

THE OKLAHOMA GEOGRAPHIC INFORMATION RETRIEVAL SYSTEM

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ABSTRACT

The Oklahoma Geographic Information Retrieval System (OGIRS) is a highly interactive data entry, storage, manipulation, and display software system for use with geographically referenced data. Although originally developed for a project concerned with coal strip mine reclamation, OGIRS is capable of handling any geographically referenced data for a variety of natural resource management applications. A special effort has been made to integrate remotely sensed data into the information system. The timeliness and synoptic coverage of satellite data are particularly useful attributes for inclusion into the geographic information system.

INTRODUCTION

The Center for Applications of Remote Sensing (CARS) at Oklahoma State University performs a major public service role by providing Oklahoma with new technologies in a wide range of disciplines. Computer based geographic information systems have become an important area of interest at CARS because of their features which allow enormous quantities of data to be managed quickly and efficiently [1]. The Oklahoma Geographic Information Retrieval System (OGIRS) was developed at CARS in response to a request by a state agency (the Oklahoma Department of Mines) for a geographic information system which could integrate remotely sensed data with field and archive data sources.

The basic concepts and techniques utilized in the OGIRS software package do not contain any outstanding advances in the state of the art of computer based geographic information system methodologies. The main criteria for the design of OGIRS were simplicity, flexibility, and efficient operation on a small computer, therefore, many proven techniques were employed in the design [2,3]. The program is very simple to use and little or no previous computer ability is required by users. Requests and system prompts are in plain English or a simple three letter mnemonic code. OGIRS accepts data in digital form from previously established magnetic disk files, or the program provides a digitization module for use with either an on-line graphics digitizer or as input from a remote terminal. All data are stored in a common format and are geographically referenced to the Universal Transverse Mercator (UTM) grid [4]. The program structure utilizes the modular overlay capabilities of the Perkin-Elmer 8/32 host minicomputer. OGIRS requires approximately 50 percent of the minicomputer's available core memory of 0.5 megabyte at any given time. The program accesses only those data files and devices required for immediate execution to save time and space.

BACKGROUND

Actual programming of the Oklahoma Geographic Information Retrieval System began

in late 1981, however, the concept began taking shape as early as 1976. A project funded by the United States Department of the Interior was undertaken by the Louisiana State University Division of Engineering Research to monitor and assess energy related activity impacts to the water resources of south Louisiana [5]. The work on this project brought into focus many of the needs currently addressed by the Oklahoma Geographic Information Retrieval System. The USDI project called for the development of methodologies which would locate geographic areas most susceptible to environmental degradation from energy related activities (primarily oil and gas exploration, transportation, and production). A technique developed by the Battelle Laboratory of Columbus, Ohio [6] was chosen as the basic model to be further elaborated on by the LSU project. The final LSU suitability analysis methodology required cellularization of the study area, a general description of the physical environment of each cell, and a complex weighting system for evaluating an environmental impacts matrix for each land cover category.

Remotely sensed data were employed in the LSU study on a cursory basis to map the vegetation of the study area. A computer was used to reduce the time required to establish weighted values from each environmental impacts matrix, and a geographic information system was developed from the land cover and physical environment data. All of the prerequisites for a computer based geographic information system were compiled during the LSU study, however, hard copy maps and clear acetate overlays were used as storage media instead of a computer data base. It became evident during the LSU study that automation, a more efficient data storage medium, and more flexible data manipulation methods were necessities when an attempt is made to manage large amounts of geographically referenced information. Specifically, the need to incorporate data from a variety of sources and in a range of original formats, especially remotely sensed data, and the ability to interactively design and implement applications models were prime motivations for the subsequent development of OGIRS.

The Center for Applications of Remote Sensing began a project funded by the Oklahoma Department of Mines in 1981 to develop techniques for monitoring reclamation of coal strip mines [7]. A preliminary examination of the problem revealed many of the same needs and difficulties evident in the 1976 LSU/USDI project. The Oklahoma Geographic Information Retrieval System began as a simple computer program designed to read coordinates from a graphics digitizer and load them onto magnetic tape. The program quickly expanded and now functions as a fully operational data base program for geographically referenced data. OGIRS is still a developmental program with new capabilities added on a continuing basis, however, a stable production version of the software is in residence on the CARS computer.

In the near future, OGIRS will have a color image display capability and a polygon to raster conversion module of its own. A continual upgrading and enhancement of the basic software package is planned, but no major changes to the program format are in the offing. The largest single addition to the program will be a predictive land cover modeling (PLCM) overlay to be added sometime in 1983. The PLCM will allow a user to interactively develop possible future scenarios by altering one or more of the existing physical parameters in a defined geographic area. The program will graphically display the possible changes in the land cover through time.

A microcomputer version of OGIRS is under development at CARS. Although the major features of the micro-OGIRS will be identical to the minicomputer version, the data handling and display capabilities will be smaller than in the original version. The anticipated date of completion for the micro-OGIRS program is mid 1983.

PROGRAM DESCRIPTION

In general, the Oklahoma Geographic Information Retrieval System has many features found on similar software systems available today [8,9]. The data entry, stor-

age, and display techniques are conventional in most respects, however, these functions have been optimized for the specific operating environment. The data manipulation algorithms are also common to many other geographic information systems [10]. The unique feature of OGIRS is the flexibility users have in constructing applications models interactively.

OGIRS is programmed in FORTRAN VII and is currently implemented on a Perkin-Elmer 8/32 host minicomputer equipped with the OS32 version 4.3 operating system. The minicomputer is the primary image processing system at the OSU Center for Applications of Remote Sensing. The CARS computer has a number of specialized peripherals that may not be commonly available, such as the digital image display system. The CARS system also has a graphics digitizer, an electrostatic printer/plotter, and a color product generation system which are not required, but are very desirable options.

The program structure consists of a root program and a series of overlay programs (see Figure 1). OGIRS uses Perkin-Elmer operating system dependent subroutines for dynamic allocation and assignment of logical units and disk files [11]. The portability of OGIRS has not been established at the present time.

Data entry and storage are accomplished by several means. OGIRS interfaces with a graphics digitizer and records x, y, and z coordinate values from a cellularized data set. New z values may be interactively entered from a remote terminal once an x and y coordinate set is established for a given study area. Scale, cell size, and coordinate system are user selectable options.

OGIRS interfaces with the NASA Earth Resources Laboratory Applications Software System (ELAS) [12] and makes use of the ELAS polygon to raster conversion algorithm for input of polygon data sets. OGIRS also makes use of the digital image display capabilities in the ELAS program.

Data are stored as digitized data sets collected into specially constructed magnetic disk files or thematic libraries. A thematic library is titled after the major theme of the data entered in it. Generally, five basic libraries (soil, geology, hydrology, climate, and land cover) are sufficient to include most data types. Each thematic library is divided into channels or individual data sets representing some specific geographically referenced information (see Figure 2).

Figure 1. OGIRS program structure.

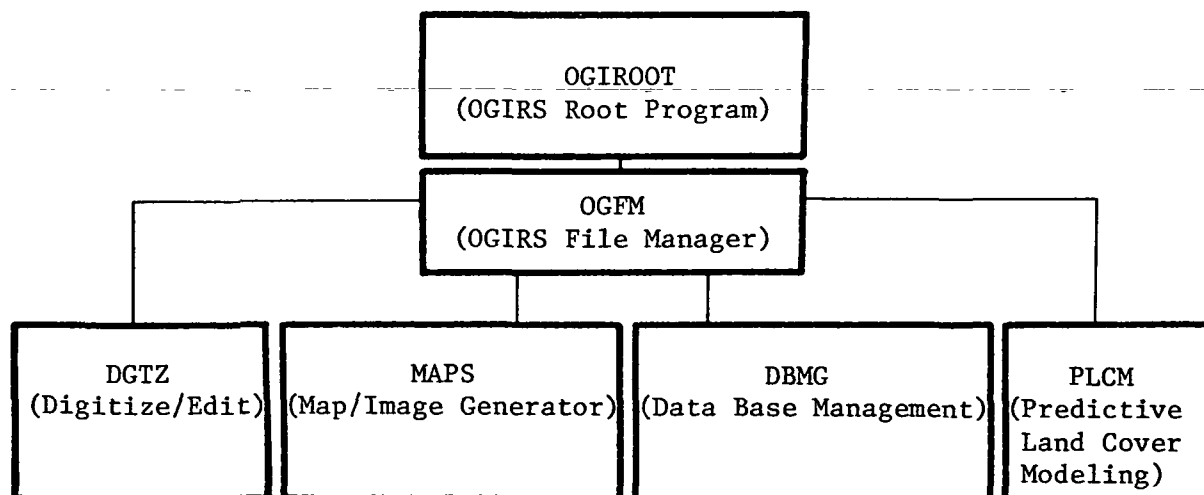


Figure 2. OGIRS thematic library contents.

GEOLOGIC LIBRARY	LANDCOVER LIBRARY	SOILS LIBRARY	TOPOGRAPHIC LIBRARY	CLIMATOLOGICAL LIBRARY
1. Surface geology	1. Landcover	1. Soil series	1. Slope angle	1. Mean annual precipitation
2. Depth to bedrock		2. Shrink/swell potential	2. Slope aspect	2. Mean January temperature
3. Type of bedrock		3. Soils subject to floods	3. Elevation	3. Mean July temperature
		4. Soil permeability		4. Mean length of frost-free season
		5. Hydrologic soil group		
		6. Soil Erodibility		

1. OGIRS PROGRAM OVERLAYS

Each of the OGIRS program overlays functions as a separate task within the Perkin-Elmer operating environment. Any overlay may be entered from any other overlay, therefore, there is not a required program flow. Upon entering the program, the master file is accessed (if a master file does not exist, the program creates one) and the devices and thematic library files are made ready. The user is always located in the OGFM overlay when program execution begins.

1.1 OGFM

The OGFM overlay is the OGIRS file management program. This overlay allows the user to allocate indexed or contiguous files, assign disk files or peripheral devices as logical units, deassign files or devices, list logical units and their status, and list the names of other overlays available. As with all of the OGIRS overlays, OGFM provides a list of directives and is highly interactive. A user types the appropriate three letter mnemonic code to select any of the program capabilities.

Disk files and peripheral devices are designated for specific uses when they are assigned. OGFM has four designations for a file or device: input, output, print, or null. The designated usage may be changed interactively.

1.2 DGTZ

The DGTZ overlay is the OGIRS data entry and edit program. As previously mentioned, data are entered from a graphics digitizer, a remote terminal, or as digital image data sets. The DGTZ edit functions allow the user to add, delete, or change the data value of any element within the input data set to correct for missing, superfluous, or incorrect values. A no-edit option is available for data sets with no er-

rors. Data are reformatted during the edit or no-edit runs and loaded into a thematic library. A library update function is available as a post-reformat edit capability. DGTZ contains a point listing capability for hard copy output of data sets in tabular form. A directives list for DGTZ is provided on entry to the program.

1.3 MAPS

The MAPS overlay is the OGIRS map and digital image generation program. This module outputs to a line printer or remote terminal an ASCII character set plot of the selected thematic library channel or DBMG generated data set. These products, although functional are primarily intended to be used as previews of the color image displays and electrostatic printer/plotter maps. In addition to the actual map of the data values, the header information, a frequency distribution, a value/character legend, and a map summary including the total number of categories, the total number of elements, and the area are printed with each map (see Figure 3).

Digital images designed for display on the CARS digital image display system are produced with the IMG directive in MAPS. The resulting images (see Figure 4) are compatible with the NASA Earth Resources Laboratory Applications Software System (ELAS). Elas is used to display the MAPS generated images at the present time, however, an image display overlay for OGIRS is under development. A directives list for MAPS is provided on entry to the program.

1.4 DBMG

The DBMG overlay is the OGIRS data base management program. Both data manipulation of single data sets and interactions between data sets are available as user selectable functions in DBMG. Three categories of data base management functions are available: arithmetic functions, relational modes, and mapping functions. A directives list for DBMG is provided upon entry to the program.

The DBMG arithmetic functions include the following set of operations: add, multiply, divide, square root, exponentiation, and natural logarithm. These operations may be applied to a thematic library data set and a constant, or between two or more data sets. The resulting data set is stored in the OGIRS master file until it is saved in a thematic library.

The five DBMG relational modes include: equals, greater than, less than, greater than and less than, and less than or greater than. Relational modes operate on individual data sets and user selected constants. The modes are used as a feature selection function giving the user the ability to isolate values, or ranges of values, from the total data set.

DBMG's mapping functions allow a user to construct composite maps from two or more thematic library data sets. Composite data sets may be generated using intersection, union, or exclusion set theory functions. The resulting data set is stored in the master file until it is saved in a thematic library.

Each of the three data base management functions has a valuable utility for manipulating data when used separately, however, when one or more of the functions are used consecutively their power increases. The interactive capability of the DBMG program overlay provides the user with a flexible model building tool. Very few constraints are placed on the user allowing the range of potential models to extend from computing soil loss to site suitability analysis. Any algorithm which uses the arithmetic functions, relational modes, and mapping functions described above may be interactively implemented on all or any part of the data available in a thematic library.

Figure 3. Line printer map produced by the MAPS overlay.

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EASTMINE HYDROLOGIC SOIL GROUP
CRAIG
LL = 1      LL = 10
LE = 1      LE = 15
CH = 4
DATE: 25/02/82      LIBRARY DESCRIPTOR: SOIL
  
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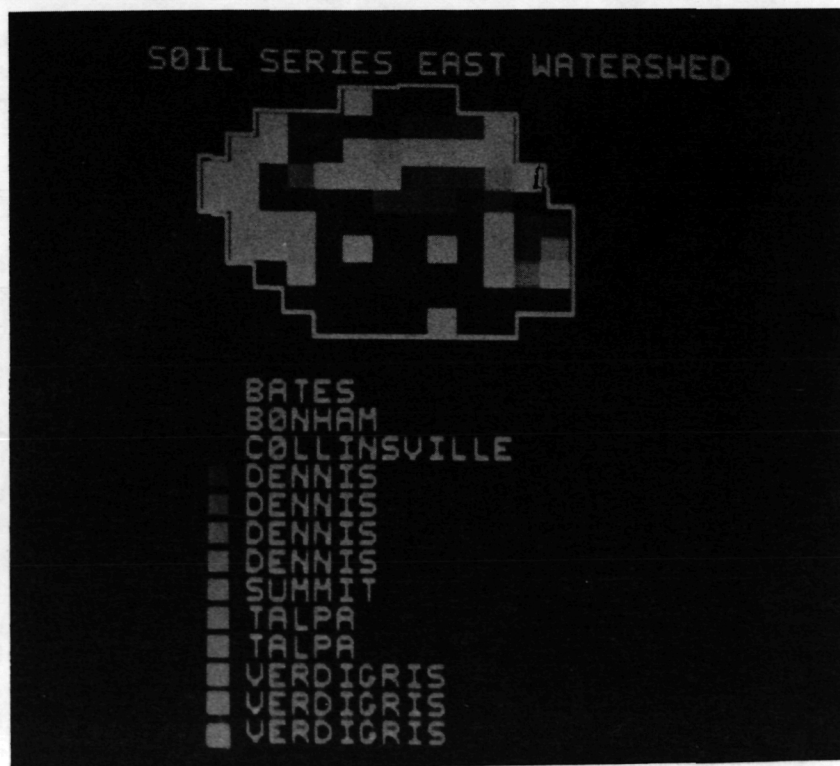
      A B B C
A A B B C C C C C
A A B B C C C B B B C
A A B B C C B B B B B
A A A B C C B B B C B B
A A A B C B B C B C B B
      B A B B B B B C B C
      B B B B B B B B
      B B B B A B B
  
```

LEGEND

CAT #	VALUE	SYMBOL	FREQ
1	4	A	16
2	3	B	63
3	2	C	20

3 CATEGORIES 99 CELLS 990A AREA

Figure 4. Digital image generated by the MAPS overlay.



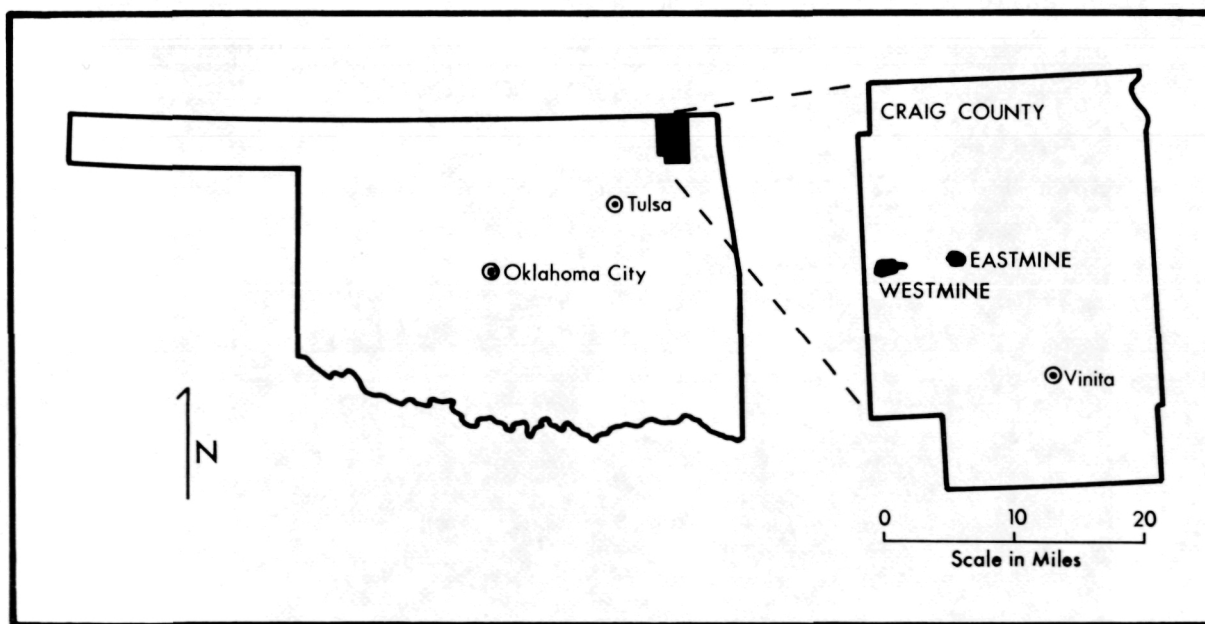
APPLICATIONS

The Oklahoma Geographic Information Retrieval System was developed for a pilot project concerned with geographic information system applications to surface mine management [13]. The Oklahoma Department of Mines provided the funds for the initial project. The main objectives of the study were: 1) to provide a computer based geographic information system to store and retrieve many disparate data sources including remotely sensed data from satellites, field data, and available map data; 2) to provide techniques for manipulation of the data sources; 3) to provide mine inspectors in the field with the data reduced to a manageable, easily interpreted format to determine compliance with state and federal mined land reclamation laws.

Oklahoma's Mining Lands Reclamation Acts of 1968 and 1971 [14] and the United States Surface Mining Control and Reclamation Act (PL 95-87) [15] require all mine operators to reclaim strip mine lands. The need for effective reclamation is keenly felt in Oklahoma where 14326 ha (35400 acres) of land had been disturbed by surface mining by 1973. Less than 25 percent of the total mined land had been reclaimed by 1973 [16]. A resurgence in surface mining occurred in the post energy crisis years of the 1970's and the demands on inspectors to cover the greatly expanded area and number of mines led to the need for updating inspection techniques. The choice was to use satellite (Landsat) remotely sensed data to monitor conditions at mine sites, however, the satellite data were capable of providing only a few of the many variables inspectors had to contend with when monitoring mine sites. A geographic information system which incorporated the timely land cover information derived from Landsat, archived geological, hydrological, pedological, climatological, and other natural resource data, and field site inspection information became a realistic solution to a mammoth data management problem.

Two small watersheds in northeastern Oklahoma's Craig county, 88.6 km (55 miles) northeast of Tulsa (see Figure 5) were chosen as study areas. The eastern watershed covers 978 ha (2416.6 acres) and includes an active coal mine. The western watershed

Figure 5. Location of study areas.



is 1403 ha (3466.8 acres) in size and does not contain any mining activity at the present time.

Data for both watersheds were collected, digitized, and stored in thematic libraries. Figure 2 presents the contents of the thematic libraries. The flexible data manipulation capabilities of the OGIRS software package were used to generate new data sets from the disparate data in the thematic libraries. Examples of the data presentation, feature selection, and modeling capabilities of OGIRS follow.

The archived data sets were used unchanged as presented as hard copy output maps to supply needed information on the physical environment of the study sites. A slope angle map is shown in Figure 6. The map was used to determine critical slope areas as well as baseline slope information.

The feature selection capability of OGIRS was used to isolate specific features from complete data sets and then present the extracted information as a new map (see Figure 7). Specific soil types were isolated from the soil series data set by this method. In addition, the OGIRS mapping functions were used to combine two or more data sets generated by the feature selection mode. A map showing areas with the greatest runoff potential was constructed by intersecting the runoff potential map with a map representing only the steepest slope angles (see Figure 8).

The modeling capability of OGIRS is specifically designed to allow maximum user flexibility. Consequently, few structured modeling modules have been included in the program package. The coefficient of areal association (CAA) model has been included as a module because of its importance in displaying the areal correspondence between two maps. The algorithm for computing the CAA [17] is included in the MAPS overlay. The CAA is a statistical model that describes the areal correspondence of two maps as a decimal value between 0 and 1. A zero value describes total dissimilarity, whereas a value of one indicates the two maps are spatially identical. The CAA model was used to determine which types of bedrock are most commonly associated with high elevations. A map displaying a specific bedrock type selected from the bedrock data set in the geological thematic library is compared to the map displaying elevations over 243.8 m (800 feet). The resulting CAA value of 0.4349 gives the degree of areal association of that bedrock type to high elevations..

Figure 6. Slope angle map for the eastern watershed.

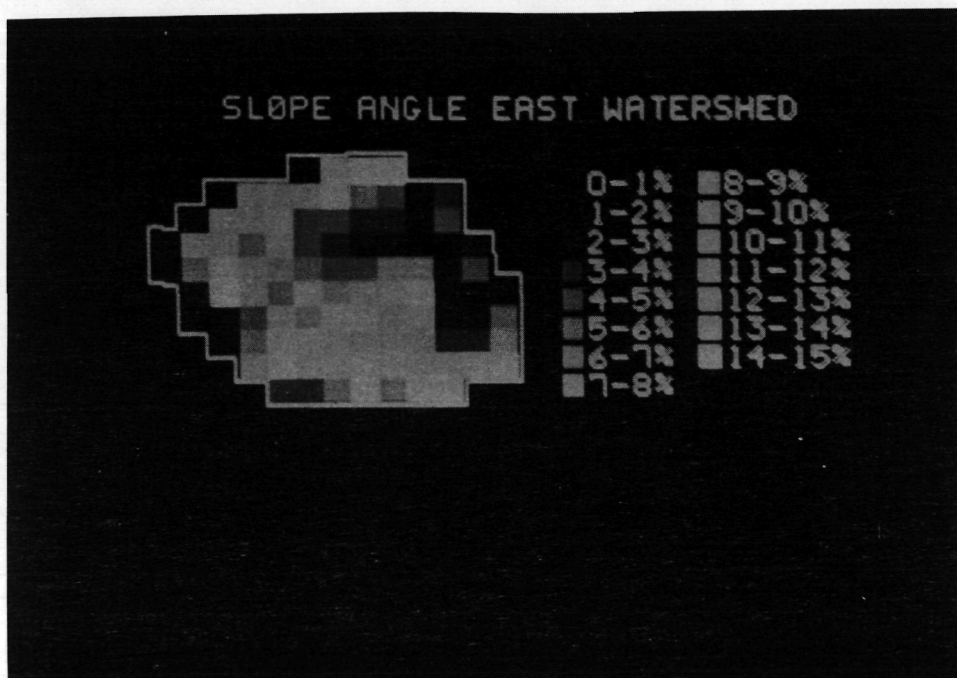


Figure 7. Map displaying feature selection capability.

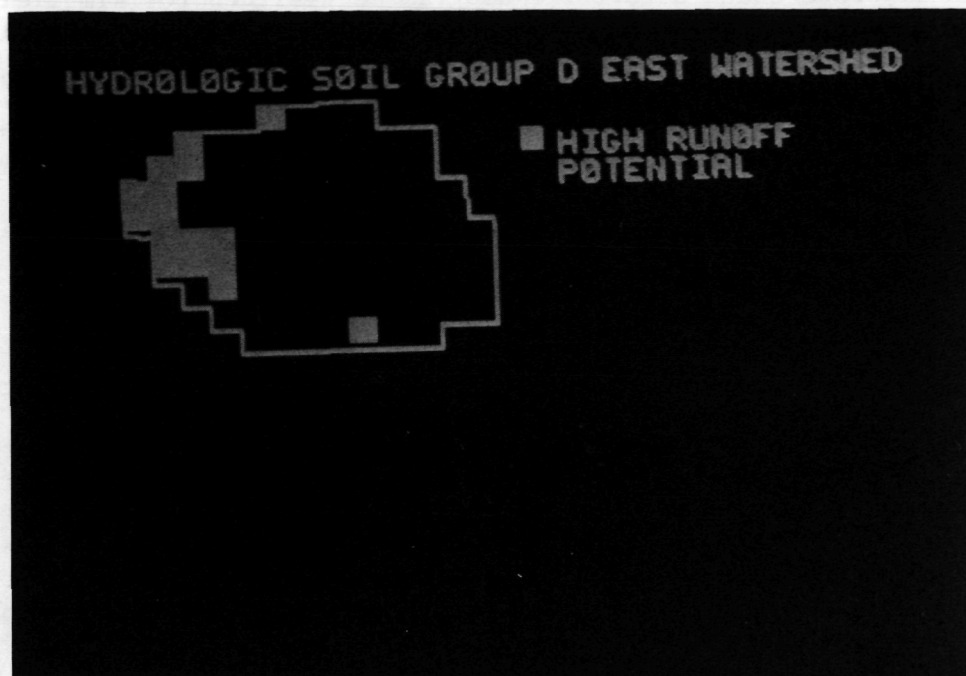
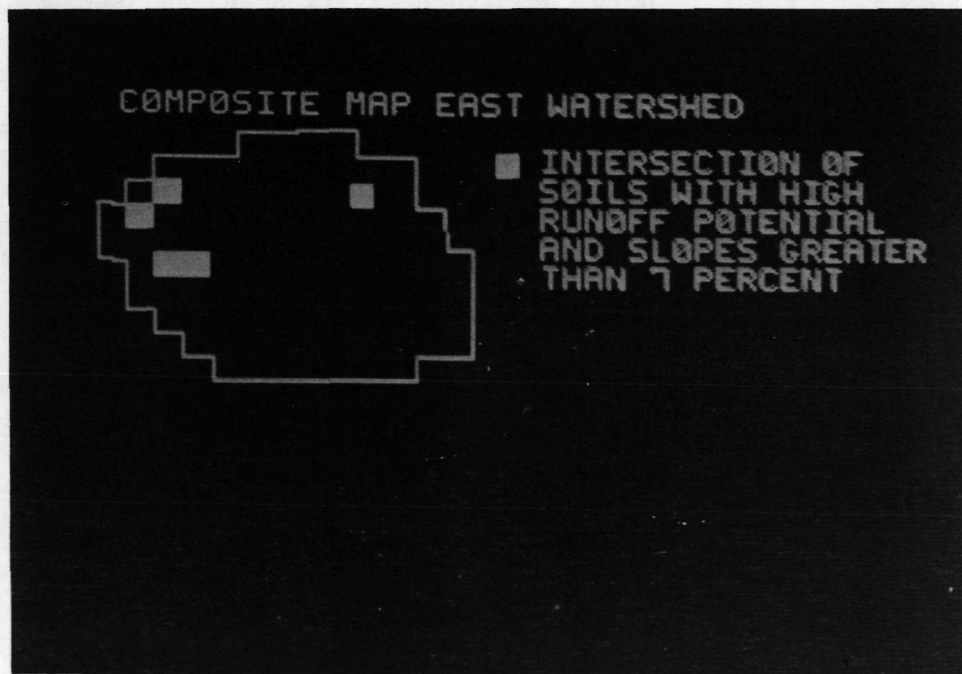


Figure 8. Greatest runoff potential map.



CONCLUSIONS

The Oklahoma Geographic Information Retrieval System (OGIRS) is a flexible, highly interactive data entry, storage, manipulation, and display software system for use with geographically referenced data. The program is designed for simplicity and efficient operation. Data are entered from a variety of original sources including: remotely sensed digital data, field samples, and archived information. The digitized data are stored in a common format in thematic libraries on magnetic disk. OGIRS allows a user to design applications models from the arithmetic operands, relational modes, and set theory mapping functions available in the data base management overlay.

The OGIRS software package has been applied to surface coal mine management and reclamation for a small pilot project in Oklahoma. The program allowed a large quantity of information to be managed quickly and efficiently.

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