Computer produced choropleth maps with overlays: An aid in urban and regional analysis

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To cite this article:

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An Aid in Urban and Regional Analysis

by
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The centuries-old art of cartography has in recent years become the activity of the computer as society in general has moved into what might be called «The Age of the Computer.» Although computer mapping as a technique is only about ten years old, geographers and others are making good use of this new technique to gain additional knowledge of the earth and its people. Today computer mapping centers are located coast to coast and simplified computer maps may be produced on limited (small) computers available to almost any researcher. Many mapping programs have been developed and these are readily available at relatively low cost.[1]

Much has been written about computer mapping but little has been said about the use of overlays along with the computer printout. The purpose of this paper is to demonstrate the advantages of the «computer mapping-overlay technique» to those who require a quickly produced visual map to aid in data analysis. CMAP (choropleth mapping program) is utilized with a variety of overlays to illustrate some of the possible uses of this technique.[2] CMAP was chosen because it is simple to use, requires limited core storage, is easily modified, and is available at almost no cost.

the CMAP technique

CMAP is a FORTRAN program designed to produce choropleth or conformant area maps using a scan-line concept. The scan-line procedure makes possible the use of small computers in that storage requirements are reduced by having only one print line of the map in memory at anytime. When the line is printed, that portion of core storage is then available for the next print line of the map. Therefore the size of the map is not restricted by the memory requirements of the program and running time on the computer is the only consideration. The author has produced single page maps on an IBM 7040 taking about one minute each and on an IBM 360 in less than fifteen seconds each.

Scan-line base maps may be produced for various types of areas including, among others, countries, states, standard metropolitan statistical areas, urbanized areas, and counties. The data areas are printed on the map according to the classification of

1. See for example SYMAP, Laboratory for Computer Graphics and Spatial Analysis, Harvard University; GRIDS, Census Use Study, US Department of Commerce; and CMAP, Bureau of the Census, US Department of Commerce.

2. The CMAP program was originally developed by Morton W. Scripter, Department of Geography, University of Idaho. The program used here was modified and adapted by David J. Cowen and Paul E. Lovingood, Jr., Department of Geography, University of South Carolina.

their statistical values. Class intervals may be chosen systematically, arbitrarily, or by use of a fixed scale. The statistical values may be totals, percentages, densities, residuals, etc. The user specifies the number and limits of statistical classes or he may request that a statistical program select them. Class symbols are assigned by the user and printed in the respective data areas. Various gray scales may be obtained by overprinting two or more printer characters. Map titles and references may be two or more print lines in length and additional information may be printed in the background area of the map.[1]

Line boundaries around data areas do not appear on the map as it comes from the computer printer (Figure 1). This may be no problem if the print symbols are carefully selected so as to produce sufficient contrast between the various data areas. In addition place names of data areas are not usually printed by the computer. The utility of computer maps is greatly enhanced by overlays to add place names, boundaries, and other information (See Figure 2). The scan-line base map may be adjusted so as to provide background area for this information. The overlay is placed on the computer printout and the map may then be photographed, printed, or copied in other ways (See Figure 3 and other maps that follow).

computer maps for data display

The increasing amount of data that is being collected in machine-readable form has been a major factor in the advancement of computer mapping. Modern urban and regional planning is demanding that this data base be brought to its optimal use by the combination of analytical techniques and immediate mapping. Conventional cartography does not offer a viable solution to this problem. There is a lack of personnel for manual production, mapped data are out of date before the map is even finished, and the cartographer cannot adjust to the ever-changing needs of the planner and other researchers.

The CMAP technique used with overlays provides a method for rapid display of data in atlas form. Such atlases may be produced in a matter of hours at relatively low cost. Computer produced atlases may not «look so good» when compared to those produced by conventional methods, but the

planner and others are interested in quick responses with the latest data when questions come up.[2] The planner really needs a «loose-leaf» atlas that can be quickly adjusted to display today's data today.

The following maps illustrate some possible uses of computer produced choropleth maps with overlays for data display. Maps of this type are easily converted into transparencies as visual aids in data display. Figure 3 shows the range of per capita income by counties in South Carolina for 1969. Class intervals were arbitrarily chosen and are uniform. An overlay was used to show county boundaries, place names, and map scale. The spatial patterns demonstrated by this map might have value in the location of future industries in the State.

Figure 4 shows a map of a rapidly changing variable characteristic of much of the data used by government agencies. Class intervals were arbitrarily chosen and are irregular. The pattern of motor vehicle accidents is essentially the same as that of population in the State. An overlay was used to show county boundaries, place names, and map scale.

Figure 5 is a map of cropland as a percentage of total land by counties in South Carolina for 1967. An overlay was used to show county boundaries, place names, map scale, and the area of the Lower Savannah Planning Region. The planner is able to see how counties in this region vary in terms of a particular variable and how they compare to other counties in the State.
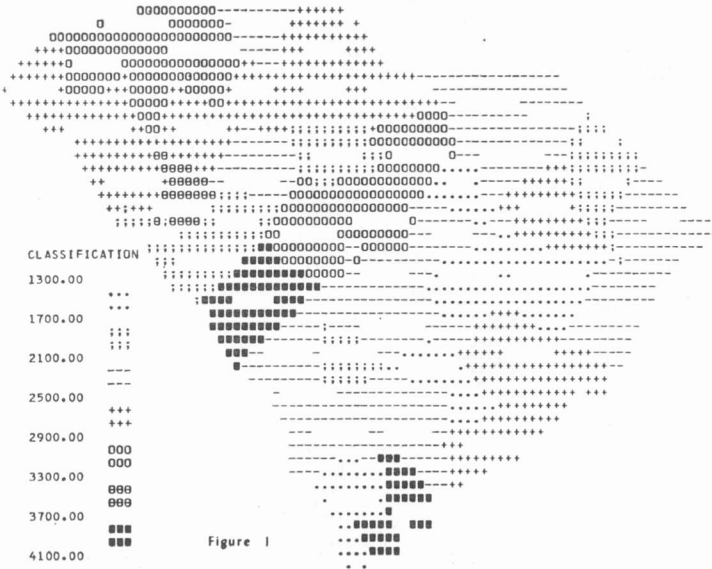
Figure 6 is a map of the percentage of Black population for the ten planning regions in South Carolina. The counties in a given region were mapped showing the percentage for the region as a whole and not on an individual county basis as on the previous map. An overlay was used to show county boundaries, place names, map scale, and the boundaries of the planning districts. Planning at the state level demands a knowledge of differences between regions as depicted on this map.

Figure 7 shows the percentage of cash receipts from sale of cattle and calves on a county basis for South Carolina in 1970. An overlay was used to show county boundaries, place names, map scale, and the boundary between the piedmont and coastal plain physiographic provinces. The map clearly illustrates the dominance of the piedmont in this important economic activity. Overlays showing edaphic, climatic, and other types of regions may also be used on computer maps.

1. For a detailed study of CMAP procedures see Mark S. Monmonier, «*The* Production of Shaded Maps on the Digital Computer,*»* The *Professional Geographer,* XVII (September, 1965), 13-14, and Morton W. Scripter, «Choropleth Maps on Small Digital Computers,» *Proceedings of the Association of American Geographers,* I (1969), 133-136.

2. For a look at a computer produced atlas using the CMAP program with overlays see David J. Cowen and Paul E. Lovingood, Jr., *South Carolina Industrial Atlas,* The Research Services Division, S. C. State Development Board, Columbia, S. C., 1972.
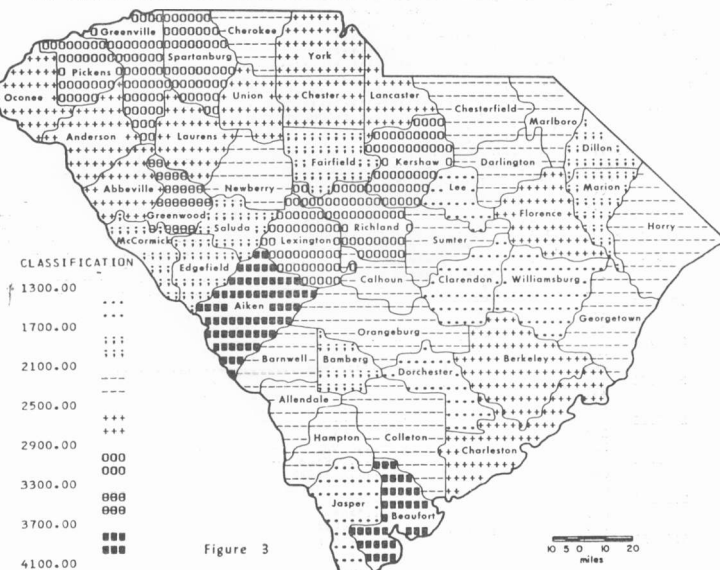
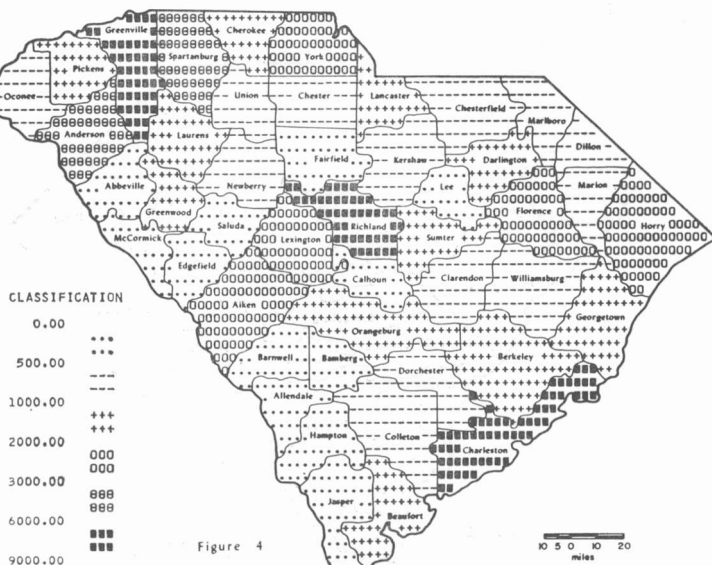PER CAPITA PERSONAL INCOME, BY COUNTIES, IN SOUTH CAROLINA — 1969

Figure 1

BASIC OVERLAY

Figure 2

PER CAPITA PERSONAL INCOME, BY COUNTIES, IN SOUTH CAROLINA - 1969

CLASSIFICATION

1300.00

1700.00

2100.00

2500.00

2900.00

3300.00

3700.00

4100.00

Figure 3

TOTAL MOTOR VEHICLE TRAFFIC ACCIDENTS
SOUTH CAROLINA 1971

CLASSIFICATION

0.00

500.00

1000.00

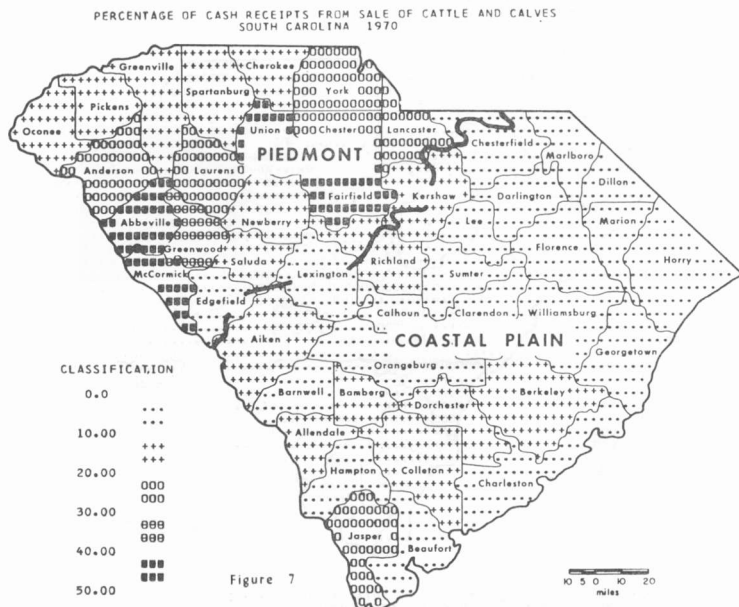2000.00

3000.00

6000.00

9000.00

Figure 4

314.

CROPLAND AS A PERCENT OF TOTAL LAND BY COUNTIES,
LOWER SAVANNAH REGION AND SOUTH CAROLINA — 1967

Figure 5
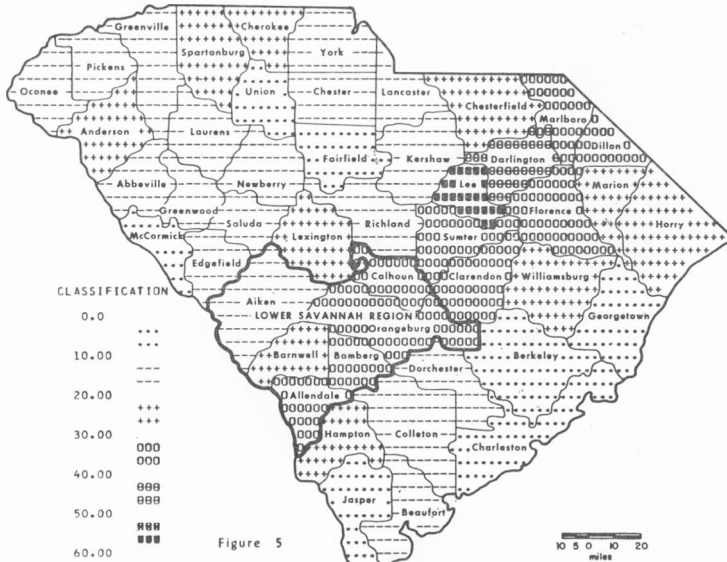
BLACK POPULATION AS A PERCENT OF TOTAL POPULATION — 1970
SOUTH CAROLINA PLANNING AND DEVELOPMENT REGIONS

Figure 6

PERCENTAGE OF CASH RECEIPTS FROM SALE OF CATTLE AND CALVES
SOUTH CAROLINA 1970

Figure 7
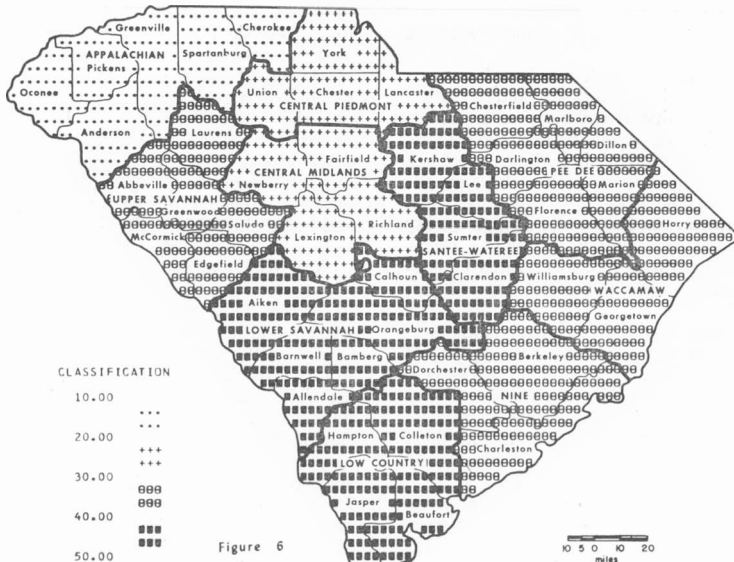
other applications of computer mapping

The CMAP technique with overlays has great potential for geography, planning, and/or other sectors of society in that it can play an important role in data gathering, data analysis, and formulation and reformulation of hypotheses. In such analyses maps are necessary because they are the only means of storing data in a two-dimensional context. The maps do not have to be of high quality but they do have to be produced quickly at a relatively low cost. In fact CMAP along with other computer mapping routines was initially developed just for these uses.
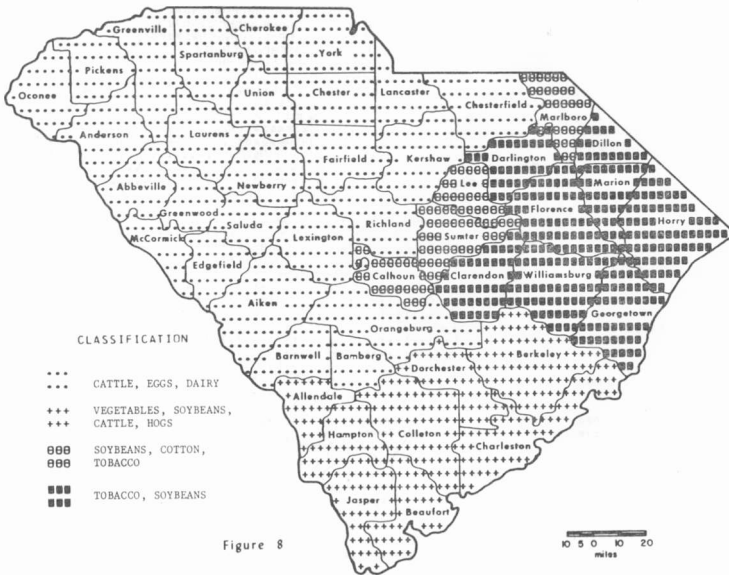
A computer map is only as accurate as the original information, or data, fed into the computer. If the original data is inaccurate, the map will show a false or unexpected pattern. An inaccurate computer map may have value in the data gathering process in that it quickly tells the researcher that he must recheck his original data for errors. Conventional map making does not offer this advantage.

More and more research is now conducted using data which has been subjected to numerous and complex calculations by digital computers. Many packaged programs are available for such analyses in map
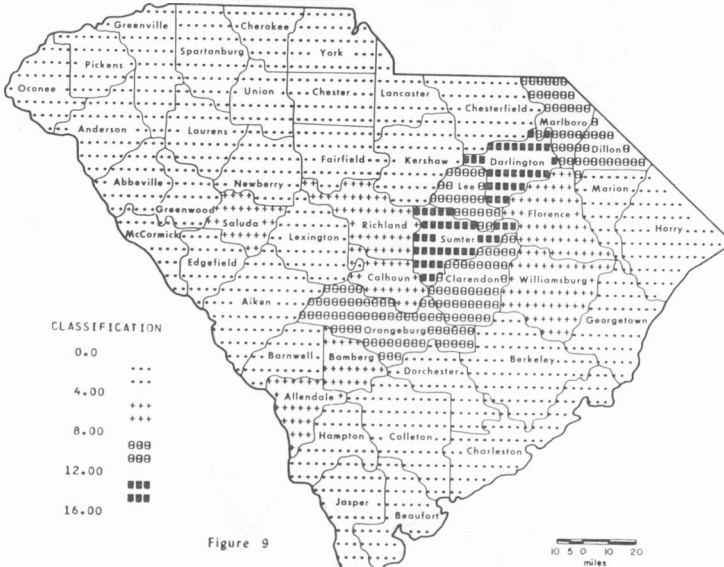
form. Thus the maps serve as a logical extension and adjunct to the numerical analyses presently performed on digital computers. It is possible, therefore, to compare hypothetical and real distributions and to map their residuals. Figure 8 shows crop-livestock regions for South Carolina in 1970. The regions were derived by employing a computer algorithm that performed a multivariate grouping operation on the forty-six counties of the State using sixteen crop and livestock variables. An overlay was used to show county boundaries, place names, and map scale.

The display of data by means of computer maps often causes spatial distributions and relationships to emerge. Such distributions and relationships may not be evident by examining data in tabular form. Computer maps may then play a role in the formulation of hypotheses. Figure 9 and 10 demonstrate a significant correlation between the variables high quality land and percentage of cash receipts from sale of cotton in South Carolina for 1960. The author had previously carried out a correlation analysis using land quality with percentage of cash receipts from cotton, dollar value of cotton, acres of cotton, and yields of cotton. After the two maps were made, the spatial relationships became evident and the hypothesis that cotton production remains econom-
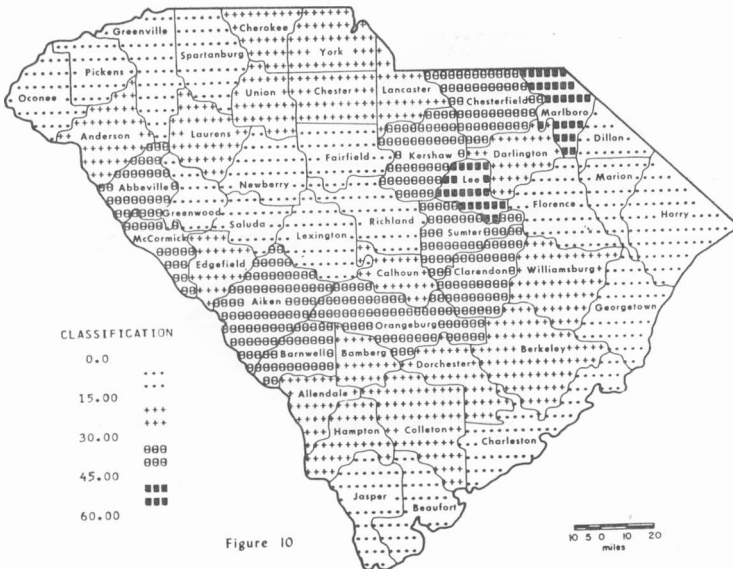
CROP-LIVESTOCK REGIONS -- BASED ON PERCENTAGE OF CASH RECEIPTS
SOUTH CAROLINA 1970

CLASSIFICATION

```
...
...    CATTLE, EGGS, DAIRY

+++    VEGETABLES, SOYBEANS,
+++    CATTLE, HOGS

888    SOYBEANS, COTTON,
888    TOBACCO

███    TOBACCO, SOYBEANS
███
```

Figure 8

10 5 0   10   20
        miles

CAPABILITY CLASS 1 LAND AS A PERCENT OF TOTAL LAND
BY COUNTIES, SOUTH CAROLINA


```
CLASSIFICATION

0.0      ...
         ...
4.00     +++
         +++
8.00     888
         888
12.00    ███
         ███
16.00
```

Figure 9

10 5 0   10   20
        miles

317

PERCENTAGE OF CASH RECEIPTS FROM SALE OF COTTON AND COTTONSEED
SOUTH CAROLINA 1960

CLASSIFICATION

0.0

15.00

30.00

45.00

60.00

Figure 10

10 5 0 10 20
miles

PERCENT NEGRO OF ALL PERSONS, BY CENSUS TRACTS,
COLUMBIA, S.C. —URBANIZED AREA— 1970

CLASSIFICATION

0.0

20.00

40.00

60.00

80.00

100.00

N

3 2 1 0   3   6
1,000 ft
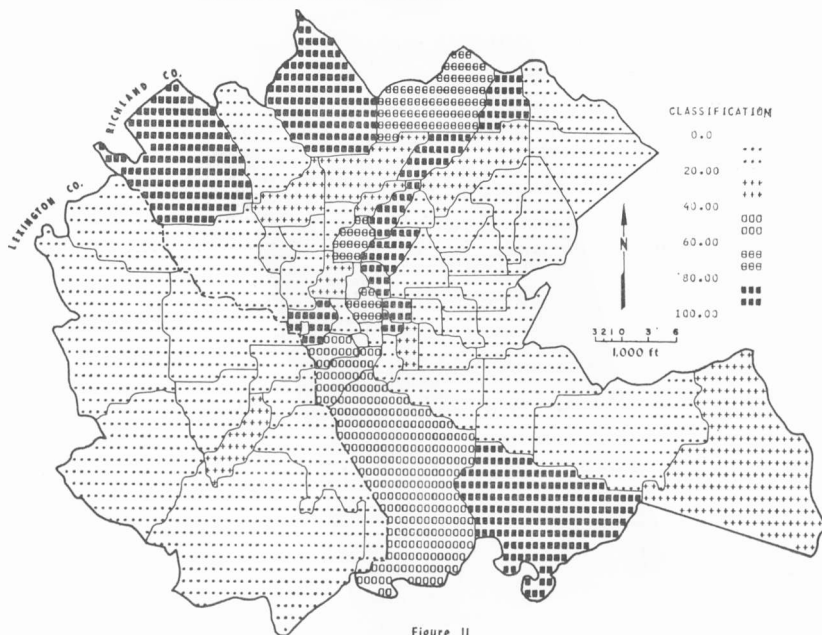
BLANK = INSTITUTIONAL AREAS

Figure 11

RATE OF INFANT DEATHS PER 1000 LIVE BIRTHS, BY COUNTY OF RESIDENCE
SOUTH CAROLINA 1970

Figure 12
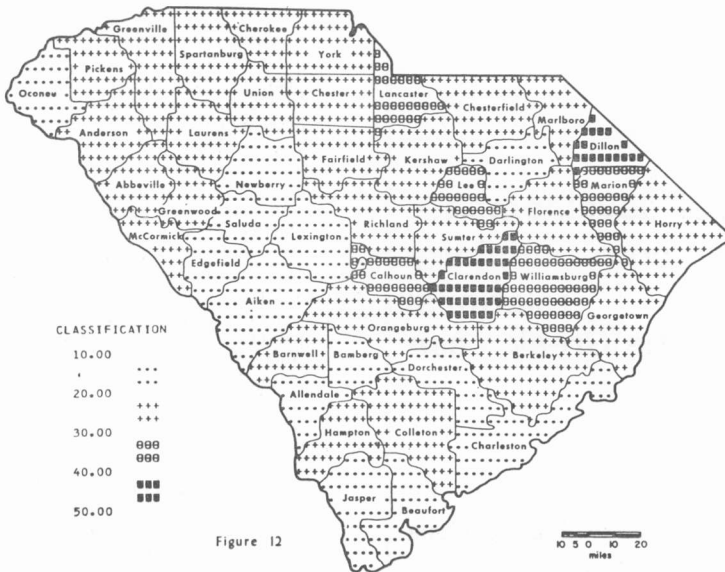
ical only in those counties having a high percentage of high quality land was accepted. A transparency of one map may be superimposed on the print of the other map as an aid in understanding spatial distributions and relationships. Overlays were used on both maps to show county boundaries, place names, and map scale.

Computer maps serve as «data-banks» and may provide information and ideas for other studies. Figure 11 is one of several maps made for a population and economy study of the Urbanized Area of Columbia, South Carolina. In studying the distribution of Black population in Columbia, the idea of testing Hoyt's Sector Model arises.[1] The CMAP technique, because of its speed and low cost, makes possible the mapping of many variables in theoretical research. Map comparison may then give rise to many questions for future study. Figure 12 shows the rate of infant deaths by counties in South Carolina for 1970. The immediate question which one gets from this map is: how is it possible for the infant death rate to vary so much from county to county or why the concentration in the Pee Dee Region of the State?

1. Homer Hoyt, *The Structure and Growth of Residential Neighborhoods in American Cities* (Washington: Federal Housing Administration, 1939).

summary

Modern urban and regional analysis demands a rapid and accurate system of mapping a wide range of societal information. Conventional cartography cannot satisfy this demand and the planner and researcher have turned to the computer. CMAP is only one of many systems of computer mapping but it is easily adapted for use with overlays. The advantage of this system is that once the computer base map is operational only the overlays need to be changed to vary the maps. All of the South Carolina maps presented in this paper were produced on the same computer base map.

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