

ALTERNATIVE APPROACHES TO DISPLAY OF USGS
LAND USE/LAND COVER DIGITAL DATA

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ABSTRACT

This paper outlines a procedure for converting the USGS GEODATA Land Use and Land Cover files into polygon and raster formats that are compatible with several widely used software systems. Examples are included for SAS/GRAPH®, GIMMS and MAP. There is also a discussion of an approach to handling the grid format on IBM-PCs and color frame buffer systems.

INTRODUCTION

Through the recent advertisements of GEODATA in commercial magazines, the US Geological Survey has made a major statement concerning digital cartographic products (Computer Graphics World, 1984). The "Quiet Revolution" is ready to evolve into the accepted standard for future map products (USGS, 1983). While the suppliers of digital cartographic data appear eager to disseminate their products, the ultimate success of digital cartography will be measured only by its adoption within the user community. The value of all data is determined by its utility in problem solving environments. The utility of digital data is dependent upon its integration with powerful, inexpensive and easy to use hardware and software systems. While the geographic equivalent of the financial spreadsheet may not yet exist there are several alternatives available which can greatly facilitate the use of the GEODATA files. The twofold purpose of this paper is to examine the basic file structure of the land use/land cover component of the GEODATA files and to demonstrate a procedure that converts the file structure into formats compatible with the widely used vector and raster based processing systems. Furthermore, this paper will demonstrate how this type of data now can be handled on the new generation of personal computers and color frame buffer systems.

THE LAND USE/LAND COVER FILES AND GIRAS

In 1973 the USGS began creating maps and digital files of land use and land cover at the scale of 1:250,000 (Fegeas et al, 1983). At this scale, each land use polygon is classified into the 37 USGS level II codes (Anderson et al, 1976). Urban, or built-up land and water are compiled and mapped at 4 ha. minimum polygon sizes, while other polygons must exceed 16 ha. in area. At these minimum mapping units the 1° by 2° quadrangles contain an average of almost 3000 polygons. The decision to map the Nation in digital form at this scale dictated that the USGS develop both an efficient topological data structure and a sophisticated geographical data handling system. The data structure, based on arcs, is a direct descendant of DIME segments and POLYVRT chains (Fig. 1) (Peucker and Christman, 1975). These arcs can be

created, edited, mapped and converted into polygons and grid cells with the Geographical Information Retrieval and Analysis System (GIRAS) (Mitchell et al, 1977). Although it was not designed to be a mapping system, GIRAS does include two map generating programs: SHADE, a sophisticated shading routine that efficiently handles complex islands (Fig. 2): and PTC-MAP which generates crude lineprinter displays of the grid cell data. Neither of these routines allows the type of flexibility needed in a comprehensive mapping system.

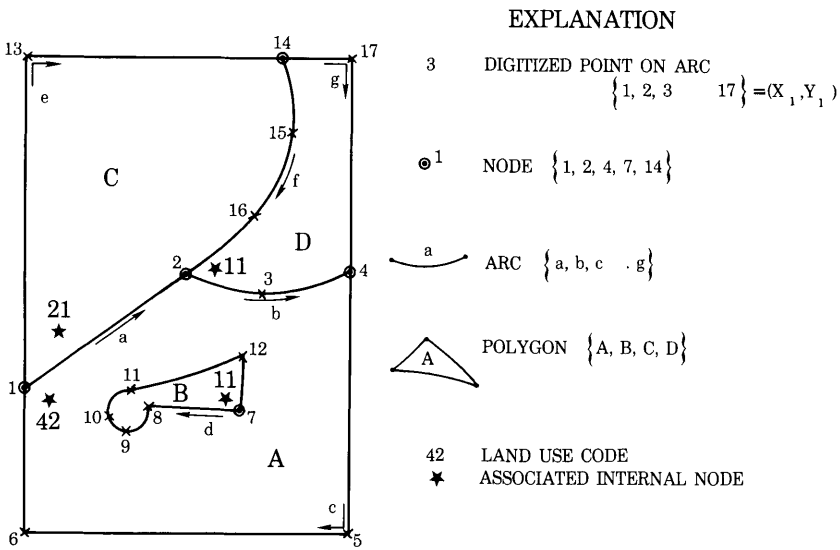


FIGURE 1
Simplified Version of Giras Topological Structure after Fegeas et al. 1983, p.5.

While GIRAS incorporated several approaches to geographical data processing which were state-of-the-art during the mid 1970's it is cumbersome to operate and, was never widely distributed by the USGS. Clearly a public organization such as the USGS is not staffed to provide user support for software as complex as GIRAS. More importantly, it can be argued that such developmental activities should be left to the private sector. The consequence of this decision has limited applications of digital land use data to organizations with sufficient resources to support a full scale integrated GIS system. Unfortunately, a large number of groups that could potentially benefit from the data collection efforts of the USGS have been left without appropriate software alternatives.

POLYGON CONVERSION ROUTINE

One approach to increasing the use of any database is to ensure that it is compatible with widely used software systems. Based on this premise an effort was undertaken to develop a computer program to convert the efficient GIRAS data structure into a more redundant but versatile format. The program creates a file compatible with any standard choropleth mapping routine, requiring a file of coordinate pairs (X_i, Y_i) to define the perimeter of a closed polygon. Usually this ring around the polygon (RAP) file circumscribes the polygon in a

clockwise direction and jumps inside the polygon to trace any embedded islands in a counterclockwise direction.

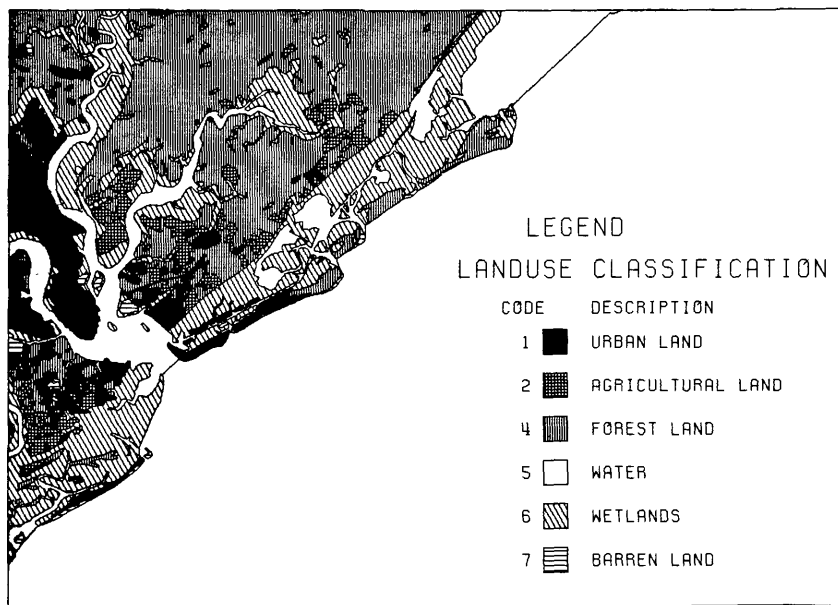


Fig. 2 GIRAS Output - SHADE Program - James Island, SC Quad.

The procedure developing a RAP file from four GIRAS subfiles is demonstrated in Table 1 which corresponds to the simple topological structure portrayed in Figure 1. The four subfiles consist of a sequential list of polygon labels, or two digit land use codes (PID), a list of ordered arcs that are chained to form a polygon (FAP), a file of pointers to the last coordinate contained in each arc (PLC), and a file of the arc coordinates arranged sequentially by arc (ARC). It should be noted that the **nodes** identified by the USGS on Figure 1 are actually end points of arcs that are computed during the GIRAS digitizing and editing steps. These **nodes** should not be confused with the points which locate internal labels for each polygon during this process. Furthermore, since the nodes in Figure 1 are common to at least two arcs they must be duplicated in the ARC file.

The conversion process combines each polygon in sequential order and writes out a file with land use codes and the corresponding coordinate points needed for mapping. For example, the first polygon (A) is processed by reading its land use code (42) from the PID file and writing it to a data file. The topology of the polygon is then read from the FAP subfile. This file contains the number of arcs (5) and the correct order (a, b, c, 0, -d) in which the arcs are to be linked to complete the polygon. In this example the first three arcs (a, b, c) define the perimeter of the polygon, while the zero "arc" acts as a flag to indicate the inclusion of an island. Such islands are always followed by the arcs that define the island in a counterclockwise direction (-d). The next polygon processed is the island B which consists solely of one arc (d). Similarly the FAP entry

for polygons C and D in Figure 1 would be 3, e, f, -a and 3, -f, g, -b respectively. Once the topology of the polygon is determined, the location of the coordinates in the ARC subfile are read from the PLC subfile. For example, the first arc (a) ends at the location of the second coordinate pair in the ARC file. Therefore, we know that it consists of X_1, Y_1 and X_2, Y_2 . The example in Table 1 demonstrates the manner in which these coordinates are ordered in the RAP file.

TABLE 1. CREATION OF RAP FILE FROM GIRAS

Polygon Sequence	GIRAS FILES				OUTPUT FILE	
	PID Polygon ID	FAP ARCS of Polygon	PLC Pointer Last Coord.	ARC Coordinates	RAP (Ring Around Polygon)	
				Order Xi,Yi	Polygon	Xi,Yi
A	42	5 (# of ARCS)				
	(Ever. Forest)					
		a (1st ARC)	2 ----->	1 1	1	1
				2 2	1	2
		b (2nd ARC)	5 ----->	3 2		
				4 3	1	3
				5 4	1	4
		c (3rd ARC)	9 ----->	6 4		
				7 5	1	5
				8 6	1	6
				9 1		
		0 (Flag)			1	0,0
		-d (Island)	16 ----->	16 7	1	7
				15 12	1	12
				14 11	1	11
				13 10	1	10
				12 9	1	9
				11 8	1	8
				10 7	1	7
----- End of 1st Polygon -----						
B	11	1 (Single ARC Polygon - Must be an Island)				
	(Residential)					
		d	16 ----->	10 7	2	7
				11 8	2	8
				12 9	2	9
				13 10	2	10
				14 11	2	11
				15 12	2	12
				16 7		

SAS Environment

The format of the RAP file described in Table 1 is directly compatible with SAS/GRAPH® polygon mapping files (SAS Institute, 1981). The PROC GMAP choropleth mapping procedure is capable of handling the lengthy polygon files and complex islands encountered within the land use/land cover files (Fig. 3). Although it lacks flexibility in terms of placement of legends and does not provide extensive shading options it does conveniently eliminates polygons which do not have corresponding data values (Fig. 4).

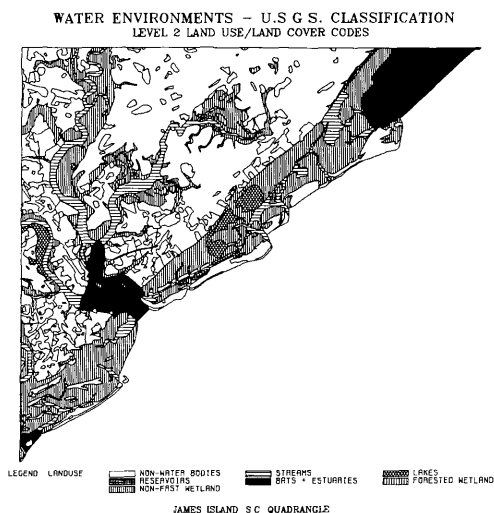


Fig. 3. SAS/GRAPH® Output - PROC GMAP

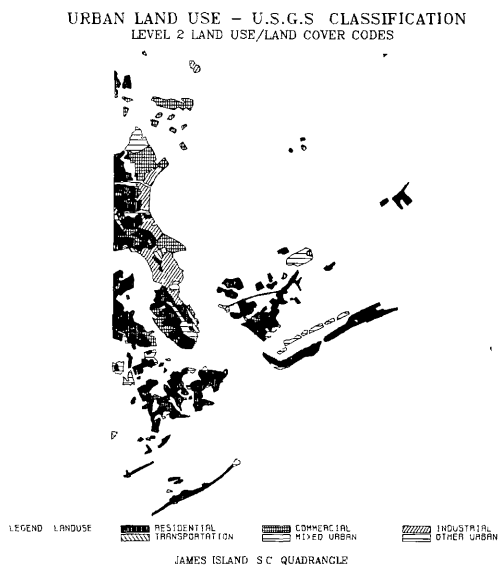


Fig. 4. SAS/GRAPH® Output - Drop Line Feature

Alternative Choropleth Programs

SYMAP: Once the polygon data are linked to SAS in RAP format they can easily be reformatted into basemap formats compatible with most other choropleth mapping routines. For example, even SYMAP A-Conformolines can be created from SAS/GRAPH® by explicitly closing the polygon, writing out appropriate labels, shifting the output order to

Y, X and translating the origin to the upper left. While limited experiments indicate that SYMAP has some difficulty handling the large number points contained in very complex land use polygons the logic of the conversion is straight forward.

GIMMS provides an excellent set of options for handling the GEODATA land use data. It actually serves as a useful combination of mapping procedures and geographical information system functions. In addition to extensive options for legends and symbolization (Fig. 5) GIMMS also provides functions for area calculation, centroid labeling and even statistical graphics. The SAS to GIMMS link simply formats the SAS file by removing the ID variable and closing each polygon with a slash.

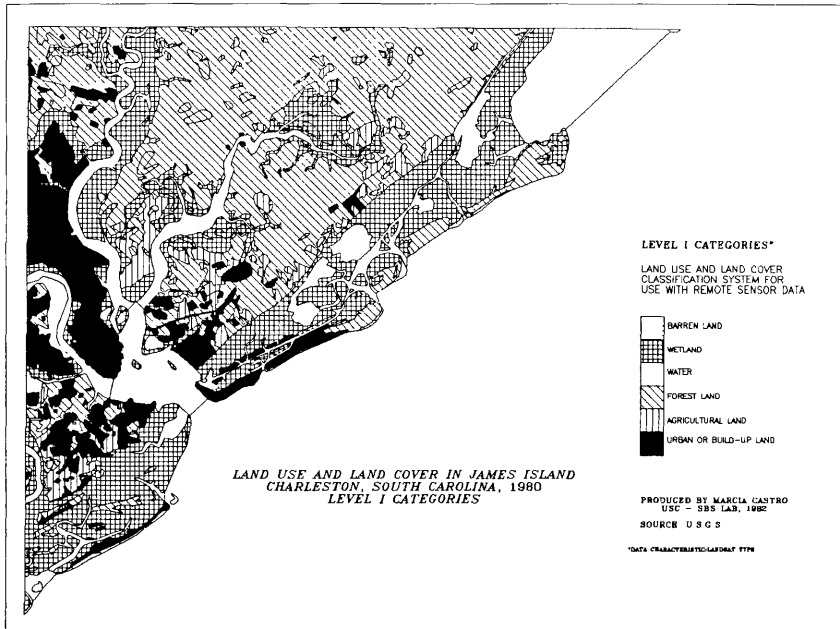


Fig. 5. GIMMS Output - Various Text and Legend Options

RASTER PROCESSING WITH MAP

Except for a polygon to grid conversion routine and some area calculation procedures, GIRAS remains a data base creation system. The GIRAS polygon to grid (PTG) procedure, which generates a single theme grid file in metric units registered to a UTM projection, provides a useful interface into grid oriented GIS functions. The Map Analysis Package (MAP) developed at Yale University provides an excellent set of procedures to analyze, integrate and display the USGS land use data in grid format. Since a MAP formatted database consists of rectangular matrices of map overlays, the output from PTG can be converted into a MAP dataset. Within the MAP environment line printer maps can easily be generated with the DISPLAY command (Fig. 6). Although the variation in lineprinter spacing results in distorted output of cellular data, MAP's ability to locate each cell and to associate it with its neighbors or other overlays more than offset the poor quality of the output for many applications.

Fig. 6. MAP Lineprinter Output - 500 Meter Grid Cells

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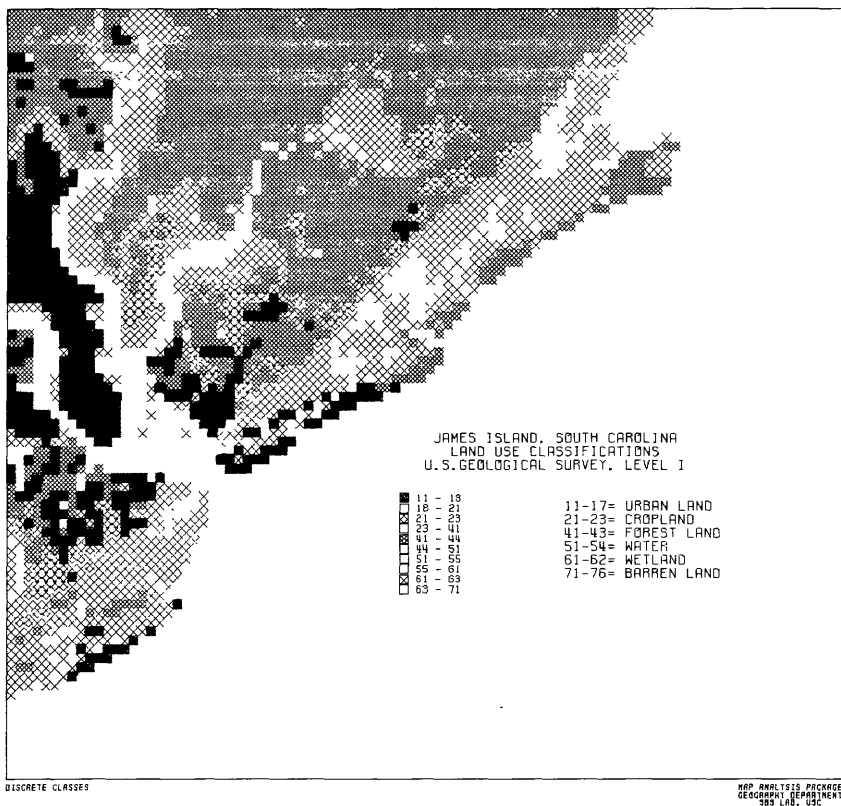


Fig. 7. Electrostatic BITMAP Output - 500 m. Grid Cells

IBM-PC COLOR FRAME BUFFER

Current technology has made it cost effective for most serious geographic data processing organizations to begin using high resolution color frame buffer systems. For example, several frame buffer systems are available for the IBM PC which provide high resolution and extensive color capabilities for less than \$5,000 (including monitor). Although MAP is still a mainframe based system several recent developments make it easy to download data from such systems to the IBM-PC. The IBM-3270 PC allows the user to run concurrent sessions of MAP using CMS on the mainframe as well as PC-DOS. MAP data sets can be quickly transferred (9600 BAUD) onto floppy or hard disk for additional processing. Using the XT-370 the entire MAP session can be downloaded and run locally. Using either device a MAP dataset can be converted into a bit plane format that can be converted easily and displayed by the frame buffer system.

A system with 9 bit planes and a resolution of 672 x 480 was used to display, at a scale of 200 m, the USGS land use data previously stored as a MAP data base (Fig. 8). Within the system the data are represented as color palette locations which can be assigned any of 16,000,000 different colors by indicating the 512 intensity levels of the RGB guns. Since color change does not involve any additional data transfer the resultant image can be changed quickly based on user

criteria. For example, by a simple color assignment step any of the land use categories can be viewed individually or in combination of any of the colors. In addition, the user can interactively add legends and text to the image (Fig. 9). Presently there are several color ink jet and thermal transfer devices available that should provide inexpensive means of generating color hard copy from the frame buffer system. Such devices will have an enormous impact on the practicality of using color raster processing of such land use data and, probably, will further accelerate raster processing of land use data. In such a processing environment there could be wide spread use made of the composite theme grid format for the USGS GEODATA digital data.

CONCLUSION

This paper has demonstrated a set of procedures which can greatly increase the use of the USGS GEODATA Land Use and Land Cover digital data by converting them into more compatible polygon and grid formats. In these formats the data can be easily processed by a number of widely available software systems. Furthermore, the paper has demonstrated that the data can also take advantage of recent advancements in personal computers and raster display technology.

ACKNOWLEDGMENTS

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Fig. 8. IBM-PC/Color Frame Buffer Configuration

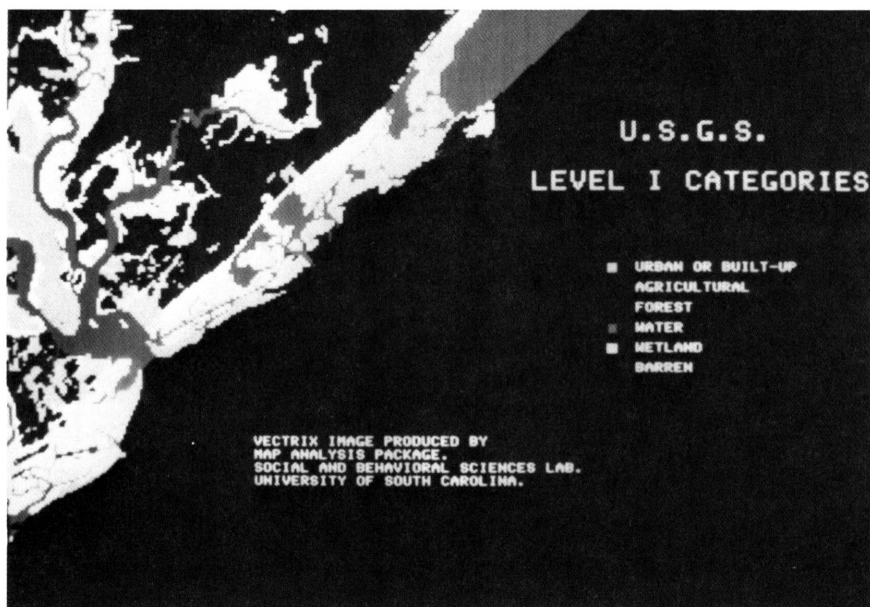


Fig. 9. Color Frame Buffer Display - 200 Meter Grid Cells



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