2 in.)	Paper	26	105.00

FALSE COLOR COMPOSITE PRODUCTS

NOMINAL IMAGE SIZE	PRODUCT MATERIAL	CODE	PRICE
18.5cm (7.3 in.)	Paper	63	$ 50.00
18.5cm (7.3 in.)	Film Postive	53	80.00
37.1cm (14.6 in.)	Paper	64	110.00
74.2cm (29.2 in.)	Paper	66	195.00

COLOR COMPOSITE GENERATION*

NOMINAL IMAGE SIZE	PRODUCT MATERIAL	CODE	PRICE
18.5cm (7.3 in.)	Printing Master	59	$220.00

*Each MSS Color Composite Printing Master (generated from bands 1, 2, and 4) is retained by NOAA. Color Composite product costs must be added to the generation fee.

COMPUTER COMPATIBLE TAPES (CCT)

These tapes may be ordered either corrected or uncorrected (geometrically).

TRACKS	BPI	FORMAT	MSS All Bands (Band Sequential) PRODUCT CODE	PRICE	MSS All Bands (Band Interleaved) PRODUCT CODE	PRICE
9	1600	TAPE SET	184-A	$730.00	184-B	$730.00
9	6250	TAPE SET	185-A	$730.00	185-B	$730.00

PAYMENT MUST ACCOMPANY ORDER

CHECK, MONEY ORDER ☐

PURCHASE ORDER ☐

GOV'T ACCOUNT ☐

Comments: ____________

NOAA FORM 34-1200
February 1985

HOW TO ORDER LANDSAT STANDARD MSS PRODUCTS

This order form is used to order all standard Landsat 4 MSS data. Necessary order information can normally be extracted from a computer listing of available data or from other Landsat references.

Please provide the following information in the indicated areas of the order form:

A. List your complete NAME, ADDRESS, ZIP CODE, and name of your COMPANY if applicable.

B. If you desire to have the products mailed to an address or individual other than yourself, please complete the "SHIP TO" address.

C. List a PHONE NUMBER where you can be contacted during business hours.

D. If you have had previous business with the EROS DATA CENTER, please list your EROS ACCOUNT NUMBER if known.

E. Enter the complete SCENE IDENTIFICATION NUMBER. This number can be transcribed directly from the COMPUTER LISTING or from a Landsat catalog.

F. Review the STANDARD PRODUCTS table on the front of the ORDER FORM and determine the type of product desired.

G. Enter the PRODUCT CODE of the type product being ordered from the STANDARD PRODUCTS table.

H. Check columns for bands you desire and also indicate the number of copies you desire of each band in the NUMBER OF EACH column. Check the CCT box only if a digital tape is being ordered. In selecting the tape format, make sure that you consider your equipment and usage. Please complete the QUANTITY column. Count the number of MSS bands checked, multiply by the figure in the NUMBER OF EACH column and enter the RESULT in the QUANTITY column.

I. Enter the UNIT PRICE of the type product as reflected in the STANDARD PRODUCTS table.

J. Multiply the figure in the QUANTITY column by the UNIT PRICE, and enter the result in the TOTAL PRICE column.

K. Repeat steps E through J for each product ordered.

L. TOTAL the costs of all products ordered on this order form and enter the net result in BLOCK A (TOTAL ABOVE).

M. For a single order form, enter the Figure from BLOCK A in BLOCK C (TOTAL COST). If more than one order form is required, on the last order form enter the sum of the figures in all BLOCK A's in BLOCK B and then total BLOCK A and BLOCK B in BLOCK C (TOTAL COST).

N. The COMMENTS portion is completed only when special consideration is desired in printing, as in print for water detail, desert detail, etc. which does not necessarily fall in the CUSTOM PRODUCT category. If a CUSTOM PRODUCT is desired, the COMMENTS portion will also be used, and the cost determination will be normally based on three times the standard cost. If an uncorrected tape is desired, it should be noted in the comments portion.

O. PHOTOGRAPHIC and DIGITAL TAPE products are available in other formats but require special ordering procedures. If interested, please call the EROS Data Center for further instructions.

P. Include type of payment (purchase order, check or money order). Make all drafts payable to EROS Data Center. DO NOT SEND CASH.

Q. Mail ORDER FORM(S) and PRE-PAYMENT to the EROS DATA CENTER. IF PAYMENT HAS BEEN PREVIOUSLY FORWARDED TO ANOTHER FACILITY, PLEASE FORWARD THIS ORDER TO THAT FACILITY FOR PROCESSING.

FOR INFORMATION OR ASSISTANCE PLEASE CONTACT
NOAA/NESDIS
LANDSAT CUSTOMER SERVICES
EROS DATA CENTER
SIOUX FALLS, SD 57198
COMM: 605/594-6151 • FTS: 784-7151

INFORMATION OR ASSISTANCE MAY ALSO BE OBTAINED FROM THE FOLLOWING U.S. GEOLOGICAL SURVEY, NATIONAL CARTOGRAPHIC INFORMATION CENTER, OFFICES

Eastern Mapping Center
536 National Center
Reston, VA 22092
FTS: 928-6336
Comm: 703/860-6336

Mid-Continent Mapping Center
1400 Independence Road
Rolla, MO 65401
FTS: 277-0851
Comm: 314/341-0851

Rocky Mountain Mapping Center
Stop 504, Denver Federal Center
Denver, CO 80225
FTS: 234-2326
Comm: 303/234-2326

Western Mapping Center
345 Middlefield Road
Menlo Park, CA 94025
FTS: 467-2426
Comm: 415/323-8111

National Space Technology Laboratories
NSTL Station, MS 39529
FTS: 494-3541
Comm: 601/688-3544

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MSS/RBV PRICE LIST
Standard Landsat Data Products

Department of Commerce
NOAA/NESDIS
EROS Data Center
Sioux Falls, SD 57198
February 1, 1985

Landsat Multispectral Scanner and Return Beam Vidicon

STANDARD MSS/RBV

NOMINAL IMAGE SIZE	PRODUCT MATERIAL	BLACK & WHITE UNIT PRICE	BLACK & WHITE PRODUCT CODE	COLOR UNIT PRICE	COLOR PRODUCT CODE
18.5cm (7.3 in.)	Paper	$35.00	23	$50.00	63
18.5cm (7.3 in.)	Film Positive	35.00	13	80.00	53
18.5cm (7.3 in.)	Film Negative	40.00	03	N/A	N/A
37.1cm (14.6 in.)	Paper	65.00	24	110.00	64
74.2cm (29.2 in.)	Paper	105.00	26	195.00	66

COLOR COMPOSITE GENERATION $220.00 59

NOTES FOR COLOR COMPOSITE GENERATION:

(1) Portrayed in false (infrared) color and not natural color; bands used are 1, 2 and 4; colors are blue, green and red.
(2) Cost of product from this composite must be added to total costs.
(3) Not applicable for MSS band 8 or RBV subscenes.
(4) Master composite retained at EDC.
(5) For non-standard color products contact Customer Services.

CCT MSS AND RBV

TRACKS	BPI	FORMAT	MSS All Bands (Band Sequential)		MSS All Bands (Band Interleaved)		RBV Single Subscene		Set of Four RBV Subscenes	
			PRODUCT CODE	PRICE	PRODUCT CODE	PRICE	PRODUCT CODE	PRICE	PRODUCT CODE	PRICE
9	1600	TAPE SET	184A	$730.00	184B	$730.00	184C	$730.00	184D	$1460.00
9	6250	TAPE SET	185A	$730.00	185B	$730.00	185C	$730.00	185D	$1460.00

SPECIAL MSS ACQUISITION PLUS PRODUCT COSTS

Delivery of MSS HDT via communications satellite - per scene	$ 885.00
Delivery of standard MSS imagery (4 bands; product code 13 or 23) - per scene	985.00
Delivery of MSS CCT or HDT - per scene	1120.00
Surcharge for color composite generation with acquisition - per scene	170.00
Surcharge for specified maximum cloud cover - per scene	275.00

	UNIT PRICE	PRODUCT CODE
Browse 16mm (30.5m/100 ft.) microfilm (black & white only, to be discontinued in 1985)	$60.00	72
Browse microfiche (approximately 1200 scenes per set; band 2; available after Jan. 1, 1985)	20.00	74
35mm color mounted slides - preselected Landsat coverage of the conterminous United States	4.00	50
35mm color mounted slides from existing color composite	64.00	50

NOTE:

35mm mounted slides are intended for projection purposes only.

Custom processing for non-standard products is available at three times the standard product price. If a non-standard size is desired, the cost is three times the next larger standard product price.

Extra care should be taken to insure that monies and related order forms are forwarded to the same facility.

Landsat microfiche catalog subscriptions are available.

For further information and assistance please contact Landsat Customer Services at the EROS Data Center.
Comm: (605) 594-6151
FTS: 784-7151

PRICES SUBJECT TO CHANGE

TM PRICE LIST
Standard Landsat Data Products

Department of Commerce
NOAA/NESDIS
EROS Data Center
Sioux Falls, SD 57198
February 1, 1985

LANDSAT THEMATIC MAPPER
STANDARD TM

NOMINAL IMAGE SIZE	PRODUCT MATERIAL	BLACK & WHITE UNIT PRICE	BLACK & WHITE PRODUCT CODE	COLOR UNIT PRICE	COLOR PRODUCT CODE
18.5cm (7.3 in.)	Paper	$75.00	23	$170.00	63
18.5cm (7.3 in.)	Film Positive	75.00	13	190.00	53
18.5cm (7.3 in.)	Film Negative	80.00	03	N/A	N/A
37.1cm (14.6 in.)	Paper	140.00	24	235.00	64
74.2cm (29.2 in.)	Paper	200.00	26	290.00	66
COLOR COMPOSITE GENERATION				$325.00	59

NOTES FOR COLOR COMPOSITE GENERATION:
(1) Bands must be in ascending order. Color sequence must be blue, green, red.
(2) Cost of product from this composite must be added to total costs.
(3) Not applicable for night time data.
(4) Master composite retained at EDC.
(5) For non-standard color products contact Landsat Customer Services.

CCT THEMATIC MAPPER

TRACKS	BPI	FORMAT	TM Full Scene PRODUCT CODE	TM Full Scene PRICE	TM Quadrant Scene PRODUCT CODE	TM Quadrant Scene PRICE
9	1600	TAPE SET	80	$4400.00	82	$1350.00
9	6250	TAPE SET	81	$4400.00	83	$1350.00

TM CCT QUADRANT NUMBERING EXAMPLE

1	2
3	4

NOTE: SOM Projection; Cubic Convolution Resampling; Band Sequential Data

SPECIAL TM ACQUISITION PLUS PRODUCT COSTS

Delivery of TM HDT via communication satellite - per scene	$1600.00
Delivery of standard TM imagery (7 bands, product code 13 or 23) - per scene	1995.00
Delivery of TM CCT or HDT - per scene	5200.00
Surcharge for color composite generation with acquisition - per scene	275.00
Surcharge for specified maximum cloud cover - per scene	275.00

	UNIT PRICE	PRODUCT CODE
Browse Microfiche (approximately 1200 scenes per set, band 3)	$20.00	74
35mm color mounted slides from existing color composite	64.00	50

NOTE:
35mm mounted slides are intended for projection purposes only.

Custom processing is available at three times the standard product price. If a non-standard size is desired, the cost is three times the next larger standard product price.

Extra care should be taken to insure that monies and related order forms are forwarded to the same facility.

Landsat microfiche catalog subscriptions are available.

For further information and assistance please contact Landsat Customer Services at the EROS Data Center.
Comm: (605) 594-6151
FTS: 784-7151

PRICES SUBJECT TO CHANGE

LANDSAT 4 & 5 THEMATIC MAPPER DATA
ORDER FORM

RETURN COMPLETED FORM TO: NOAA/NESDIS Landsat Customer Services • EROS Data Center Sioux Falls, SD 57198 • Comm: 605/594-6151 FTS: 784-7151 • TWX: 910-668-0310

SEE REVERSE SIDE FOR INSTRUCTIONS

DATE ____________

NAME ____________ COMPANY ____________

ADDRESS ____________ CITY/STATE ____________ ZIP ____________

PHONE(HOME) ____________ (BUSINESS) ____________ EROS ACCT. NO. ____________ REF. NO. ____________

SHIP TO: ____________

____

____

SCENE IDENTIFICATION	PRODUCT CODE	TM BANDS 1	2	3	4	5	6	7	COLOR COMBIN.	CCT.	QTY.	PRICE	TOTAL PRICE

PRICES SUBJECT TO CHANGE

TOTAL ABOVE	A
TOTAL FROM PEVIOUS SHEET	B
TOTAL COST	C

PAYMENT MUST ACCOMPANY ORDER CHECK, MONEY ORDER ☐ PURCHASE ORDER ☐ GOV'T ACCOUNT ☐

STANDARD PRODUCTS TABLES

BLACK AND WHITE PRODUCTS

NOMINAL IMAGE SIZE	PRODUCT MATERIAL	PRODUCT CODE	PRICE
18.5cm (7.3 in.)	Film Negative	23	$ 80.00
18.5cm (7.3 in.)	Film Positive	13	75.00
18.5cm (7.3 in.)	Paper	03	75.00
37.1cm (14.6 in.)	Paper	24	140.00
74.2cm (29.2 in.)	Paper	26	200.00

DIGITAL PRODUCTS

FORMAT	PRODUCT CODE	PRICE
Full Scene 6250 BPI	80	$4400.00
1600 BPI	81	4400.00
Quarter Scene 6250 BPI	82	~~[illegible]~~ 4400.00
1600 BPI	83	~~[illegible]~~

*CUSTOMER MUST DESIGNATE WHICH CCT IS DESIRED IN CCT COLUMN USING (1,2,3,4).

*DIGITAL DATA STANDARD IS BSQ/SOM WITH CUBIC CONVOLUTION CORRECTIONS. OTHER FORMATS MAY BE ORDERED RETROSPECTIVELY.

TM CCT QUADRANT NUMBERING EXAMPLE

1	2
3	4

COLOR COMPOSITE PRODUCTS

NOMINAL IMAGE SIZE	PRODUCT MATERIAL	PRODUCT CODE	PRICE
*35mm Slide	Film Positive	50	$ 64.00
18.5cm (7.3 in.)	Film Positive	53	190.00
18.5cm (7.3 in.)	Paper	63	170.00
37.1cm (14.6 in.)	Paper	64	235.00
74.2cm (29.2 in.)	Paper	66	290.00

*FALSE COLOR SLIDE OF EXISTING MASTER INTENDED FOR PROJECTION PURPOSES ONLY.

COLOR COMPOSITE GENERATION (unique band combination)

PRODUCT CODE	PRICE
59	$325.00

*CUSTOMER MUST DESIGNATE WHICH BAND COMBINATION IS DESIRED. ENTER IN COLOR COMBINATION AREA. PRINTING MASTER IS RETAINED BY NOAA. PRODUCT COSTS MUST BE ADDED TO THE GENERATION FEE.

Comments: ____________

____

NOAA FORM 34-1207
February 1985

HOW TO ORDER THEMATIC MAPPER DATA

This order form is used to order all Thematic Mapper data. Necessary order information can normally be extracted from a listing of available data or from other Landsat references.

Please provide the following information in the indicated areas of the order form:

A. List your complete NAME, ADDRESS, ZIP CODE, and name of your company if applicable.

B. List a PHONE NUMBER where you can be contacted during business hours.

C. If you have had previous business with NOAA/NESDIS and EROS DATA CENTER, please list your ACCOUNT NUMBER if known.

D. If you desire to have the products mailed to an address or individual other than yourself, please complete the "SHIP TO" address.

E. Enter the SCENE IDENTIFICATION NUMBER from the list of available data.

F. Review the STANDARD PRODUCTS tables on the front of the ORDER FORM and determine the type of product desired.

G. Enter the PRODUCT CODE of the type of product being ordered from the STANDARD PRODUCTS tables.

H. If you desire that a unique color composite be generated please identify the band combination in the COLOR COMBINATION area, and ENTER PRODUCT CODES 59. Use the COMMENTS section for any detailed instructions. Unique color composites that are not in ascending band order and exposed through blue, green, and red filters in turn are deemed to be custom products and a 3 time processing charge will be incurred.

I. Enter the Spectral BANDS desired when ordering black and white imagery.

J. Complete the QUANTITY column. Count the number of TM bands checked, enter in the QUANTITY column.

K. Enter the quadrant desired in the CCT column using (1,2,3,4) when ordering a quarter TM scene. See TM Quadrant numbering example on front.

L. Enter the UNIT PRICE of the type product as reflected in the STANDARD PRODUCTS tables.

M. Multiply the figure in the QUANTITY column by the UNIT PRICE, and enter the result in the TOTAL PRICE column.

N. Repeat steps E through M for each product ordered.

O. TOTAL the costs of all products ordered on this order form and enter the net result in BLOCK A (TOTAL ABOVE).

P. For single order form, enter the figure from BLOCK A in BLOCK C (TOTAL COST). If more than one order form is required, on the last order form enter the sum of the figures in all BLOCK A's in BLOCK B and then total BLOCK A and BLOCK B in BLOCK C (TOTAL COST).

Q. Include type of payment (purchase order, check or money order). Make all drafts payable to NOAA Landsat. PLEASE DO NOT SEND CASH.

R. If a CUSTOM PRODUCT is desired, the COMMENTS portion should be used, and the cost determination will be based on three times the standard cost.

S. Mail ORDER FORM(S) and PRE-PAYMENT to NOAA/NESDIS, Landsat Customer Service, address on the reverse side.

FOR FURTHER INFORMATION OR ASSISTANCE PLEASE CONTACT
U.S. GEOLOGICAL SURVEY
NATIONAL CARTOGRAPHIC INFORMATION CENTER
507 NATIONAL CENTER•RESTON, VA 22092
FTS: 928-6045 COMM: 703/860-6045

INFORMATION OR ASSISTANCE MAY ALSO BE OBTAINED FROM THE FOLLOWING U.S. GEOLOGICAL SURVEY, NATIONAL CARTOGRAPHIC INFORMATION CENTER, OFFICES

Eastern Mapping Center
536 National Center
Reston, VA 22092
FTS: 928-6336
Comm: 703/860-6336

Mid-Continent Mapping Center
1400 Independence Road
Rolla, MO 65401
FTS: 277-0851
Comm: 314/341-0851

Rocky Mountain Mapping Center
Stop 504, Denver Federal Center
Denver, CO 80225
FTS: 234-2326
Comm: 303/234-2326

Western Mapping Center
345 Middlefield Road
Menlo Park, CA 94025
FTS: 467-2426
Comm: 415/323-8111

National Space Technology Laboratories
NSTL Station, MS 39529
FTS: 494-3541
Comm: 601/688-3544

APPENDIX B.

SUMMARY OF ELAS ROUTINES

Section

REFORMATTING (5.3) - Included here are algorithms to convert data of one format into a format that ELAS can accept.

DATA FILE UTILITY (5.4) - These are the modules that allow the user to operate on a data file, ignorant or independent of the digital values in that file.

SUBFILE AND EXTERNAL FILE UTILITY (5.5) - Modules designed to build or manipulate subfiles or external files, independent of their application to data files, are in this group. Four subgroups are recognized, general purpose software, operations on polygon (PGF, APF) subfiles and operations on georeference control points, operations on other specific subfiles.

INTERACTIVE DATA DISPLAY (5.6) - Models useful for interactive work employing a color display device, such as a COMTAL, Grinell, or DeAnza, are listed here.

DATA ANALYSIS - NON-STATISTICAL (5.7) - This functional group and the following group, DATA ANALYSIS - STATISTICAL, are closely related; the division into two groups is at least partially artificial. Conceptually it is also closely related to group 5.9, GENERATION OF TRAINING STATISTICS. DATA ANALYSIS - NON-STATISTICAL is intended to include those routines which permit the user to examine specific, non-visual, characteristics or properties of a data set without use of statistical techniques. For this document, non-statistical techniques include construction of histograms, frequency of occurrence tables and scattergrams. Statistical techniques are those requiring standard deviations, variance, covariance or more sophisticated measures of characteristics defining a population.

DATA ANALYSIS-STATISTICAL (5.8) - These algorithms characterize a file, or some aspect of a file, by some relatively sophisiticated measure, such as standard deviation or the Fourier Power spectrum. For other information see the definition for the preceding functional group, 5.7.

GENERATION OF TRAINING STATISTICS (5.9) - In ELAS, the definition or specification of a class(es) is independant of assigning class numbers to each pixel. All processes which generate a definition of a class(es) for subsequent classification procedures (see CLASSIFIERS, Sec. 5.11) are grouped. This functional group is a special subset of DATA ANALYSIS-STATISTICAL, Sec. 5.8. Three subgroups are recognized, supervised, unsupervised and reclassification techniques.

MANIPULATION OF TRAINING STATISTICS STORED IN SUBFILE STF (5.10) - These modules are designed to manipulate information or display relationships between classes stored in subfile STF.

CLASSIFIERS (5.11) - In ELAS the assignment of a pixel to a class is generally independant of the processes used to define or specify a class(es). This functional group includes those routines that assign a class value to a pixel in a data file having 2 or more channels of data.

COMPUTATIONS ON CLASSIFIED DATA (5.12) - Many processes require that some spectrally, predifined subset or class be used to guide or define processing limits. This is the common characteristic of the modules in this group.

GEOMETRIC CORRECTION, REGISTRATION AND OVERLAYING (5.13) - In a sense this is a special subclass of the functional group DATA CORRECTION (5.14). These modules are designed to map a data file/image to either a base/map/projection or another file/image, here termed overlaying. Four subgroups are recognized: general purpose modules, modules specific to Landsat-MSS data, modules specific to Landsat-TM data, and modules that perform overlaying (both scene to scene and scene to map).

DATA CORRECTION AND CLEANUP FILTERS (5.14) - Techniques for editing and noise or error removal from files, subfiles, and external files are included in this group. Two subgroups are recognized: modules that operate or data files, and modules that operate on subfiles or external files.

MODELLING (5.15) - These modules are intended to aid the user in evaluating or modelling interrelationships of the data according to user defined considerations or pre-specified models.

POLYGON MANIPULATIONS (5.16) - Algorithms that enable the user to build, manipulate, or require use of polygons are grouped here.

CIRCLE MANIPULATION (5.17) - Algorithms that use circles are grouped here.

FILTERS (5.18) - This functional group includes those modules that generate use or evaluate filters in either the space (time) or frequency domain. This list does not include all mdules which operate using a moving window!

TOPOGRAPHIC DATA (5.19) - Modules operating on digital elevation data are in this group.

PLOTTER AND FILM RECORDER OUTPUT (5.20) - Modules that generate files for plotting to any device or writing to film, or modules for preparing for plotting are in this group.

DIGITIZER (5.21) - All modules directly linked to digitizing are in this group.

SPECIAL PURPOSE AND MISC. (5.22) - These are the modules that just don't fit anywhere else.

APPENDIX C.

****
*
* SJRWMD LANDSAT CCT INVENTORY
*
* LAST REVISION: 19 SEPT 85
*
****
*

DATE	PATH/ROW	LANDSAT	CLOUD COVER (%)	ID
19 OCT 74	16/41	1	20	8181815113500
21 FEB 77	17/39	2	0	8276115011500
28 JUN 77	18/39	2	0	8288815003500
25 JAN 82	16/41	3	10	82256015095X0
27 OCT 83	16/39	4	0	84046815242X0 **
19 APR 84	17/39	5		85004915282X0
28 APR 84	16/40	5	10	85005815223X0 **
07 MAY 84	15/41	5	10	85006715165X0 **
14 MAY 84	16/39	5		85007415223X0
12 SEP 84	15/41	5	20	85019515194X0 **
06 NOV 84	16/40	5	10	85025015252X0
17 FEB 85	17/39	5	0	85035315313X0 **

NOTE: ** DENOTES CCTS ON ORDER AS OF 9/11/85

APPENDIX D
INVENTORY OF AVAILABLE LANDSAT CCT DATA
(FROM STILL AND SHIH, 1984)

LANDSAT TAPE DISTRIBUTION FOR FLORIDA

DATE	SCENE ID	RACK	BRZFIL	CC	PATH&ROW	OWNER
12-20-82	40157-15181				15-42	FDOT
1-25-82	22560-15095				16-41	FDOT
2-26-77	5679-14153				16-41	FDOT
6-25-79	30477-15110				16-41	FDOT
2-20-77	20760-14564				16-42	FDOT
4-2-76	2436-1567200				16-42	FDOT
2-21-77	20761-15011				17-39	FDOT
9-28-82	40043-15275				17-39	FDOT
5-1-81	22291-15141				17-40	FDOT
3-29-77	20797-15002				17-41	FDOT
9-22-80	22039-151620				17-41	FDOT
12-8-80	22147-151-62				17-42	FDOT
2-21-77	20761-15023				17-42	FDOT
3-4-75	2041-1517400				17-42	FDOT
9-22-80	22039-15164				17-42	FDOT
3-27-81	22256-15200				18-39	FDOT
1-27-82	22562 15212				18-41	FDOT
4-17-77	20816-15051				18-41	FDOT
9-23-81	22436-15180				18-41	FDOT
12-16-82	40153-15415				19-39	FDOT
11-5-80	22114-15324				20-39	FDOT
6-18-81	822339-14342			20	11-29	SRPC
6-7-78	830094-14371			0	11-29	SRPC
7-23-76	811461-14004			0	11-29	SRPC
9-8-80	822056-15060			10	16-30	SRPC
11-17-79	830622-15134			0	17-39	SRPC
12-3-81	822507-15132			10	17-39	SRPC
3-17-81	C31108-15083			20	17-39	SRPC
12-3-81	822507-15135			0	17-40	SRPC
1-27-82	822562-15194			0	18-37	SRPC
1-27-82	822562-15200			0	18-38	SRPC
11-21-80	822130-15202			0	18-38	SRPC
1-1-75	810892-15192			0	18-39	SRPC
1-23-76	820366-15192			0	18-39	SRPC
1-27-82	822562-15205			0	18-39	SRPC
11-21-80	822130-15205			30	18-39	SRPC
2-1-81	822202-15201			30	18-39	SRPC
2-16-73	810208-15340			10	18-39	SRPC
4-7-79	821536-15121			0	18-39	SRPC
9-23-81	822436-15171			0	18-39	SRPC
1-27-82	822562-15205			0	18-40	SRPC
1-10-82	822545-15244			0	19-37	SRPC
2-20-81	822221-15253			0	19-38	SRPC
2-20-81	822221-15260			10	19-39	SRPC

DATE	SCENE ID	RACK	BRZFIL	CC	PATH&ROW	OWNER
1-11-82	822546-15303			0	20-37	SRPC
2-21-81	822222-15312			05	20-38	SRPC
2-21-81	822222-15314			0	20-39	SRPC
12-7-81	822511-15353			0	21-37	SRPC
12-12-80	822151-15373			0	21-38	SRPC
12-12-80	822151-15380			0	21-39	SRPC
11-7-80	822116-15431			0	22-37	SRPC
11-7-80	822116-15434			0	22-38	SRPC
12-8-81	822512-15415			05	22-38	SRPC
11-20-81	822494-15414			10	22-39	SRPC
11-7-80	822116-15440			0	22-39	SRPC
3-22-81	831113-15372			0	22-39	SRPC
11-8-80	822117-15485			10	23-37	SRPC
1-28-76	820371-15473			0	23-38	SRPC
10-27-79	821739-15455			0	23-38	SRPC
12-9-81	822513-15473			0	23-38	SRPC
2-24-81	822225-15483			0	23-38	SRPC
2-26-79	830358-15510			0	23-38	SRPC
1-16-73	810177-16020			0	23-39	SRPC
1-28-76	820371-15480			0	23-39	SRPC
10-27-79	821739-15461			0	23-39	SRPC
12-9-81	822513-15480			0	23-39	SRPC
2-22-78	821127-15222			0	23-39	SRPC
2-24-81	822225-15485			0	23-39	SRPC
2-26-79	830358-15512			0	23-39	SRPC
2-9-77	820749-15360			0	23-39	SRPC
8-7-72	810015-16013			0	23-39	SRPC
9-25-73	810429-16004			30	23-39	SRPC
1-15-82	822550-15534			0	24-37	SRPC
1-2-81	822172-15544			0	24-38	SRPC
10-31-79	821743-16085			0	27-38	SRPC
12-10-73	810505-16221			0	27-38	SRPC
10-31-79	821743-16091			10	27-39	SRPC
12-10-73	810505-16223			0	27-39	SRPC
5-13-79	830434-16140			10	27-39	SRPC
7-6-81	822357-16165			0	29-29	SRPC
5-31-81	822321-16212			20	29-37	SRPC
3-21-73	1241-15175	AH-02-5	10009-688	40	15-41	IFAS
5-9-72	1655-15110	AK-03-07	10024-1231	20	15-41	IFAS
8-7-72	5015-14571	AK-05-9	10037-552	40	15-41	IFAS
1-26-73	1187-15174	AA-03-13	10007-304	40	15-42	IFAS
1-3-74	1529-15142	AI-01-13	10019-844	80	15-42	IFAS
1-8-73	1169-15173	AJ-01-17	10006-1035	10	15-42	IFAS
12-21-72	1151-15175	AE-02-09	10006-456	80	15-42	IFAS
2-13-73	1205-15182	AK-01-09	10008-38	50	15-42	IFAS
2-13-73	1205-15180	AJ-04-17	10008-37	50	15-42	IFAS
2-26-74	1583-15125	AA-01-5	10022-90	30	15-42	IFAS
3-21-73	1241-15184	AD-05-13	10009-690	90	15-42	IFAS
3-21-74	1241-15182	AD-05-09	10009-689	20	15-42	IFAS
3-3-73	1223-15184	AD-02-13	10009-157	50	15-42	IFAS

DATE	SCENE ID	RACK	BRZFIL	CC	PATH&ROW	OWNER
3-3-73	1223-15181	AD-02-09	10009-156	60	15-42	IFAS
4-26-73	1277-15183	AE-02-05	10010-808	10	15-42	IFAS
4-26-73	1277-15181	AH-02-17	10010-807	20	15-42	IFAS
4-3-74	1619-15121	AI-04-1	10022-1825	10	15-42	IFAS
4-8-73	1259-15182	AH-03-09	10010-96	60	15-42	IFAS
5-14-73	1295-15183	AG-05-13	10010-1668	10	15-42	IFAS
5-27-74	1673-15105	AG-05-9	10025-833	10	15-42	IFAS
6-14-74	1691-15102	AG-06-13	10026-387	40	15-42	IFAS
6-19-73	1331-15180	AB-04-05	10011-1598	60	15-42	IFAS
7-25-73	1367-15174	AC-01-13	10013-602	20	15-42	IFAS
7-25-73	1367-15171	AC-06-1	10013-601	30	15-42	IFAS
7-7-73	1349-15175	AF-02-1	10012-1396	70	15-42	IFAS
7-7-73	1349-15173	AB-03-1	10012-1395	80	15-42	IFAS
8-30-73	1403-15164	AE-04-17	10014-884	60	15-42	IFAS
8-30-73	1403-15170	AH-01-13	10014-885	70	15-42	IFAS
8-7-72	5015-14574	AK-05-13	10037-553	30	15-42	IFAS
9-17-73	1421-15162	AH-05-9	10015-37	50	15-42	IFAS
1-26-73	1187-15181	AC-06-09	10007-305	40	15-43	IFAS
1-3-74	1529-15145	AI-02-09	10019-0845	90	15-43	IFAS
2-26-74	1583-15132	AA-01-01	10022-0092	40	15-43	IFAS
3-16-74	1601-15130	AG-01-13	10022-902	30	15-43	IFAS
3-16-74	1601-15130	AG-01-13	10022-0902	30	15-43	IFAS
3-16-74	1601-15124	AG-01-17	10022-0902	30	15-43	IFAS
4-21-74	1637-15121	AJ-02-01	10024-349	50	15-43	IFAS
4-21-74	1637-15121	AJ-02-01	10024-0349	50	15-43	IFAS
4-3-74	1619-15124	AJ-04-09	10022-1826	20	15-43	IFAS
4-3-74	1619-15124	AJ-04-09	10022-1826	20	15-43	IFAS
6-14-74	1691-15104	AF-06-13	10026-388	40	15-43	IFAS
6-14-74	1691-15104	AF-06-13	10026-0388	40	15-43	IFAS
9-17-73	1421-15164	AI-04-05	10015-0038	20	15-43	IFAS
1-27-73	1188-15224	AB-05-01	10007-341	50	16-40	IFAS
1-27-73	1188-15224	AB-05-01	10007-0341	50	16-40	IFAS
1-4-74	1530-15192	AI-01-17	10019-776	40	16-40	IFAS
1-4-74	1530-15192	AI-01-17	10019-0776	40	16-40	IFAS
10-19-74	1818-15111	AE-06-05	10030-1684	40	16-40	IFAS
10-19-74	1818-15111	AE-06-05	10030-1684	40	16-40	IFAS
12-22-72	1152-15224-1	AJ-03-09	10006-0488	90	16-40	IFAS
12-7-75	5232-14495	AH-06-07	10044-0374	10	16-40	IFAS
12-7-75	5232-14495	AH-06-07	10044-374	30	16-40	IFAS
2-14-73	1206-15225	AB-02-09	10007-931	10	16-40	IFAS
2-14-73	1206-15225-4	AB-02-09	10007-0931	10	16-40	IFAS
2-27-74	1584-15175	AJ-02-05	10022-106	60	16-40	IFAS
2-27-74	1584-15175	AJ-02-05	10022-106	60	16-40	IFAS
3-17-74	1602-15173	AI-05-09	10022-938	20	16-40	IFAS
3-17-74	1602-15173	AI-05-09	10022-0938	20	16-40	IFAS
3-21-75	2058-15105	AK-05-01	10003-097	10	16-40	IFAS
3-21-75	2058-15105	AK-05-01	10003-0097	10	16-40	IFAS
4-22-74	1638-15164	AH-05-01	10024-0231	40	16-40	IFAS
4-22-74	1620-15164	AF-01-17	10022-1719	50	16-40	IFAS
4-4-74	1620-15171	AF-01-17	10022-1719	50	16-40	IFAS

DATE	SCENE ID	RACK	BRZFIL	CC	PATH&ROW	OWNER
5-10-74	1656-15161	AK-02-01	10024-1245	30	16-40	IFAS
5-10-74	1656-15161	AK-02-01	10024-1245	30	16-40	IFAS
5-28-74	1674-15154	AB-01-01	10025-897	80	16-40	IFAS
5-28-74	1674-15154	AB-01-01	10025-0897	80	16-40	IFAS
6-15-74	1692-15151	AF-06-09	10026-423	90	16-40	IFAS
6-15-74	1692-15151	AF-06-09	10026-0423	90	16-40	IFAS
9-18-73	1422-15211	AG-03-05	10015-580	30	16-40	IFAS
9-18-73	1422-15211	AG-03-05	10015058	30	16-40	IFAS
1-12-76	5268-14475	AL-03-17	10045-0525	20	16-41	IFAS
1-27-73	1188-15230	AA-04-17	10007-0342	70	16-41	IFAS
1-30-76	5286-14464	AL-03-01	10046-0194	10	16-41	IFAS
1-4-74	1530-15194	AI-03-09	10019-0777	40	16-41	IFAS
1-9-73	1170-15225	AE-03-09	10006-1076	80	16-41	IFAS
10-11-72	1080-15224	AF-03-09	10004-0482	60	16-41	IFAS
10-19-74	1818-15113	AE-06-09	10030-1685	20	16-41	IFAS
10-29-72	1098-15230	AB-01-05	10004-1146	80	16-41	IFAS
10-5-75	2256-15095	AK-02-13	10011-0659	50	16-41	IFAS
11-10-75	2292-15093	AI-06-09	10012-0944	80	16-41	IFAS
11-29-73	1494-15202	AK-04-08	10018-0523	20	16-41	IFAS
11-4-76	2652-15004	AK-06-09	10024-0375	50	16-41	IFAS
12-12-74	1872-15093	AK-06-17	10033-0108	20	16-41	IFAS
12-22-72	1152-15231	AJ-05-01	10006-0489	90	16-41	IFAS
12-30-74	1890-15084	AL-02-15	10033-0465	10	16-41	IFAS
2-14-73	1206-15232	AC-01-05	10007-0932	10	16-41	IFAS
2-26-77	5679-14153	AL-05-18	10056-0065	10	16-41	IFAS
2-27-74	1584-15181	AI-04-12	10022-0107	50	16-41	IFAS
2-4-75	1926-15071	AH-06-01	10034-0108	20	16-41	IFAS
3-17-74	1602-15175	AI-05-13	10022-0939	30	16-41	IFAS
3-22-73	1242-15234	AG-03-09	10009-0752	10	16-41	IFAS
3-22-73	1242-15234	AG-03-19	10009-0752	10	16-41	IFAS
3-22-73	1242-15231	AC-05-17	10009-0751	30	16-41	IFAS
3-3-75	20040-15113	AL-03-15	10002-0311	10	16-41	IFAS
3-4-73	1224-15231	AI-03-13	10009-179	40	16-41	IFAS
3-4-73	1224-15233	AB-02-05	10009-180	70	16-41	IFAS
4-11-76	5358-14420	AL-03-09	10048-0508	10	16-41	IFAS
4-22-74	1638-15171	AE-05-17	10024-0232	60	16-41	IFAS
4-26-73	1277-15174	AE-02-01	10010-0806	20	16-41	IFAS
4-26-75	20094-15111	AL-04-07	10005-517	30	16-41	IFAS
4-27-73	1278-15233	AD-04-01	10010-869	30	16-41	IFAS
4-4-74	1620-15173	AG-02-01	10022-1720	70	16-41	IFAS
4-8-73	1259-15175	AH-05-13	10010-0095	70	16-41	IFAS
4-9-73	1260-15233	AA-02-05	10010-0159	10	16-41	IFAS
4-9-73	1260-15231	AE-04-05	10010-0158	10	16-41	IFAS
5-14-73	1295-15174	AB-05-13	10010-1666	20	16-41	IFAS
5-15-73	1296-15225	AH-01-09	10010-1686	20	16-41	IFAS
5-15-73	1296-15232	AA-02-09	10010-1687	40	16-41	IFAS
5-26-76	2490-15052	AL-01-01	10019-0155	10	16-41	IFAS
5-27-77	1-1769-14072	AL-05-01	10059-0075	10	16-41	IFAS
5-28-74	1674-15161	AH-01-05	10025-0898	60	16-41	IFAS
5-5-75	5016-15025	AH-06-11	10037-0649	20	16-41	IFAS

DATE	SCENE ID	RACK	BRZFIL	CC	PATH&ROW	OWNER
6-13-76	2508-15050	AK-06-13	10019-0915	30	16-41	IFAS
6-15-74	1692-15153	AG-06-05	10026-0424	50	16-41	IFAS
6-19-73	1331-15171	AB-04-01	10011-1596	90	16-41	IFAS
6-2-73	1314-15231	AH-05-17	10012-0066	60	16-41	IFAS
6-20-73	1332-15223	AD-03-13	10012-0499	60	16-41	IFAS
6-20-73	1332-15230	AD-01-09	10012-0500	70	16-41	IFAS
7-26-73	1368-15223	AG-04-17	10015-0015	30	16-41	IFAS
7-26-73	1368-15220	AG-04-13	10015-0014	30	16-41	IFAS
7-7-73	1349-15170	AB-01-09	10012-1394	30	16-41	IFAS
7-8-73	1350-15224	AE-04-01	10012-1468	10	16-41	IFAS
7-8-73	1350-15222	AA-02-17	10012-1467	10	16-41	IFAS
8-13-73	1386-15215	AH-04-13	10015-0097	30	16-41	IFAS
8-13-73	1386-15222	AH-04-17	10015-0098	40	16-41	IFAS
8-24-76	2580-15025	AK-06-05	10022-0141	50	16-41	IFAS
8-31-73	1404-15220	AG-02-09	10015-0991	80	16-41	IFAS
8-31-73	1404-15213	AG-02-05	10015-0990	90	16-41	IFAS
8-8-74	1746-15134	AK-04-12	10027-1442	20	16-41	IFAS
9-18-73	1422-15213	AE-04-13	10015-0581	30	16-41	IFAS
9-29-76	2616-15015	AK-06-01	10023-0216	30	16-41	IFAS
9-5-72	1044-15223	AE-03-05	10002-0265	50	16-41	IFAS
9-8-75	5142-14554	AJ-06-01	10041-0518	30	16-41	IFAS
1-27-73	1188-15233	AA-06-17	10007-343	30	16-42	IFAS
1-4-74	1530-15201	AJ-05-13	10019-778	40	16-42	IFAS
1-9-73	1170-15232	AF-04-09	10006-1077	60	16-42	IFAS
10-11-72	1080-15230	AC-01-17	10004-0483	70	16-42	IFAS
10-17-76	20634-15014	AL-03-19	10023-1077	20	16-42	IFAS
10-19-74	1818-15120	AE-06-13	10030-1686	10	16-42	IFAS
10-24-73	1458-15210	AK-05-07	10016-1065	10	16-42	IFAS
10-29-72	1098-15232	AD-01-17	10004-1147	60	16-42	IFAS
10-6-73	1440-15213	AK-05-17	10015-1364	60	16-42	IFAS
12-12-74	1872-15095	AL-02-01	10033-0109	20	16-42	IFAS
12-16-75	2328-15093	AL-01-17	10013-0959	30	16-42	IFAS
12-22-72	1152-15233	AE-03-13	10006-0490	90	16-42	IFAS
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2-20-77	20760-14564	AL-04-05	10027-0911	10	16-42	IFAS
2-27-74	1584-15184	AJ-02-09	1022-0108	40	16-42	IFAS
3-17-74	1602-15182	AI-05-17	10022-0940	40	16-42	IFAS
3-3-75	2040-15115	AK-03-19	10002-0312	20	16-42	IFAS
3-4-73	1224-15240	AG-02-17	10009-0181	20	16-42	IFAS
4-11-76	5358-14422	AL-03-13	10048-0509	10	16-42	IFAS
4-2-76	20436-15072	AL-04-05	10017-0569	10	16-42	IFAS
4-27-73	1278-15235	AA-03-01	10010-0870	30	16-42	IFAS
4-4-74	1620-15180	AG-03-01	10022-1721	70	16-42	IFAS
4-9-73	1260-15240	AD-04-17	10010-0168	20	16-42	IFAS
5-15-73	1296-15234	AD-05-01	10010-1688	50	16-42	IFAS
5-26-76	20490-15055	AL-04-11	10019-0156	40	16-42	IFAS
5-28-74	1674-15163	AC-03-09	10025-0899	70	16-42	IFAS
6-1-75	2130-15114	AH-06-05	10006-0928	30	16-42	IFAS
6-15-74	1692-15160	AG-06-09	10026-0425	90	16-42	IFAS

DATE	SCENE ID	RACK	BRZFIL	CC	PATH&ROW	OWNER
6-2-73	1314-15233	AH-05-05	10012-0067	70	16-42	IFAS
6-20-73	1332-15232	AC-06-17	10012-0501	10	16-42	IFAS
7-26-73	1368-15225	AA-04-05	10015-0016	20	16-42	IFAS
7-7-73	1350-15231	AC-06-05	10012-1469	10	16-42	IFAS
8-13-73	1386-15224	AD-02-01	10015-0099	40	16-42	IFAS
8-18-72	1026-15230	AF-03-13	10001-1461	20	16-42	IFAS
8-31-73	1404-15222	AD-01-05	10015-0992	90	16-42	IFAS
8-8-74	1746-15141	AE-06-01	10027-1443	20	16-42	IFAS
9-18-73	1422-15220	AG-03-17	10015-0582	30	16-42	IFAS
9-5-72	1044-15230	AA-05-17	10002-0266	60	16-42	IFAS
1-27-73	1188-15235	AA-06-09	10007-0344	20	16-43	IFAS
1-4-74	1530-15203	AI-01-05	10019-779	40	16-43	IFAS
10-29-72	1098-15235-1	AK-01-13	10004-1148	20	16-43	IFAS
2-14-73	1206-15241	AC-01-01	10007-0934	20	16-43	IFAS
2-27-74	1584-15190	AK-02-05	10022-109	50	16-43	IFAS
2-8-76	2382-15085	AL-01-19	10015-534	40	16-43	IFAS
3-17-74	1602-15184	AI-05-05	10022-0941	90	16-43	IFAS
3-22-73	1242-15243	AG-05-17	10009-0754	40	16-43	IFAS
3-4-73	1224-15242	AB-02-01	10009-182	70	16-43	IFAS
4-22-74	1638-15180	AI-05-01	10024-0234	60	16-43	IFAS
4-27-73	1278-15242	AD-01-05	10010-871	90	16-43	IFAS
4-4-74	1620-15182	AG-01-01	10022-1722	40	16-43	IFAS
4-9-73	1260-15242	AE-04-09	10010-0161	40	16-43	IFAS
5-15-73	1296-15241	AG-03-13	10010-1689	30	16-43	IFAS
5-28-74	1674-15170	AH-02-09	10025-0900	60	16-43	IFAS
6-15-74	1692-15162	AF-06-17	10026-0426	80	16-43	IFAS
6-20-73	1332-15235	AA-04-01	10012-0502	90	16-43	IFAS
7-26-73	1368-15232	AD-01-01	10015-0017	10	16-43	IFAS
8-13-73	1386-15231	AD-02-05	10015-0100	30	16-43	IFAS
8-18-72	1026-15232	AB-04-17	10001-1462	0	16-43	IFAS
8-31-73	1404-15225	AL-03-17	10015-0993	80	16-43	IFAS
9-18-73	1422-15222	AJ-045-17	10015-0583	10	16-43	IFAS
1-10-73	1171-15281	AB-06-17	10006-1115	10	17-40	IFAS
1-22-76	2365-15140	AL-02-13	10015-0088	0	17-40	IFAS
1-29-78	1103-14465	AL-05-06			17-40	IFAS
12-17-75	2329-15142	AL-02-11	10013-0788	10	17-40	IFAS
12-18-73	1513-15252	AJ-04-05	10019-0721	10	17-40	IFAS
12-23-72	1153-15283	AB-03-09	10006-0523	50	17-40	IFAS
2-14-75	2023-15165	AK-02-09	10001-0037	10	17-40	IFAS
2-15-73	1207-15284	AI-03-05	10008-0091	60	17-40	IFAS
2-28-74	1585-15233	AI-03-17	10022-0263	70	17-40	IFAS
2-9-76	2383-15135	AJ-06-05	10015-0688	10	17-40	IFAS
3-18-74	1603-15231	AI-02-13	10022-0957	0	17-40	IFAS
3-23-73	1243-15285	AF-03-01	10009-0811	10	17-40	IFAS
3-5-73	1225-15285	AB-03-17	10009-197	10	17-40	IFAS
4-23-74	1639-15223	AG-05-01	10024-0600	70	17-40	IFAS
4-27-73	1278-15230	AA-03-09	10010-0868	20	17-40	IFAS
4-28-73	1279-15285	AJ-03-01	10010-0925	10	17-40	IFAS
4-5-74	1621-15225	AF-04-17	10022-1657	90	17-40	IFAS
5-16-73	1297-15284	AG-04-05	10010-1748	80	17-40	IFAS

DATE	SCENE ID	RACK	BRZFIL	CC	PATH&ROW	OWNER
5-29-74	1675-15212	AH-04-05	10025-799	90	17-40	IFAS
6-16-74	1693-15205	AE-06-17	10026-0483	50	17-40	IFAS
6-2-73	1314-15224	AB-06-13	10012-0065	20	17-40	IFAS
6-21-73	1333-15281	AD-03-01	10012-0584	60	17-40	IFAS
6-3-73	1315-15283	AE-01-01	10011-1014	60	17-40	IFAS
7-27-73	1369-15275	AJ-03-17	10013-0707	40	17-40	IFAS
7-9-73	1351-15280	AF-03-05	10012-1513	90	17-40	IFAS
8-14-73	1387-15273	AC-03-05	10015-0134	30	17-40	IFAS
8-31-75	2221-15153	AI-06-05	10010-0840	30	17-40	IFAS
9-1-73	1405-15271	AC-05-01	10014-1019	90	17-40	IFAS
9-6-72	1045-15275	AK-03-13	10002-0281	10	17-40	IFAS
11-17-72	1117-15285	AG04-09	10005-0189	10	17-41	IFAS
11-17-72	1117-15283	AI-06-13	10005-0188	30	17-41	IFAS
12-18-73	1513-15255	AJ-05-05	10019-722	0	17-41	IFAS
12-23-72	1153-15285-1	AJ-02-17	10006-524	40	17-41	IFAS
2-15-73	1207-15290	AH-02-13	10008-0092	70	17-41	IFAS
2-28-74	1585-15240	AK-01-05	10022-0264	70	17-41	IFAS
3-18-74	1603-15234	AI-01-09	10022-0958	10	17-41	IFAS
3-18-74	1603-15234	AI-01-09	10022-0958	10	17-41	IFAS
3-5-73	1225-15291	AB-03-13	10009-198	30	17-41	IFAS
4-23-74	1639-15225	AH-01-01	10024-0601	60	17-41	IFAS
4-28-73	1279-15291	AK-04-04	10010-0926	10	17-41	IFAS
4-5-74	1621-15232	AF-05-01	10022-1658	80	17-41	IFAS
5-16-73	1297-15290	AF-04-01	10010-1749	60	17-41	IFAS
5-29-74	1675-15215	AJ-01-05	10025-0800	80	17-41	IFAS
6-16-74	1693-15212	AG-06-01	10026-0484	70	17-41	IFAS
6-21-73	1333-15284	AC-03-01	10012-0585	70	17-41	IFAS
7-27-73	1369-15281	AJ-03-05	10013-0708	40	17-41	IFAS
8-14-73	1387-15280	AH-03-05	10015-0135	30	17-41	IFAS
8-19-72	1027-15281	AB-04-13	10001-1510	0	17-41	IFAS
9-1-73	1405-15274	AJ-04-13	10014-1020	90	17-41	IFAS
10-12-72	1081-15282	AC-02-01	10004-0527	80	17-42	IFAS
10-30-72	1099-15284	AI-02-17	10004-1182	10	17-42	IFAS
10-30-72	1099-15291	AB-03-05	10004-1183	20	17-42	IFAS
11-17-72	1117-15292	AG-02-13	10005-0191	30	17-42	IFAS
12-23-72	1153-15292	AA-04-09	10006-0525	10	17-42	IFAS
2-21-77	20761-15023	AL-04-03	10028-0192	0	17-42	IFAS
2-28-74	1585-15242	AI-04-17	10022-0271	60	17-42	IFAS
3-18-74	1603-15240	AJ-04-01	10022-0959	50	17-42	IFAS
3-23-73	1243-15294	AF-04-13	10009-0813	30	17-42	IFAS
3-4-75	2041-15174	AK-04-02	10003-0449	0	17-42	IFAS
3-5-73	1225-15294	AA-05-09	1009-0199	30	17-42	IFAS
4-10-73	1261-15294	AA-01-17	10009-1520	20	17-42	IFAS
4-23-74	1639-15232	AH-03-01	10024-602	40	17-42	IFAS
4-28-73	1279-15294	AJ-01-13	10010-0927	20	17-42	IFAS
4-5-74	1621-15234	AI-02-01	10022-1659	50	17-42	IFAS
5-16-73	1297-15293	AF-04-05	10010-1750	40	17-42	IFAS
5-29-74	1675-15221	AJ-03-13	10025-0801	40	17-42	IFAS
6-16-74	1693-15214	AF-06-05	10026-0485	50	17-42	IFAS
6-21-73	1333-15290	AD-03-05	10012-0586	50	17-42	IFAS

DATE	SCENE ID	RACK	BRZFIL	CC	PATH&ROW	OWNER
8-1-72	1009-15282	AB-05-09	10001-0700	70	17-42	IFAS
8-14-73	1387-15282	AA-02-01	10015-0136	70	17-42	IFAS
9-1-73	1405-15280	AJ-01-09	10014-1021	80	17-42	IFAS
1-5-74	1531-15261	AF-01-13	10023-0631	20	17-43	IFAS
4-23-74	1639-15234	AH-04-01	10024-603	20	17-43	IFAS
4-5-74	1621-15241	AI-01-01	10022-1660	50	17-43	IFAS
6-16-74	1693-15221	AF-06-01	10026-0509	90	17-43	IFAS
6-21-73	1333-15293	AD-05-17	10012-0696	80	17-43	IFAS
7-9-73	1351-15292	AF-03-17	10012-1514	10	17-43	IFAS
8-14-73	1387-15285	AK-03-01	10015-0137	40	17-43	IFAS
8-19-72	1027-15290	AA-06-13	1001-1512	0	17-43	IFAS
1-23-76	2366-15192	AJ-06-09	10014-1051	0	18-39	IFAS
10-14-77	2-0996-14544	AL-04-15	10035-0957	10	18-39	IFAS
4-17-77	20816-15042	AL-04-01	10029-1141	0	18-39	IFAS
4-28-75	2096-15215	AK-04-16	10005-0703	10	18-39	IFAS
1-11-73	1172-15335	AE-01-13	10006-1152	10	18-40	IFAS
1-29-73	1190-15341	AB-02-13	10007-417	80	18-40	IFAS
1-6-74	1532-15304	AA-06-05	10019-0863	40	18-40	IFAS
12-24-72	1154-15341	AD-02-17	10006-0556	10	18-40	IFAS
12-6-72	1136-15342	AC-04-05	10006-0093	60	18-40	IFAS
3-1-74	1586-15291	AG-04-01	10022-0298	0	18-40	IFAS
3-24-73	1244-15344	AD-04-09	1000-9-0868	50	18-40	IFAS
3-6-73	1226-15343	AF-01-01	10009-0217	70	18-40	IFAS
4-6-74	1622-15283	AI-04-13	10024-0087	0	18-40	IFAS
6-17-74	1694-15263	AB-06-01	10026-0595	80	18-40	IFAS
6-22-73	1334-15340	AF-02-05	10012-0647	60	18-40	IFAS
6-4-73	1316-15341	AF-02-13	10012-0086	50	18-40	IFAS
7-10-73	1352-15334	AD-03-17	10012-1636	10	18-40	IFAS
7-28-73	1370-15333	AE-01-17	10013-728	30	18-40	IFAS
8-15-73	1388-15332	AE-05-13	10014-0295	40	18-40	IFAS
9-2-73	1406-15330	AE-05-05	10014-0973	50	18-40	IFAS
9-20-73	1424-15323	AH-02-01	10015-0726	60	18-40	IFAS
1-6-74	1532-15310	AA-01-09	10019-0864	10	18-41	IFAS
10-31-72	1100-15343	AF-02-17	10004-1217	10	18-41	IFAS
11-18-72	1118-15344	AE-01-09	10005-0221	90	18-41	IFAS
12-24-72	1154-15344	AC-05-13	10006-557	30	18-41	IFAS
12-6-72	1136-15344	AC-04-09	10006-0094	20	18-41	IFAS
2-16-73	1208-15345	AI-02-05	10008-0124	40	18-41	IFAS
4-29-73	1280-15343	AA-04-13	10010-0984	10	18-41	IFAS
4-6-74	1622-15290	AJ-01-01	10024-0088	0	18-41	IFAS
5-17-73	1298-15342	AA-02-13	10011-0239	10	18-41	IFAS
5-30-74	1676-15273	AH-04-09	10025-0816	0	18-41	IFAS
6-17-74	1694-15270	AG-06-17	10026-0596	50	18-41	IFAS
8-2-72	1010-15333	AB-04-09	10001-0782	30	18-41	IFAS
9-20-73	1424-15330	AH-01-17	10015-0727	40	18-41	IFAS
9-25-72	1064-15335	AE-01-05	10003-0661	40	18-41	IFAS
9-73	1406-15332	AK-01-01	10014-0974	70	18-41	IFAS
1-11-73	1172-15342	AC-05-05	10006-1153	90	18-42	IFAS
1-29-73	1190-15343	AE-03-17	10007-418	70	18-42	IFAS
2-16-73	1208-15351	AK-01-17	10008-125	40	18-42	IFAS

DATE	SCENE ID	RACK	BRZFIL	CC	PATH&ROW	OWNER
3-24-73	1244-415350	AD-04-13	10009-869	30	18-42	IFAS
3-24-73	1244-15353	AD-03-09	10009-870	40	18-42	IFAS
3-6-73	1226-15350	AF-01-05	10009-0218	10	18-42	IFAS
3-6-73	1226-15352	AF-01-09	10009-0219	50	18-42	IFAS
4-11-73	1262-15350	AC-02-05	10010-0187	0	18-42	IFAS
4-11-73	1262-15353	AC-02-09	10010-0188	10	18-42	IFAS
4-29-73	1280-15350	AC-01-09	10010-0985	20	18-42	IFAS
5-17-73	1298-15351	AD-05-05	10011-241	10	18-42	IFAS
5-17-73	1298-15345	AC-02-13	10011-0240	10	18-42	IFAS
6-22-73	1334-15345	AC-04-01	10012-0649	10	18-42	IFAS
6-22-73	1334-15342	AE-05-09	10012-0648	50	18-42	IFAS
6-4-73	1316-15350	AF-02-09	10012-0088	40	18-42	IFAS
6-4-73	1316-15344	AA-03-05	10012-0087	50	18-42	IFAS
7-10-73	1352-15341	AC-03-13	10012-1637	50	18-42	IFAS
7-10-73	1352-15343	AA-03-17	10012-1638	90	18-42	IFAS
8-15-73	1388-15341	AG-01-09	10014-0297	20	18-42	IFAS
8-15-73	1388-15334	AG-01-05	10014-0296	20	18-42	IFAS
8-2-72	1010-15340	AJ-02-13	10001-0784	10	18-42	IFAS
8-20-72	1028-15340	AE-02-17	10003-0058	30	18-42	IFAS
10-15-77	2997-15002	AM-01-01		0	19-39	IFAS
12-28-75	5253-15051	AJ-06-13	10045-0282	0	20-39	IFAS
2-15-73	1207-15293	AA-06-01	10008-0093	80	17-42	IFAS

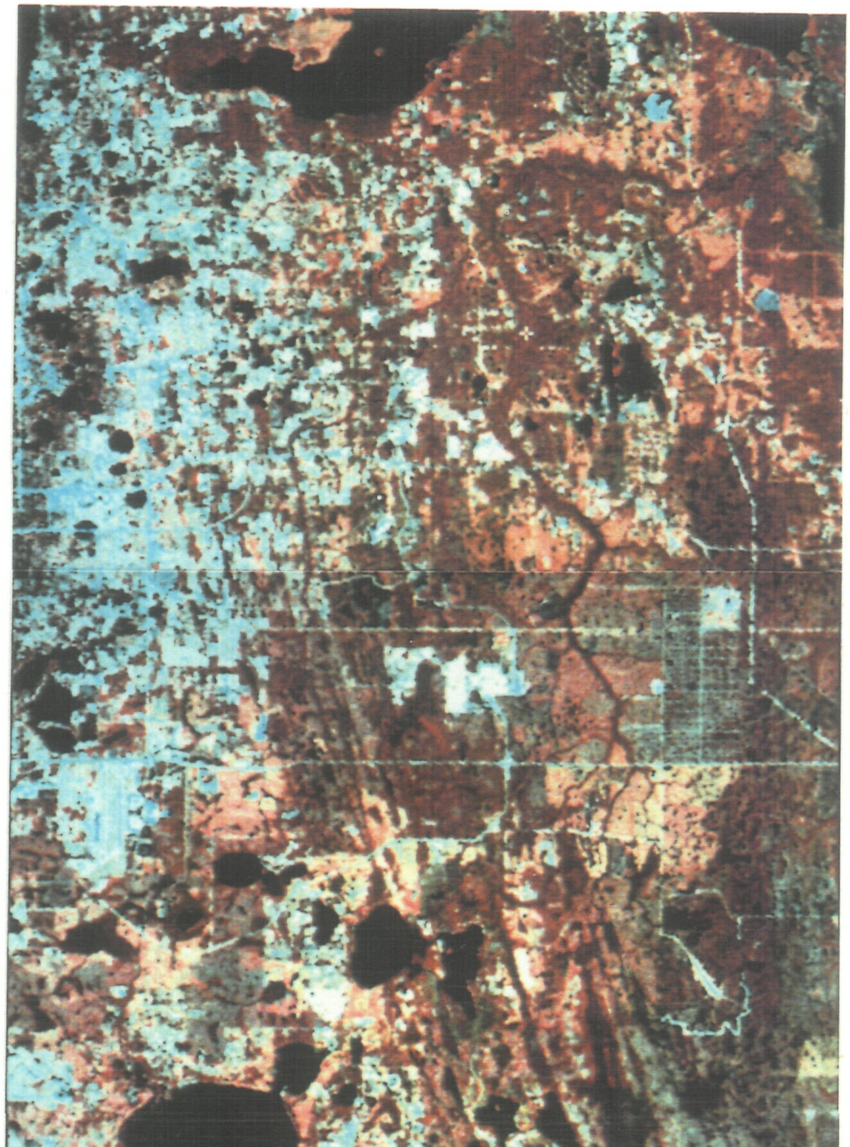

FIGURE 11. 1984 MSS DATA FOR ECONLOCKHATCHEE BASIN

FIGURE 15. MAJOR RIVER BASINS IN DUVAL COUNTY.

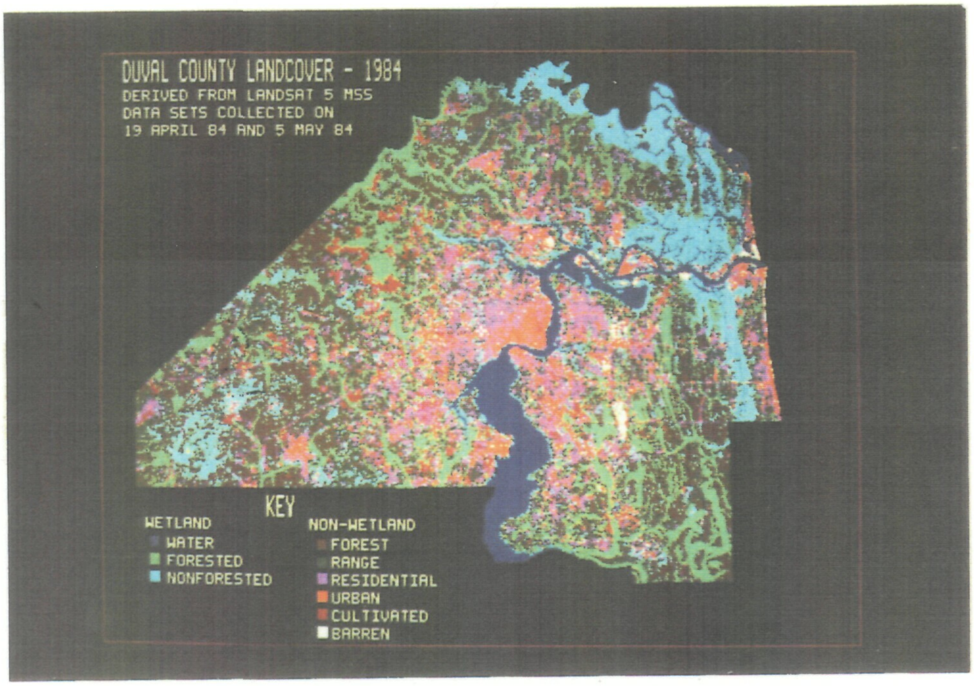

FIGURE 16. DUVAL COUNTY 1984 LANDCOVER MAP.