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Design Considerations in a Microcomputer program for Choropleth Mapping

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Introduction

A little more than 500 years ago and not very far from here, cartography entered a new era with the invention of printing. This development made possible the distribution of maps to a much larger portion of the population. However, these early printed maps were by no means inexpensive and could not be purchased by all people but a significant portion of the population at least had access to this new medium -- the printed map.

A little more than 10 years ago, with the development of the microcomputer, cartography may have entered another era. This development made possible the use of computers by a much larger portion of the population. Initially, computers were used in cartography to assist in the production of the printed map. Now, maps are routinely created and used directly from the screen of a computer. These maps are rarely printed on paper and yet they serve as a form of cartographic communication. Microcomputers are also not inexpensive and cannot be obtained by all people but a significant portion of the population now has access to this new cartographic medium for cartography.

The distinctive nature of the map on the screen of the computer comes from the level of control that is provided the map user in how the map is displayed and what is represented. In contrast, the map on paper is a static representation and uncompromising with the map user. Once a person has experienced the level of control, interaction and display speed that is possible with a computer, they are rarely satisfied with a map on paper.

We are dealing with a new medium in cartography. It is an exciting time. We have new questions to answer. Foremost among these is how we can improve the level of interaction between computer and map user. The purpose of my presentation today is to first review recent developments in the man-computer interface, particularly with microcomputers. Then a particular cartographic user interface is presented by examining a choropleth mapping program that has been written for the Apple Macintosh computer. Finally, a critical aspect of this interface - the speed of map display - is given closer attention.

INTERFACE

The interaction between man and computer has been of great concern since the introduction of computers in the 1950's. The word 'interface' is used to describe the junction or boundary between man and computer. Interface represents the bridge between these two very different systems.

In the late 1960's, researchers at the Xerox Palo Alto Research Center or PARC in California began to pursue a 'desk-top' metaphor design for a user interface. They envisioned a computer screen as an analog to a desk that consists of a variety of documents and tools to manipulate them. The research at PARC eventually produced a number of revolutionary computer designs that incorporated this desk-top, graphical user interface. The Star computer, for example, released in the late 1970's and priced at 16,000 dollars used a hand-held pointing device called a mouse, displayed information in separate windows and supported pop-up menus that appeared on the screen in response to a click of the mouse. The Star computer changed how we think of user interfaces.

In 1984, Apple Computer introduced the Macintosh that implemented the desk-top, graphical user interface complete with icons, windows, dialogs and the mouse. What made the Macintosh distinctive was its price - about two-thousand dollars. Millions of people could now interact with computers in an entirely new way.

The Macintosh microcomputer has since earned the reputation for having an intuitive user interface. It is within this particular interface that a cartographic user interface has been created.

Cartographic User Interface

A cartographic user interface is a particular interface that is intended for the creation of maps. It encompasses the rules and conventions that governs how a map user interacts with a computer to make maps. This interface must make use of a graphic pointing device, be intuitive to use and incorporate accepted cartographic principles. The program that has been developed here is called MacChoro and it is designed for the creation of choropleth maps that use shadings to represent value by area.

This cartographic user interface incorporates a variety of components including icons, windows, menus, heirarchical menus, dialogs and the integration of the mouse. Let me depict through slides these individual elements:

FIRST SLIDE PLEASE

ICONS - These are the file icons for this program. They are used to distinguish the different files. Icons that are clearly understood by all people are difficult to develop. They are represented with a 32 by 32 grid, as is seen here (NEXT SLIDE). Here a movie camera with a small map in the middle is used to represent a file that contains a series of maps and can be viewed at animation speeds.

WINDOWS - Graphics and Reduced-View (SLIDE)
Reduced-View (SLIDE)
Reduced-View with individual pages (SLIDE)
Reduced-View with large map (SLIDE).
Spreadsheet (SLIDE).
All Together (SLIDE).

MENUS - Classify menu(SLIDE)
Heirarchical menu(SLIDE)
Menu with map(SLIDE).

DIALOGS - Legend dialog(SLIDE)
Dialog with explanation(SLIDE)

Map Design

The MacChoro map display consists of five different elements. These include the map itself, a legend, a bar scale, the text fields and a neatline. The size and placement of these map elements is specified by a bounding rectangle that is defined with the mouse before the particular element is placed on the screen (SLIDE).

While the concept of the bounding rectangle to control the size of a map element is perhaps intuitive, its implementation is not without problems. For example, maps can be scaled to fit the limiting x- or y- coordinate dimension but this creates maps of non-standard sizes (SLIDE). Elements that incorporate text, including the legend also cannot be placed precisely because text is limited to specific point sizes. The bounding rectangle for the legend, for example, is used only to specify the vertical component (SLIDE) the horizontal dimension of the bounding rectangle is ignorned. For the text fields, two alternatives have been tested (SLIDE). Under the first method, implemented in a previous version of the program, the largest point size was found that would fit within the bounding rectangle. The second method, and the preferred method, is to specify the size of the text and to use the bounding rectangle only for the placement of the text. A dialog allows the user to change text display characteristics.(SLIDE).

While it will become possible in the near future to display text any any size on the computer screen, this may not be acceptable from a cartographic standpoint where standard text sizes are used to order map elements in a heirarchichal way.

The bounding rectangle represents an intuitive way to place and size map elements, however, it is only a general guide for the placement of map elements on the screen. In fact, all bounding rectangles are redefined once the map element has been drawn.

Map Display Speed

An important element of a cartographic user interface is the map display speed. Increasing the rate at which maps are updated on the screen can be accomplished in several ways. In MacChoro, polygons are created from lists of x,y coordinates (SLIDE) and stored in memory as a polygon data structure. Their shading can be redefined quickly by accessing the single variable that represents the location of the polygon in memory. Approximately, three seconds are required to display 50 polygons with new shadings.

Different attempts have been made to increase the display speed even further. In one attempt, the map was updated by redrawing only those polygons that had a different shading from the previous map on the screen. However, this caused the map update time to vary as a function of the number of polygons that needed to be updated and users objected to this inconsistency. While speed of map display is desirable, it seems the display speed must be consistent.

The procedure chosen to increase display speed is to place the maps in memory as bit-maps (SLIDE). Bit-maps are not really maps. They can be thought of as a matrix of 1's and 0's where 1 represents black and 0 is white. A bit-map the size of the Macintosh screen requires approximately 20 kilobytes. With 50 times that much memory or more available on many microcomputers, it is possible to place many screen displays in memory in the form of bit-maps. Once these bit-maps are defined in memory, they may be displayed at animation speeds - up to 60 frames per second. I will refer to these displays as map animations and the general procedure to create such an animation is as follows:

Step 1: a map display is created with map, legend, text and neatline (SLIDE)

Step 2: the classification method, number of classes and variable to map are chosen with a dialog (SLIDE)

Step 3: the maps are placed in memory as bit-maps.

Step 4: the animation display proceeds with maps being displayed on the screen at a user-defined rate. Various aspects of the animation can be adjusted with a menu palette and a dialog(SLIDE). The speed of display can be adjusted with a palette menu, shown here (SLIDE), that is activated with the mouse.

It is impossible for me to demonstrate the animation feature for you here. What I will do is to show you five maps very quickly so you have some idea of the visual affect that is achieved by the program. (SLIDEs) These maps depict the percent of births to mothers under 20 years of age. The maps presented here represent different classifications of this variable at 2, 3, 4, 5, and 6 classes.

The possibility of viewing a series of maps so quickly obviously alters the map use process considerably and the question arises: What is the ideal speed for map display? Studies with computer users on a variety of systems have shown that people adjust to display speed and begin to interact more effectively with the computer as display speed increases. It has been reported that in the absence of such constraints as cost or technical feasibility, people will eventually force response time to well under a second. It is interesting to note that this has been observed with the MacChoro program as well. Users will typically select a display speed of 1 second per map during the animation sequence. Presumably, however, if the animation sequence shows a trend or movement from one side to another then a faster display speed would be possible.

CONCLUSION

The program developed here represents an initial attempt at a cartograhic user interface. The separate windows provide a work area for the different map creation activities. The graphics window is much like a sheet of paper on which map elements can be placed, moved and resized. The reduced view window provides an overall view of the map display that facilitates the map design process.

A bounding rectangle approach has been used to size and place map elements on the screen. This procedure is workable but problems with the sizing of the text among other things make the bounding rectangles only a general guide for placement of elements.

The ability to display a series of maps very quickly represents perhaps the most distinctive aspect of the program. The potential of this technique to improve map communication still needs to be investigated.

As the computer becomes a more common medium for cartography, the interface between map and computer will assume a greater significance. Developments in microcomputer operating systems have drastically changed how we interact with computers and microcomputer mapping programs will drastically change how people interact with maps.

The screen of the computer represents a new medium for cartography. By incorporating new developments in the microcomputer-user interface and research in software psychology, cartographers can properly exploit the potential of this medium. Cartographers must be involved in the design of the cartographic user interface to best serve the needs of this new generation of map users. Thankyou.

File Icons

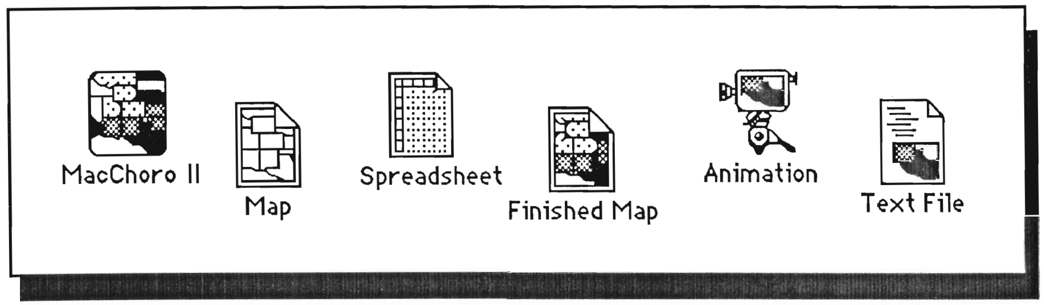


FIG. 1

Graphics and Reduced-View Windows

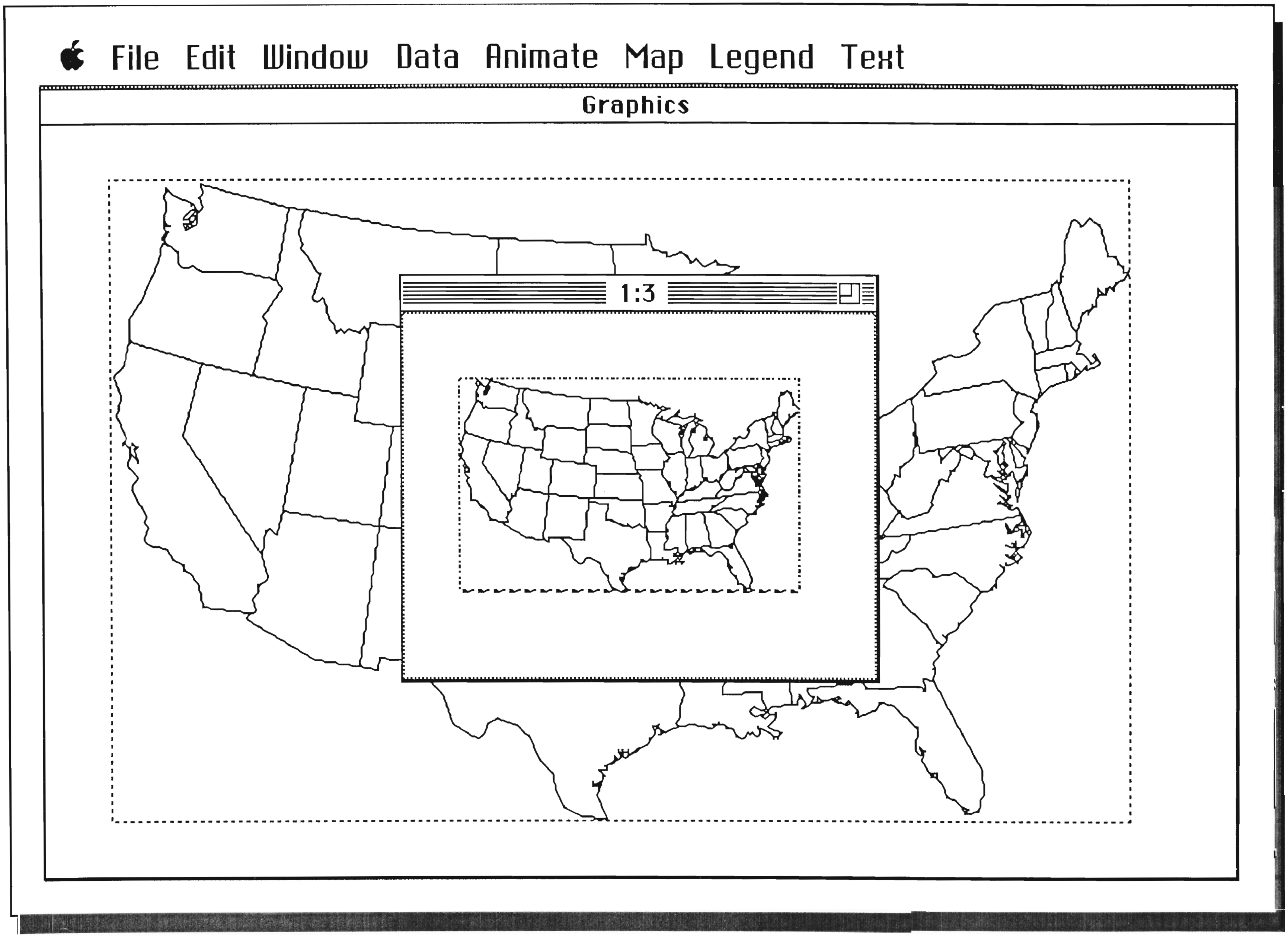


FIG. 3

A File Icon

32 x 32 grid

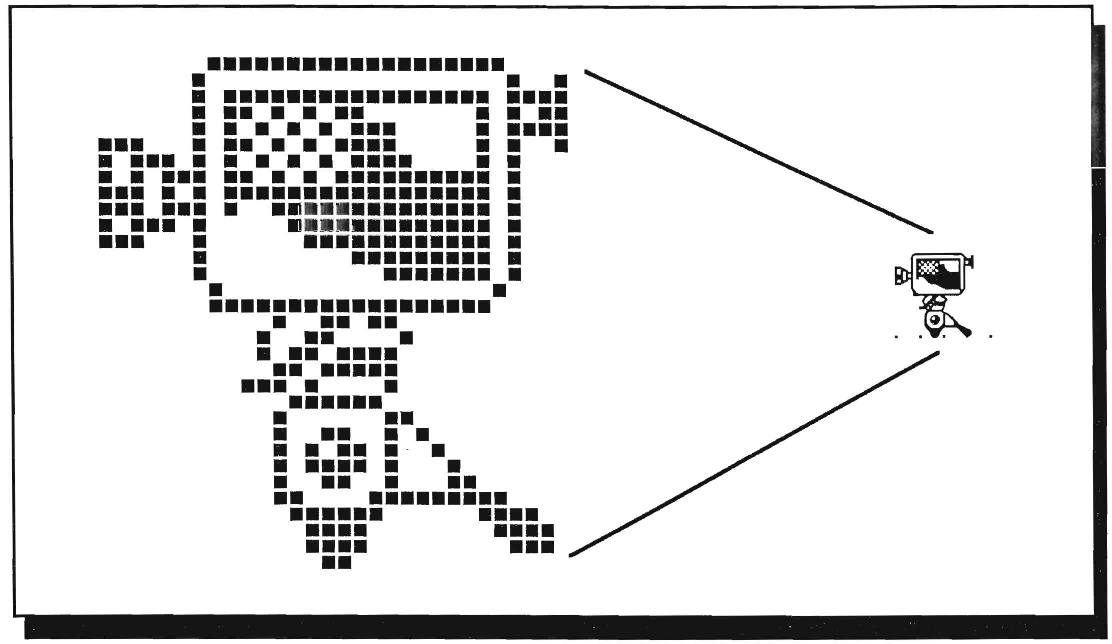


FIG. 2

Reduced View window depicting individual A4 pages

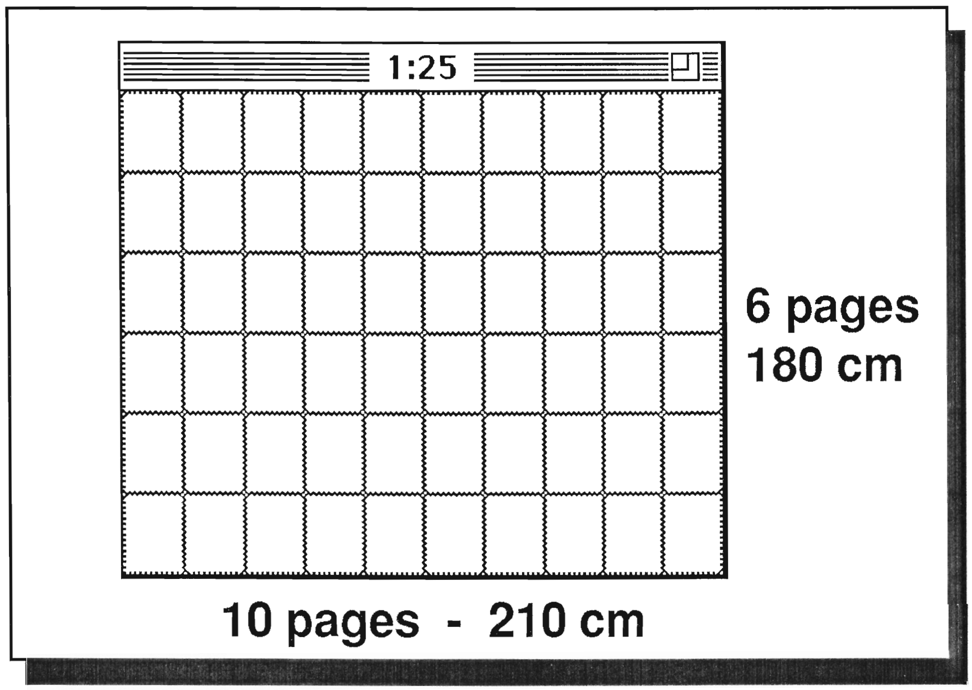


FIG. 4

Reduced-View window with large map

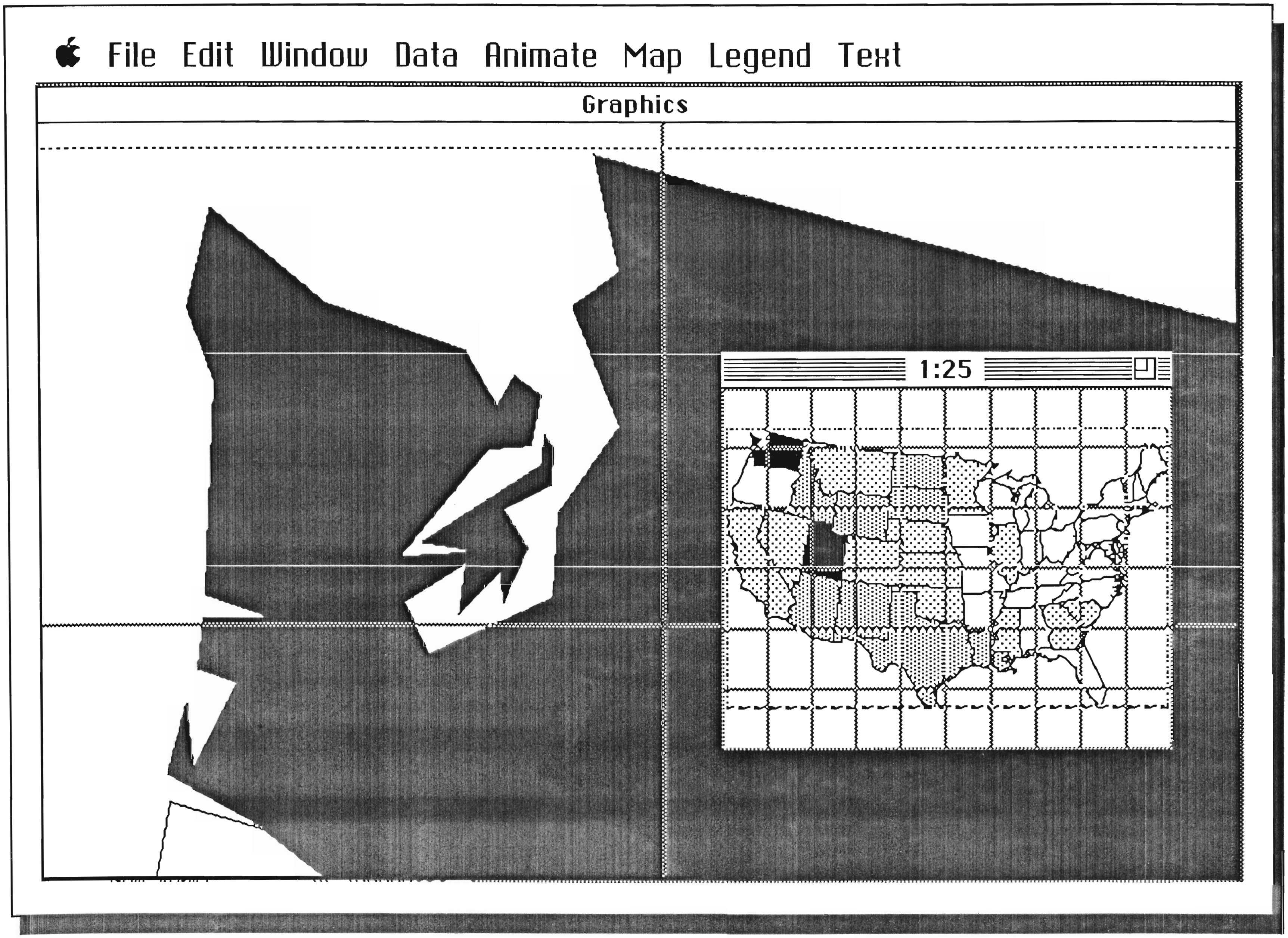


FIG. 5

A Spreadsheet

Data {US48.data}

Draw Map	Birth Rate 1983	% Births to Mothers < 20	US Crime Rate 1984
	Birth Rate 1983	% Births to Mothers < 20	US Crime Rate 1984
Alabama	14.90	18.90	3902.00
Arizona	18.10	15.20	6499.00
Arkansas	15.10	20.80	3368.00
California	17.30	12.60	6468.00
Colorado	17.40	12.00	6471.00
Connecticut	13.10	10.70	4629.00
Delaware	15.20	16.20	5007.00
Florida	13.90	16.40	6821.00
Georgia	15.70	18.80	4498.00
Idaho	19.00	12.00	3672.00
Illinois	15.60	18.20	5304.00
Indiana	14.80	15.20	3929.00
Iowa	14.90	10.70	3800.00
Kansas	16.70	13.40	4339.00
Kentucky	14.70	19.40	2959.00
Louisiana	18.60	18.70	5111.00
Maine	14.60	13.20	3527.00
Maryland	14.90	13.90	5215.00
Massachusetts	13.20	9.70	4588.00
Michigan	14.70	12.80	6556.00
Minnesota	15.80	8.90	3842.00
Mississippi	17.00	21.90	3060.00
Missouri	15.20	14.90	4297.00
Montana	17.30	11.40	4653.00
Nebraska	16.40	10.50	3497.00
Nevada	16.00	14.60	6561.00
New Hampshire	14.40	10.20	3138.00
New Jersey	13.30	11.50	4297.00

FIG. 6

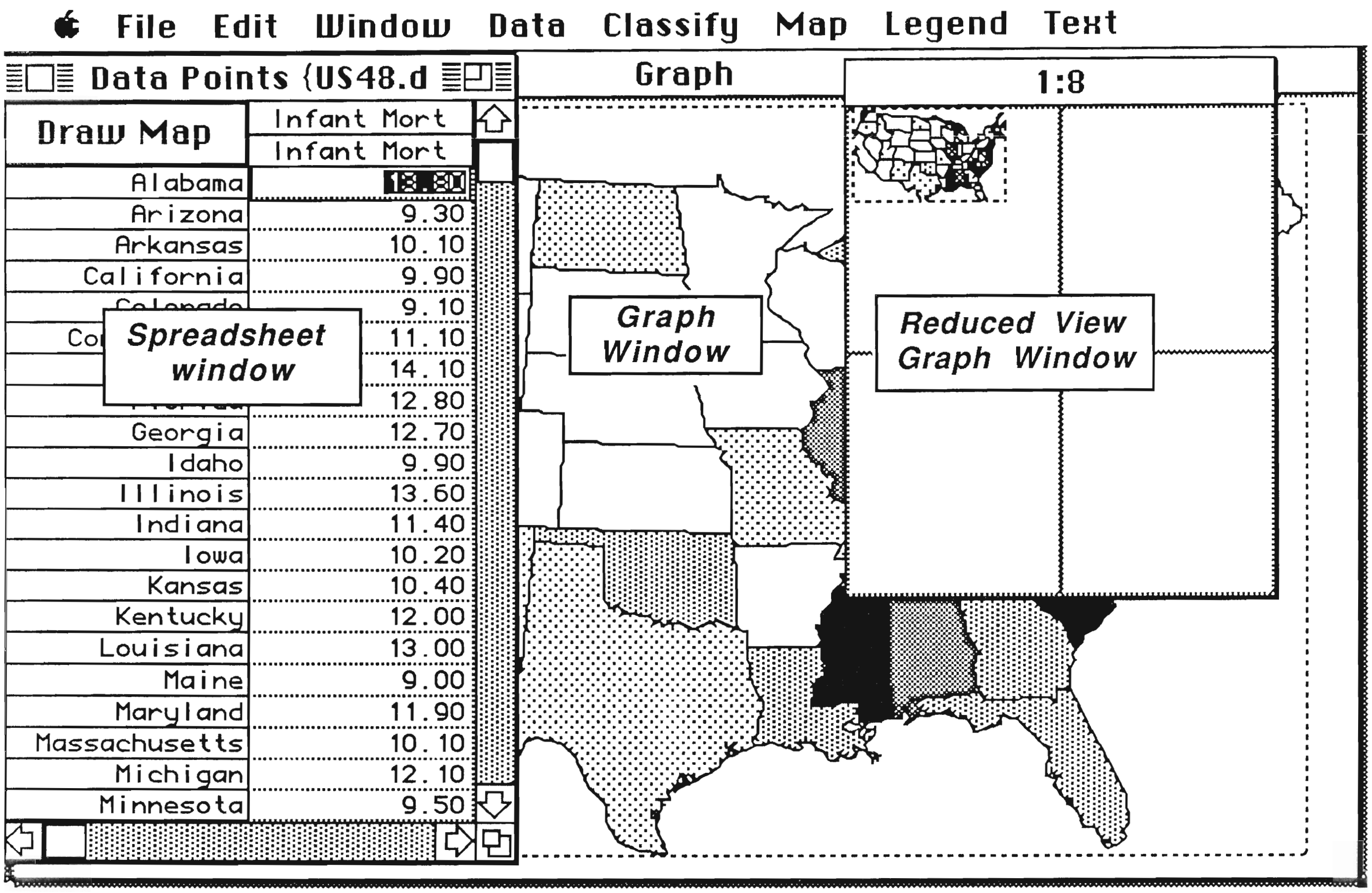


Figure 1.

FIG. 7

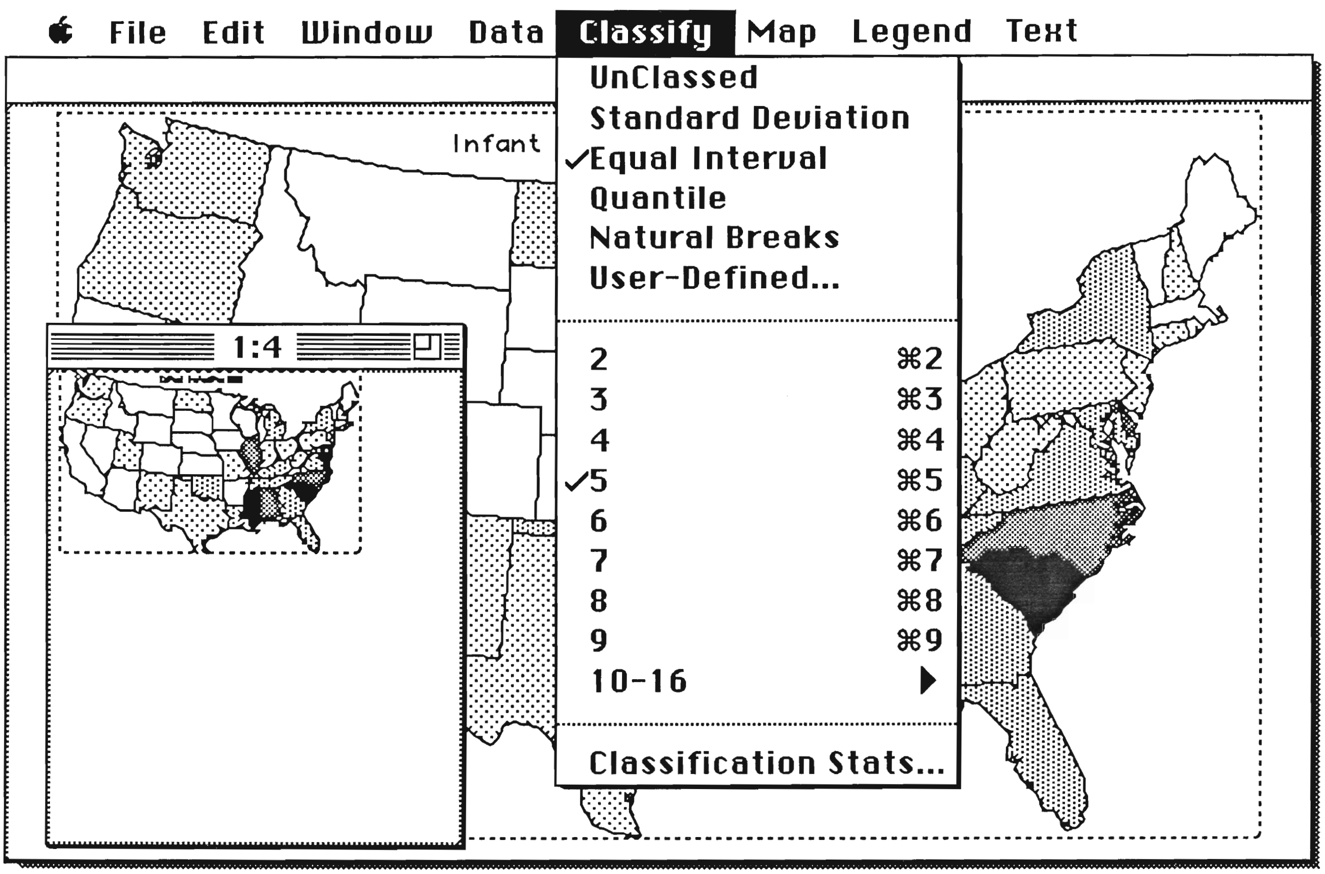

File Edit Window Data Classify Map Legend Text
UnClassed
Standard Deviation
✓Equal Interval
Quantile
Natural Breaks
User-Defined...
2 ⌘2
3 ⌘3
4 ⌘4
✓5 ⌘5
6 ⌘6
7 ⌘7
8 ⌘8
9 ⌘9
10-16
Classification Stats...
Infant
1:4

FIG. 8

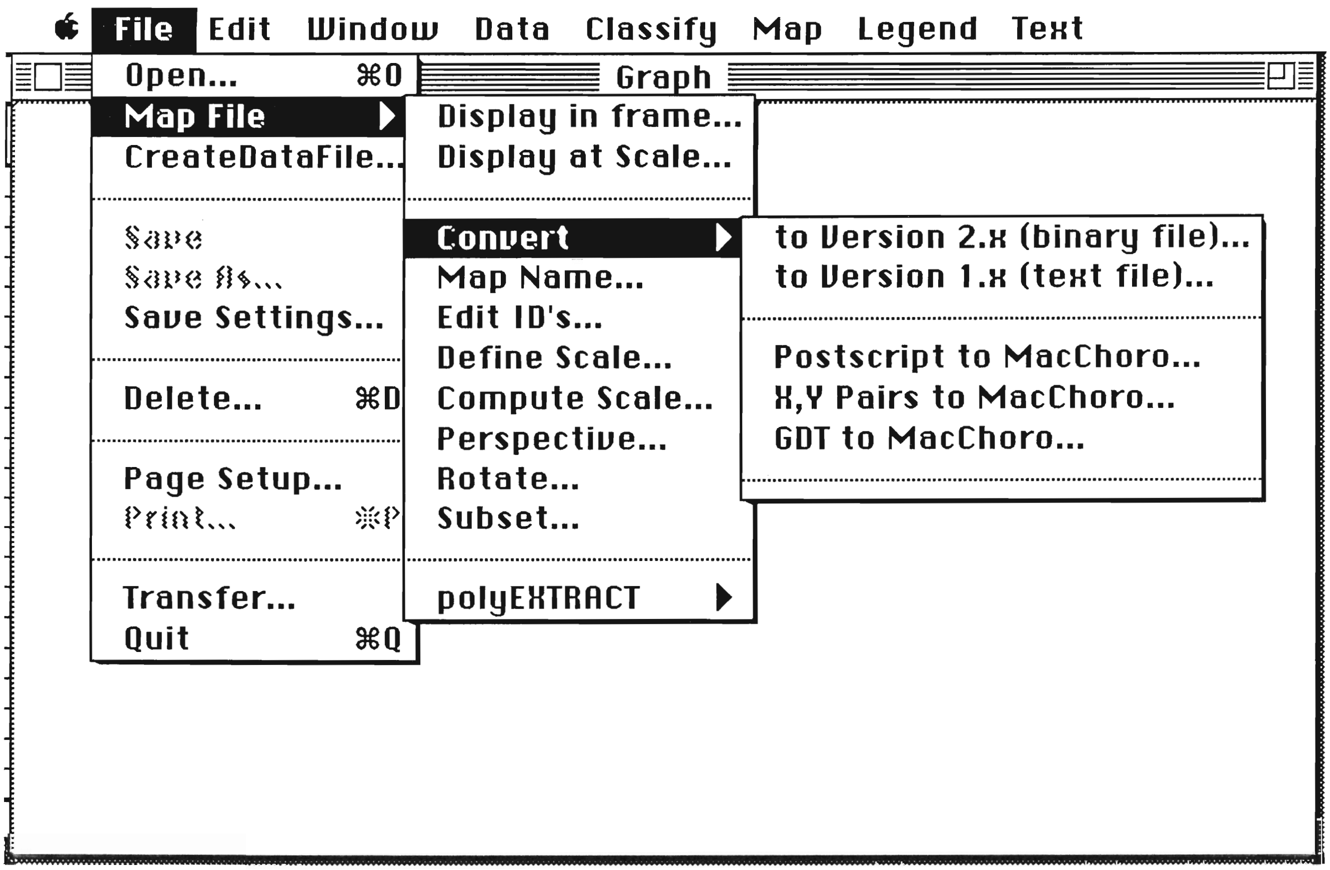

File
Edit
Window
Data
Classify
Map
Legend
Text
Graph
Open... ⌘O
Map File
CreateDataFile...
Save
Save As...
Save Settings...
Delete... ⌘D
Page Setup...
Print... ⌘P
Transfer...
Quit ⌘Q
Display in frame...
Display at Scale...
Convert
Map Name...
Edit ID's...
Define Scale...
Compute Scale...
Perspective...
Rotate...
Subset...
polyEXTRACT
to Version 2.x (binary file)...
to Version 1.x (text file)...
Postscript to MacChoro...
X,Y Pairs to MacChoro...
GDT to MacChoro...

FIG. 9

Menu with map

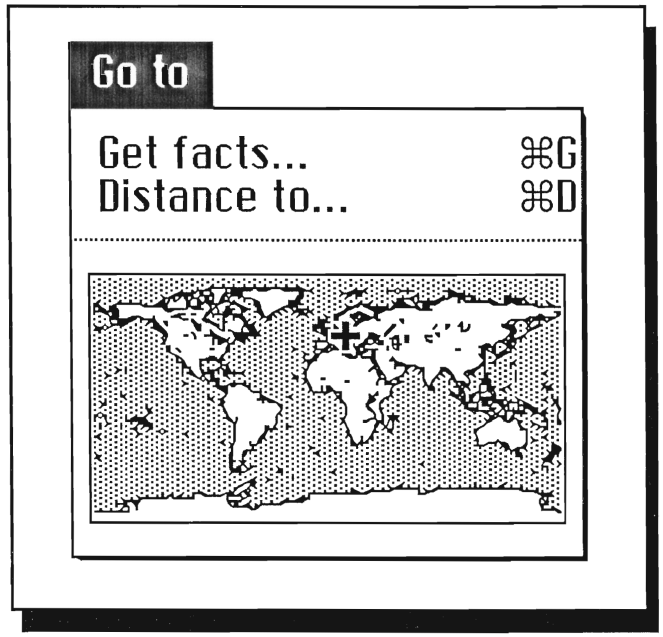


FIG. 10

A Dialog

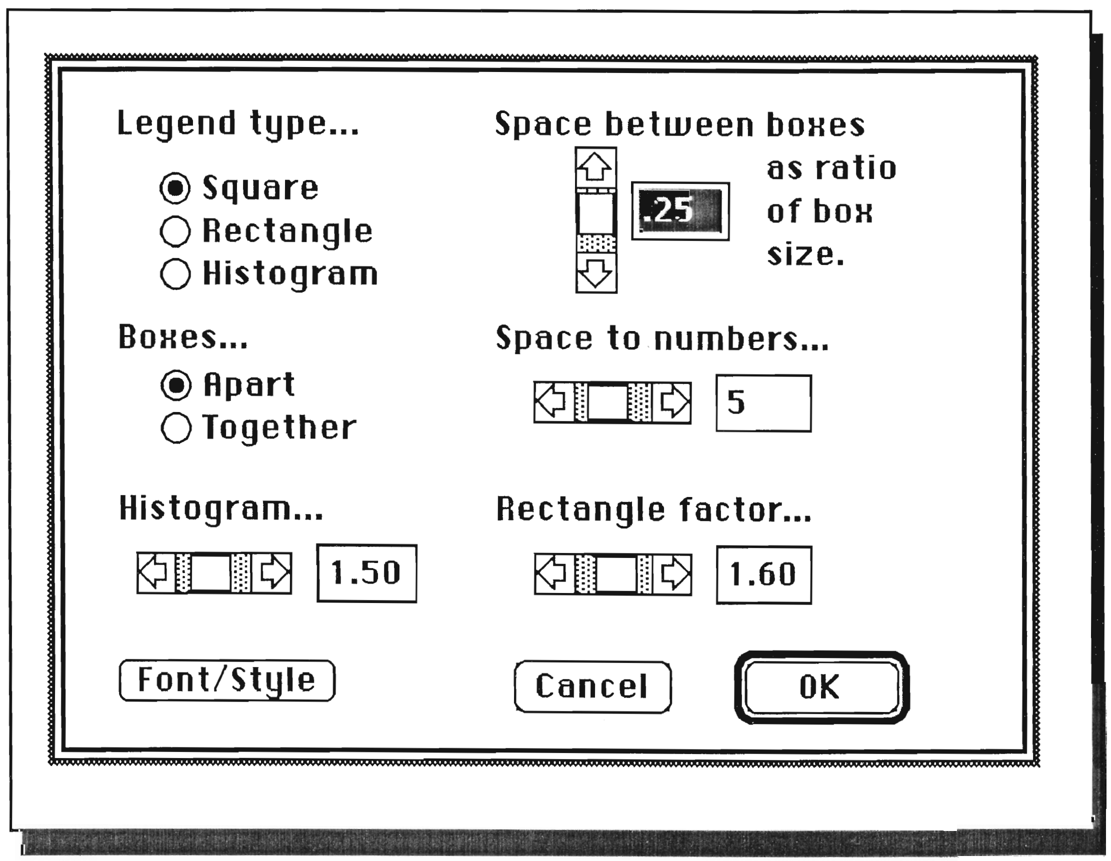


FIG. 11

Elements of a Dialog

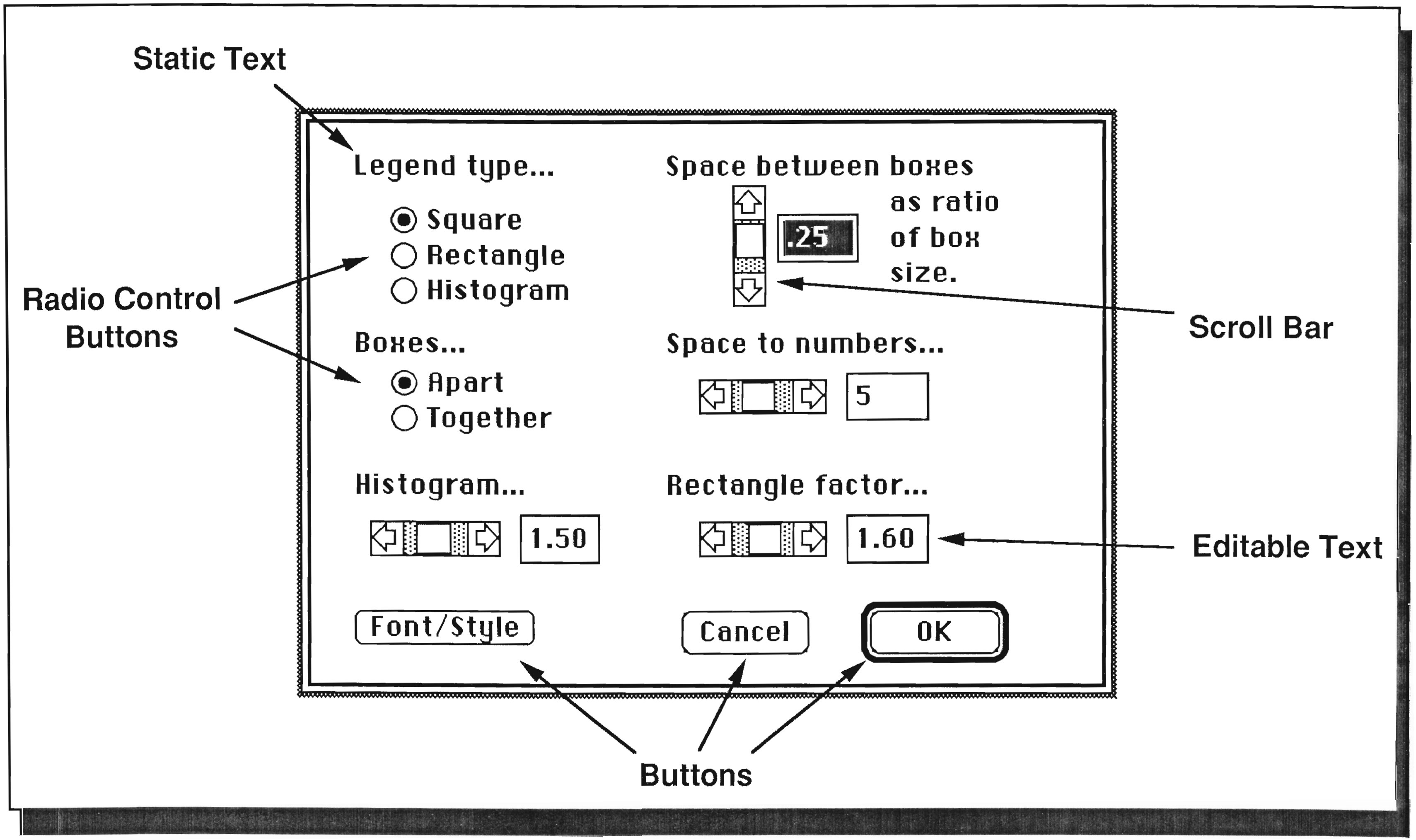


FIG. 12

Map Design with Bounding Rectangles

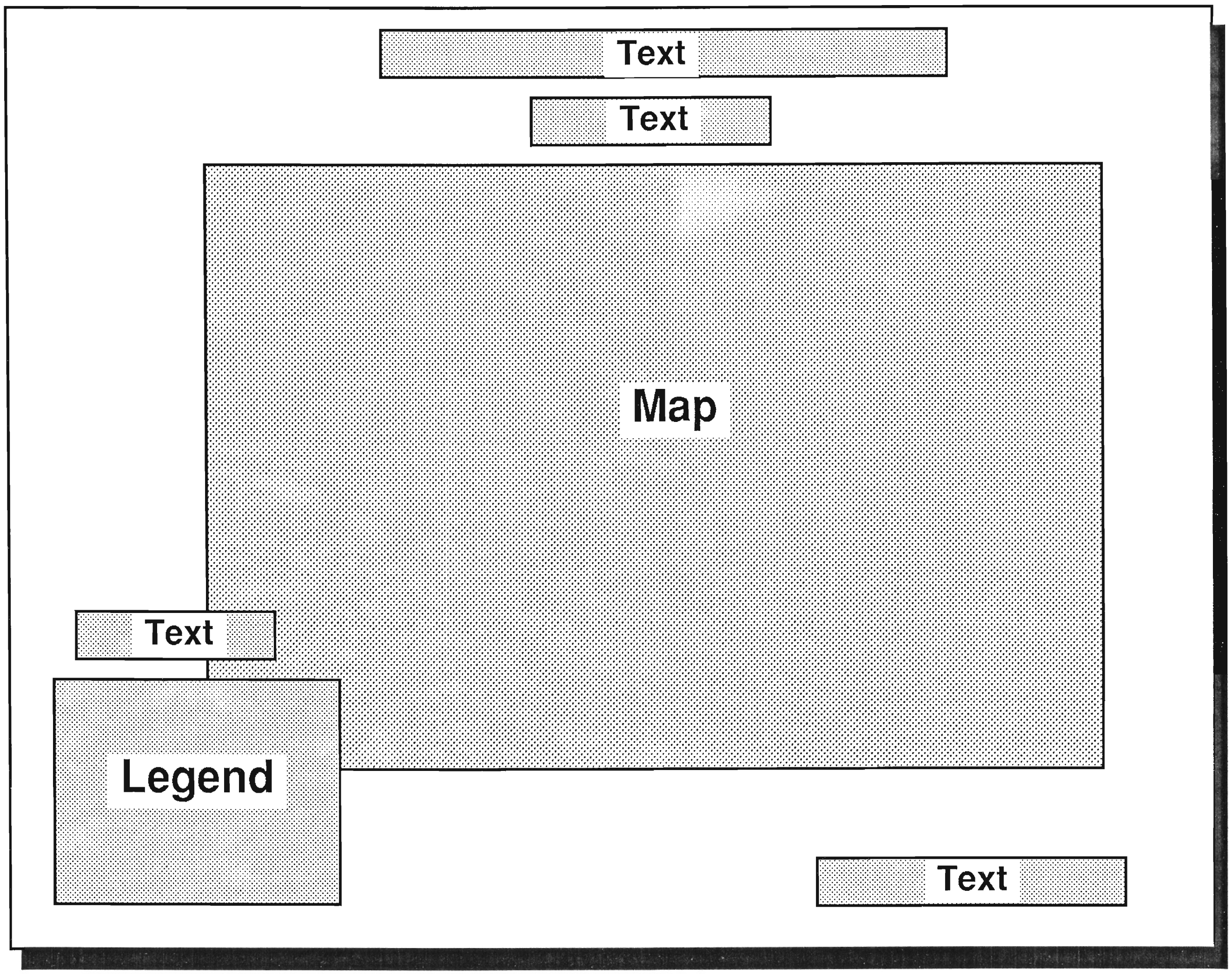


FIG. 13

Bounding Rectangle for Map

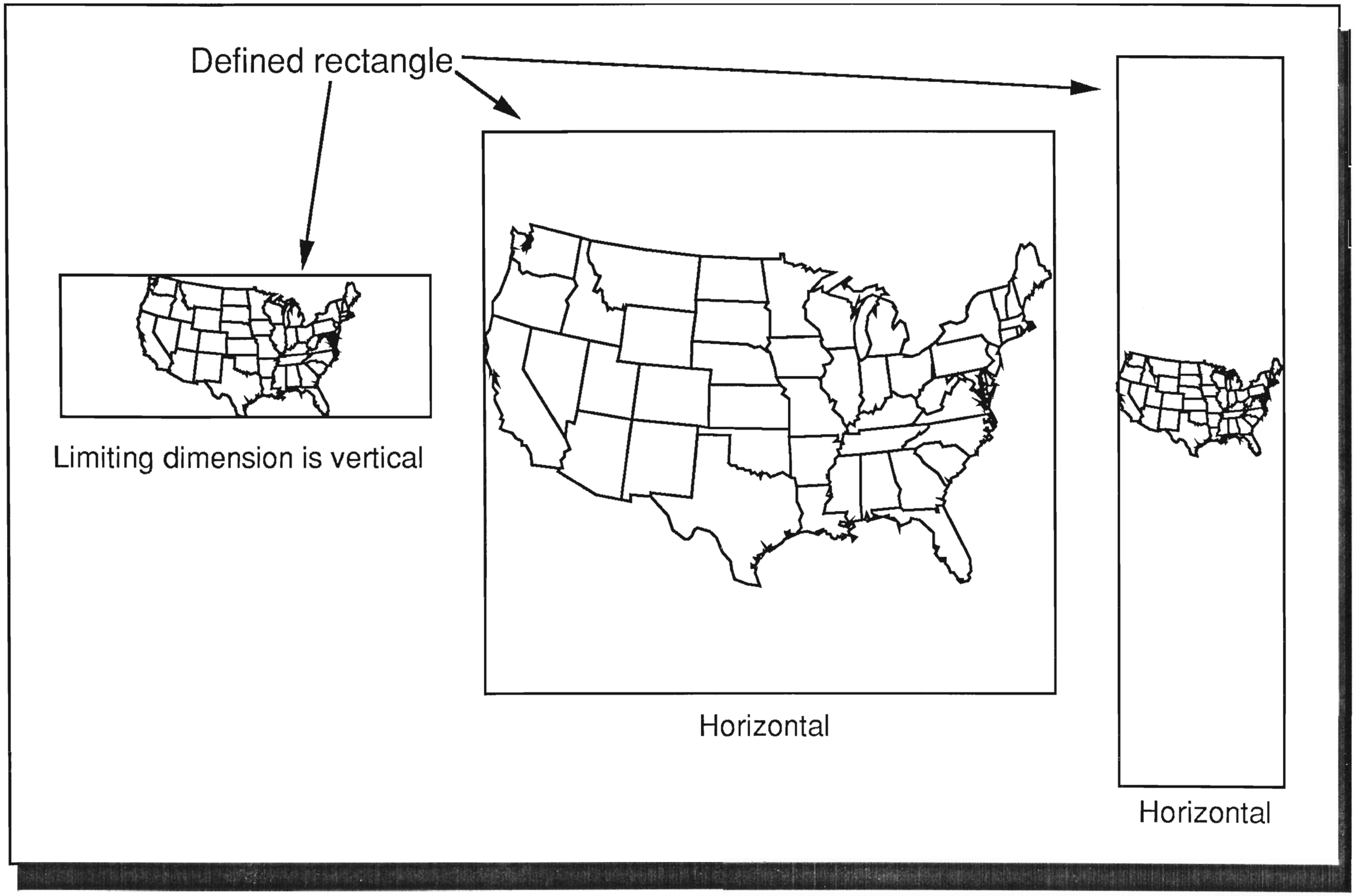
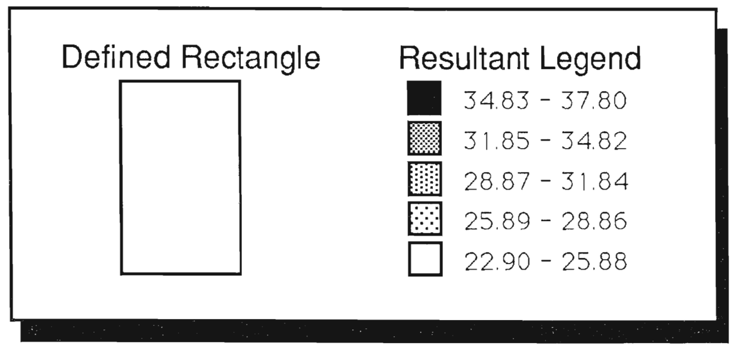


FIG. 14

Bounding Rectangle for Legend



Horizontal component ignored!

FIG. 15

Bounding Rectangle for Text

Point sizes: 9, 10, 12, 14, 18

Method 1: Point size determined from size of bounding rectangle.

Method 2: Point size is user-defined. Bounding rectangle used only to place text.

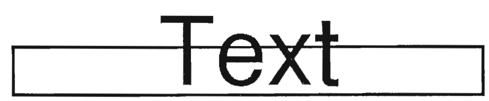


FIG. 16

Text characteristics Dialog

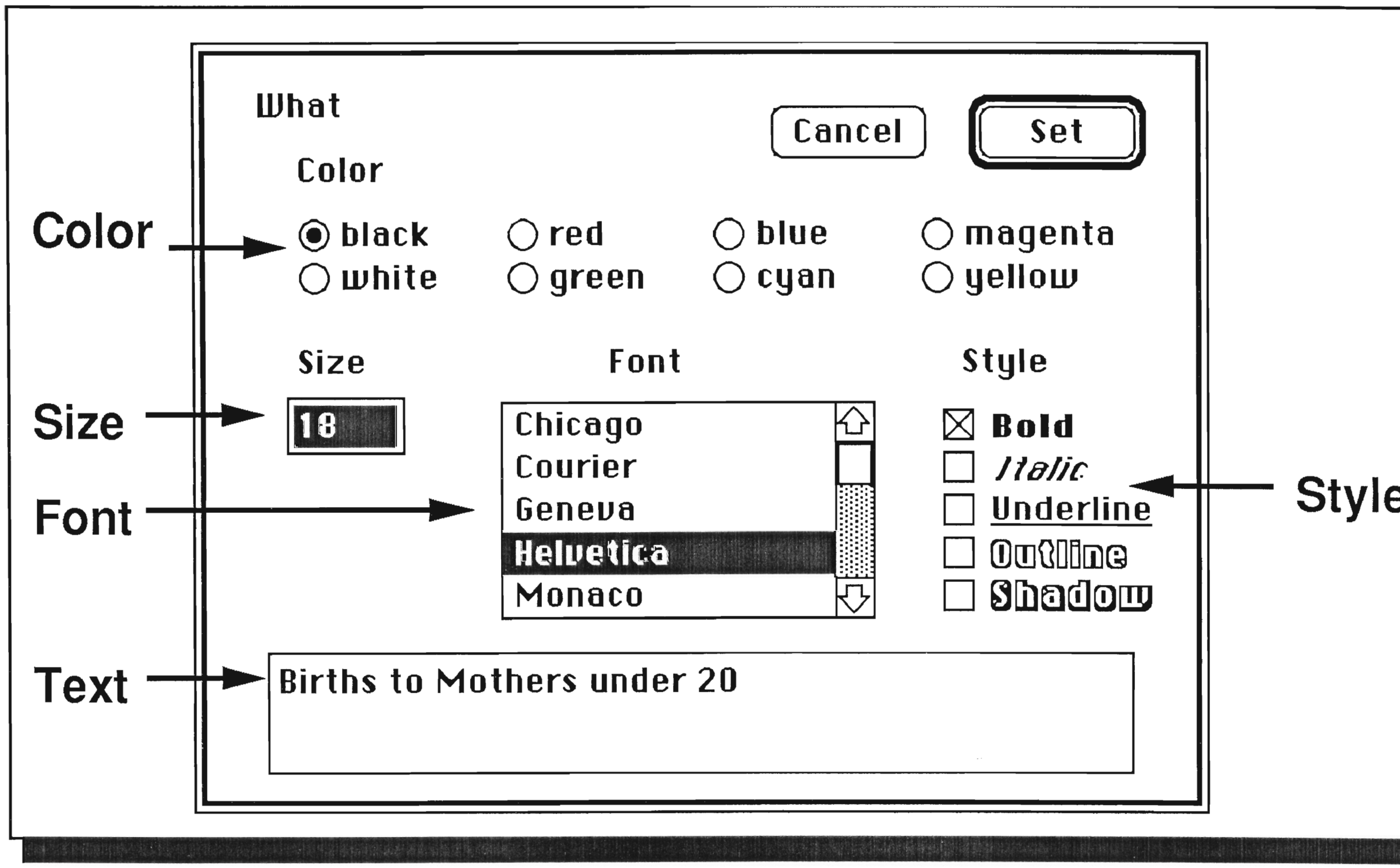


FIG. 17

X,Y coordinates to Objects

x, y coordinates

US48.Map
Scale = .0000000
Number of Statistical units: 48
MacChoro Map File
MacChoro Map File
Number of polygons: 53

.86470	4.48680	4.72485	6.95040				
1	16	1	Alabama				
3.53210	5.20677	3.33860	5.18820	3.33815	5.17505	3.35665	5.15847
3.35475	5.13562	3.31470	5.11912	3.32980	5.12790	3.30980	5.16776
3.30380	5.12737	3.28460	5.13161	3.26850	5.25974	3.26710	5.53258
3.45055	5.54838	3.50070	5.36709	3.52795	5.31734	3.51405	5.28115
2	15	4	Arizona				
1.74205	5.25989	1.59055	5.28312	1.33965	5.43159	1.34920	5.44914
1.37015	5.45754	1.35865	5.49886	1.37905	5.52337	1.38360	5.54872
1.41805	5.57214	1.39550	5.64403	1.40520	5.73540	1.42025	5.74052
1.44745	5.72510	1.46990	5.80629	1.81175	5.74948		
3	25	5	Arkansas				
3.06270	5.34348	2.85425	5.34022	2.85290	5.38718	2.82115	5.39494
2.82265	5.54660	2.80865	5.64384	3.11910	5.65449	3.12595	5.63570
3.10635	5.61033	3.15330	5.61309	3.15865	5.60608	3.13970	5.58851
3.14280	5.57105	3.12340	5.55773	3.13370	5.53620	3.11910	5.52236
3.10225	5.50041	3.10090	5.47069	3.06705	5.43270	3.06890	5.40600
3.05770	5.40636	3.05850	5.38357	3.06905	5.38304	3.06300	5.37385
3.07260	5.36704						

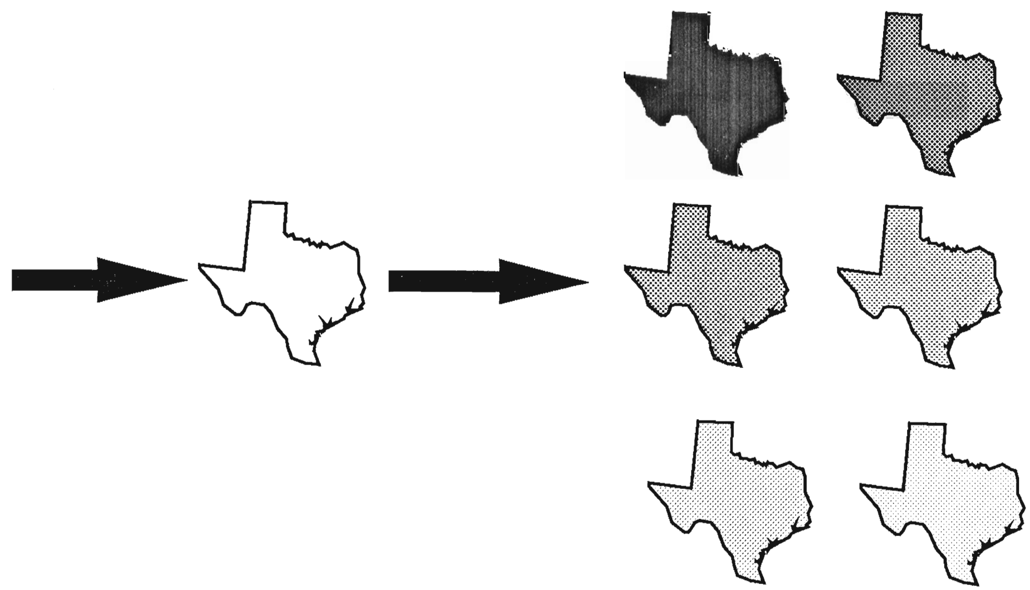
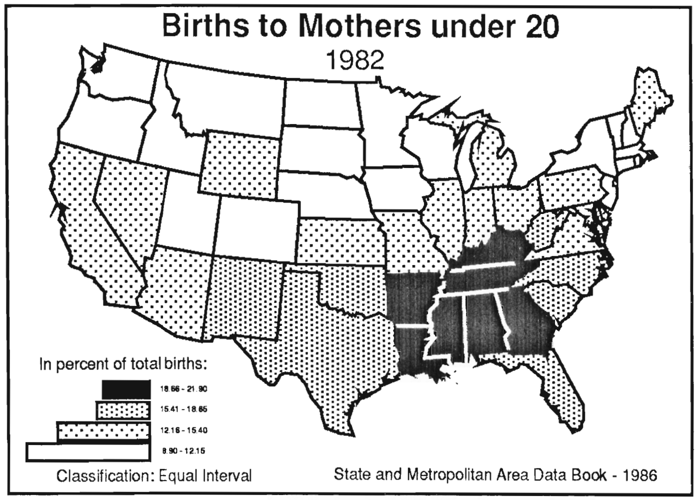
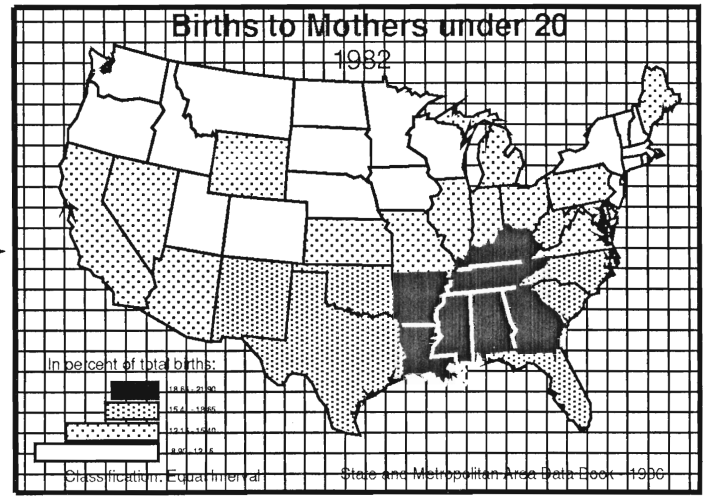


FIG. 18

From map to bit-map

0 = white
1 = black





0
0
0
1
1
1
1
1
1
0
1
1
1
0
0
0
1
1
1
.
.

Total storage required for each bit-map: 22 Kb

FIG. 19

Step 1:
Place map elements with bounding rectangles

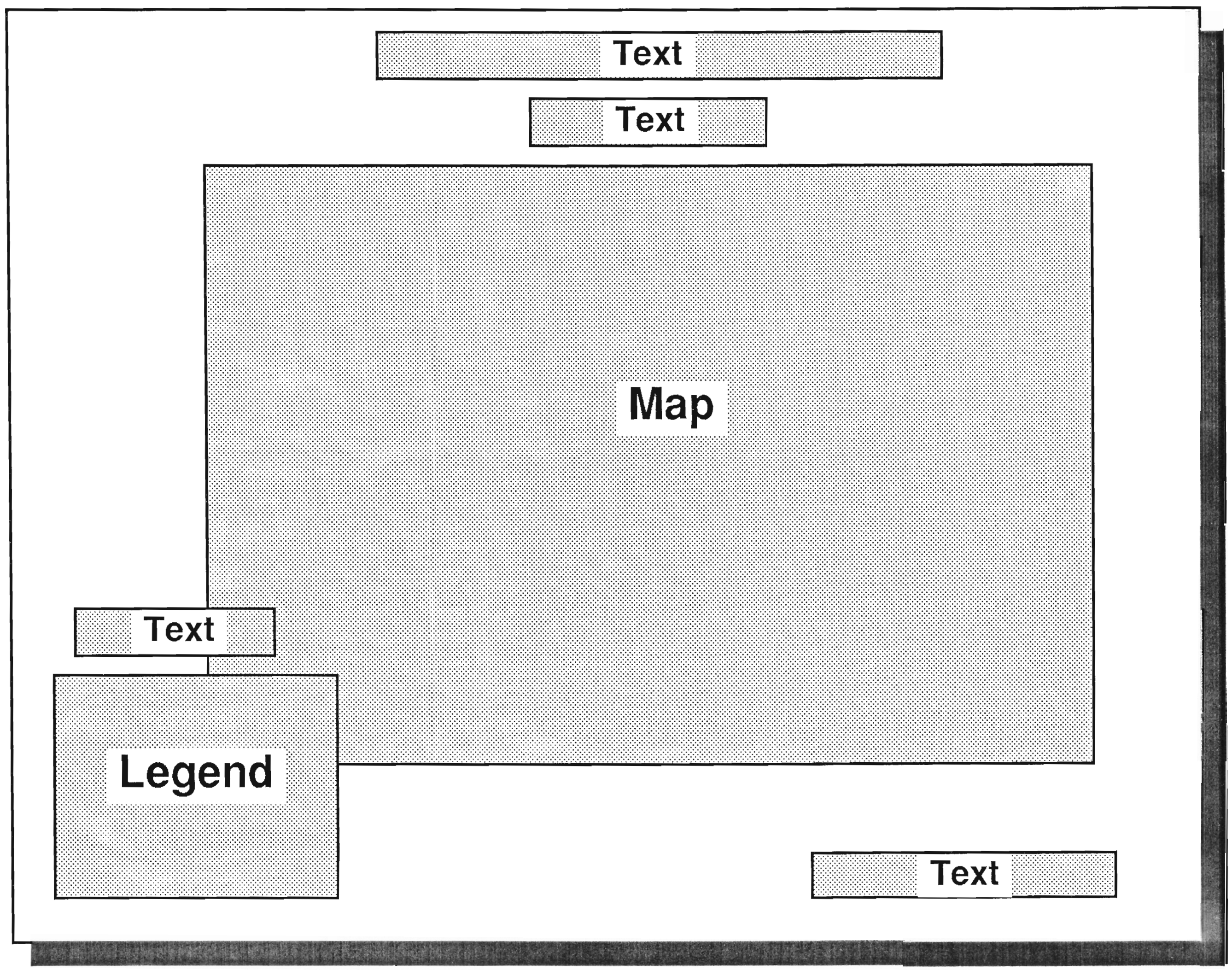


FIG. 20

Step 2: Specify:

- classification methods
- number of classes
- variables to animate.

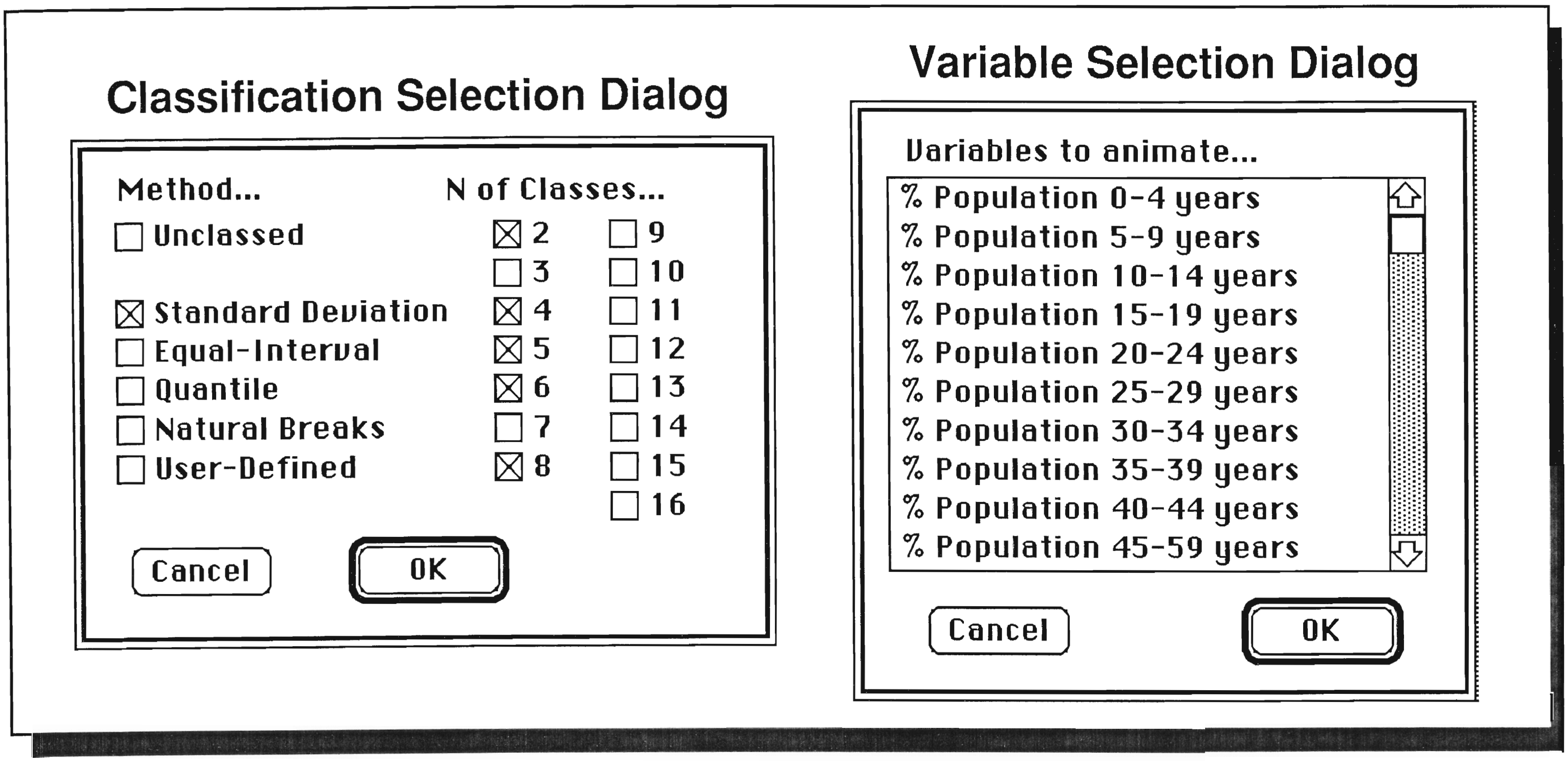


FIG. 21

Step 3:
Creating the individual frames.

Memory required: 442 Kb; Time: 2-3 seconds per frame

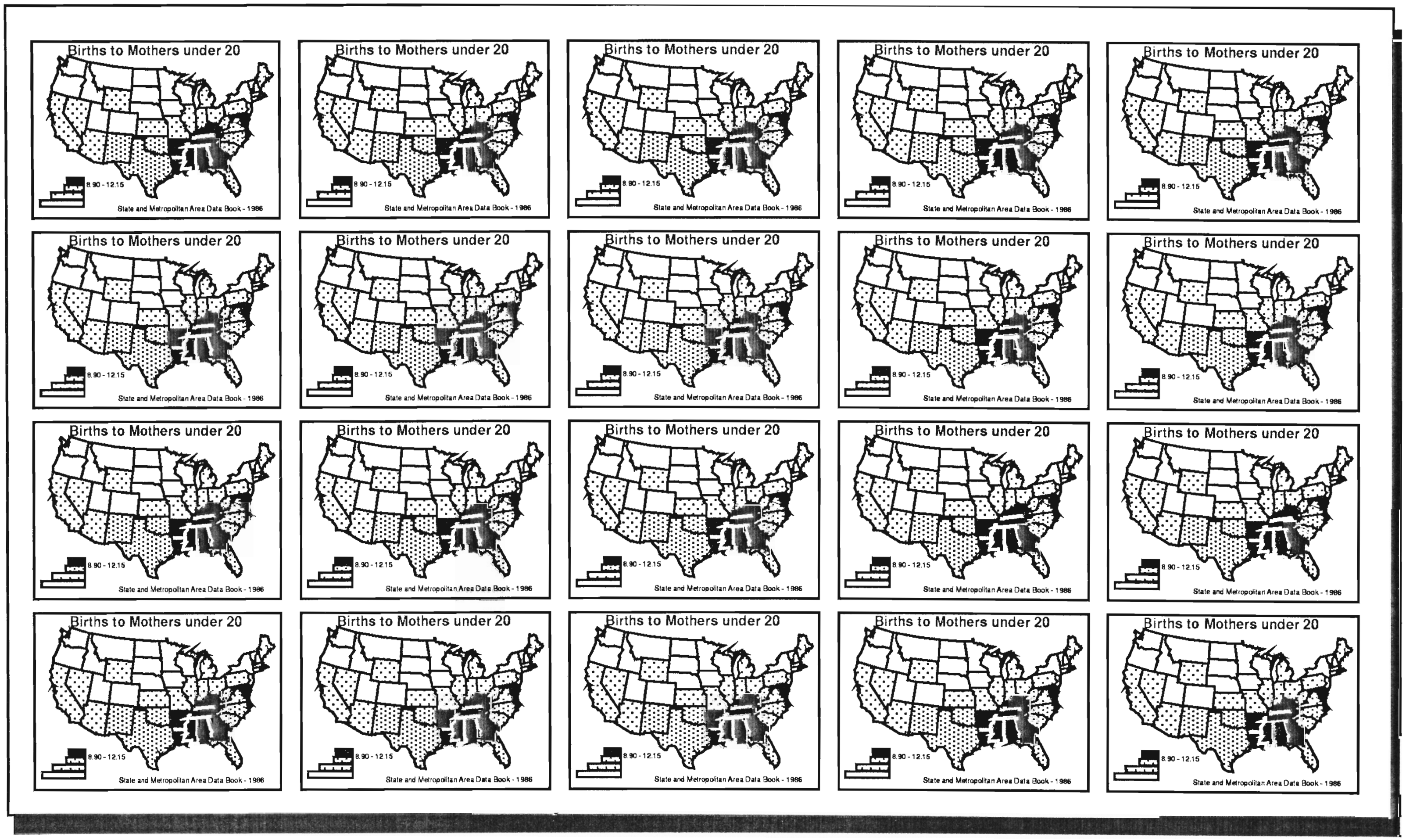
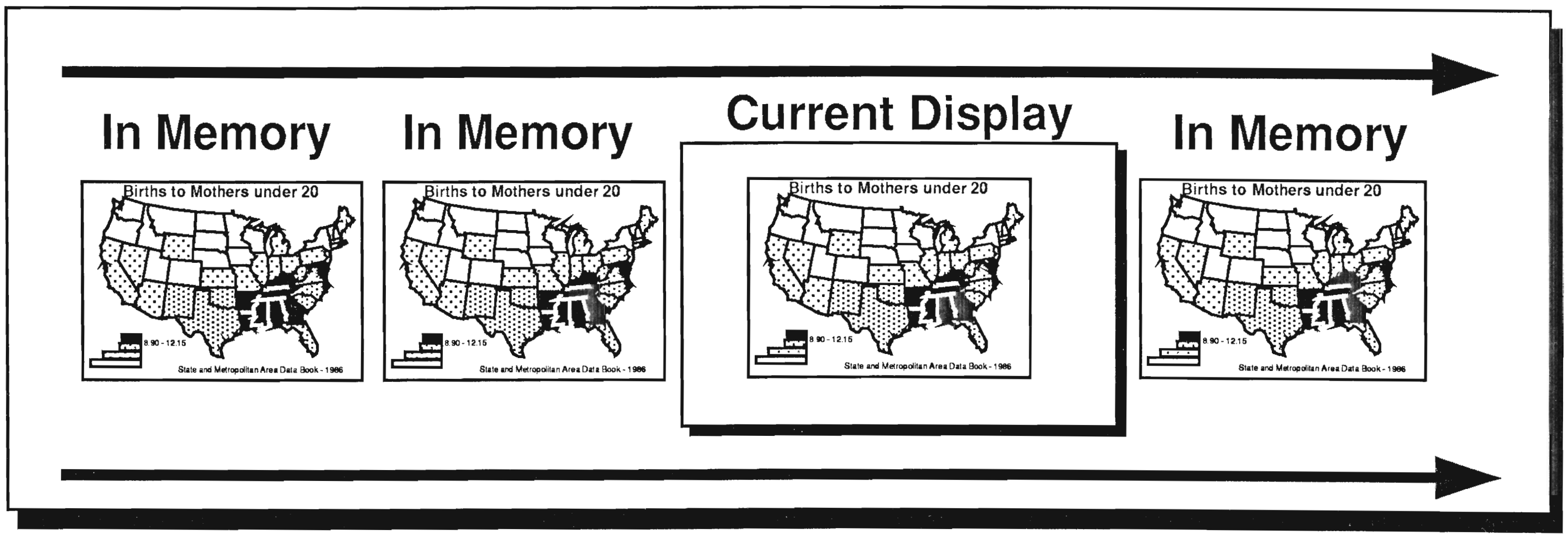


FIG. 22

Step 4:

Displaying the Animation



Maximum Speed: 60 frames a second

FIG. 23

Menu palette and dialog used to control animation

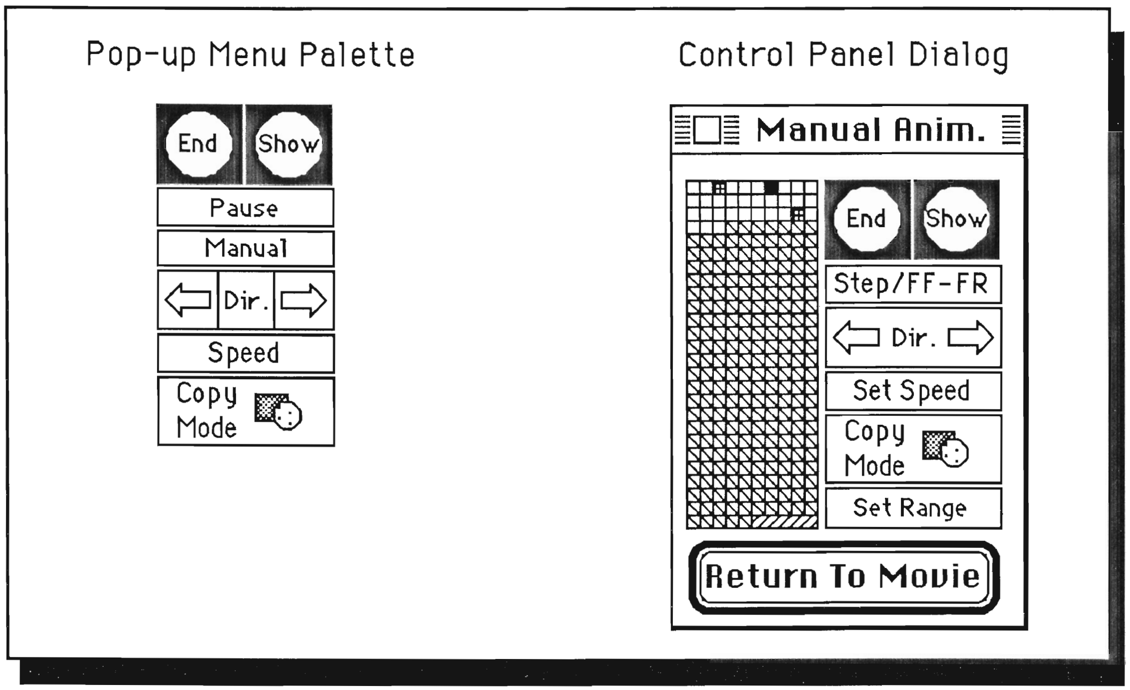


FIG. 24

Changing Animation Speed

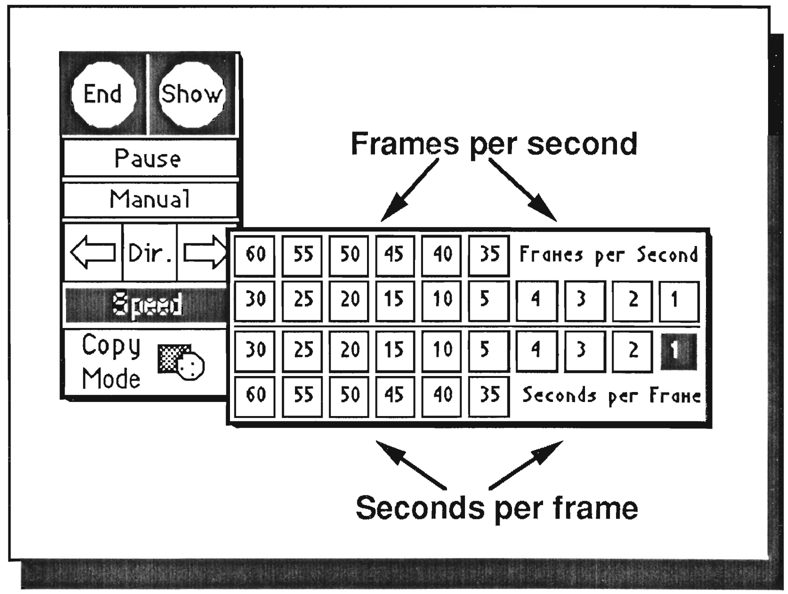


FIG. 25

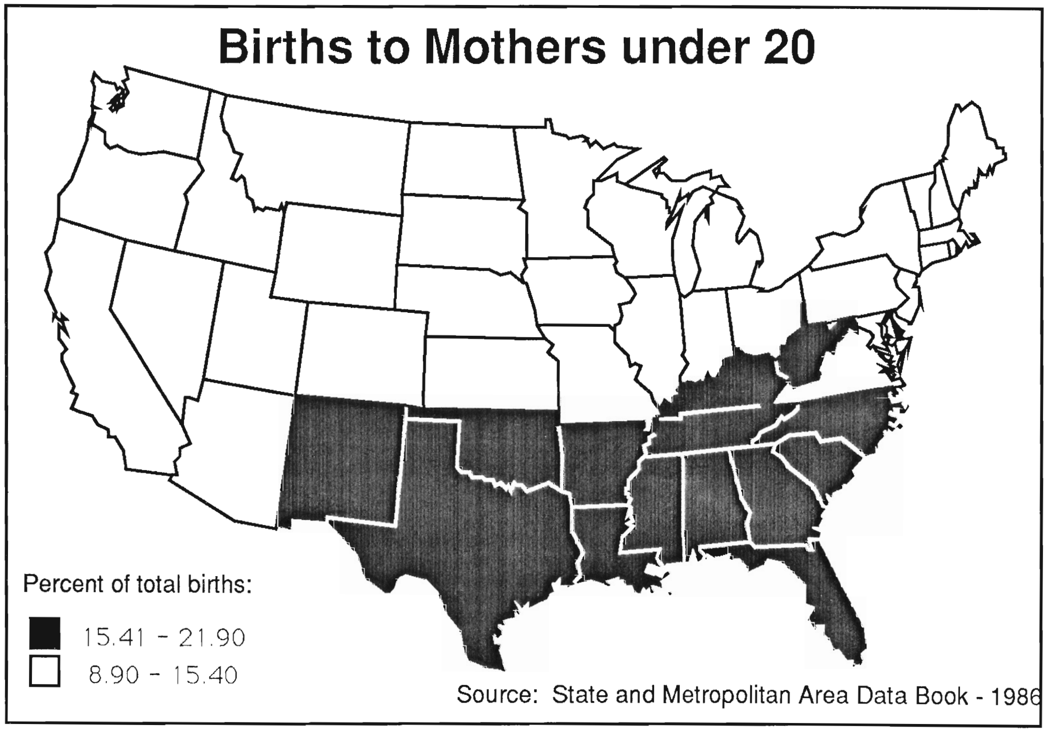

Births to Mothers under 20
Percent of total births:
15.41 - 21.90
8.90 - 15.40
Source: State and Metropolitan Area Data Book - 1986

FIG. 26

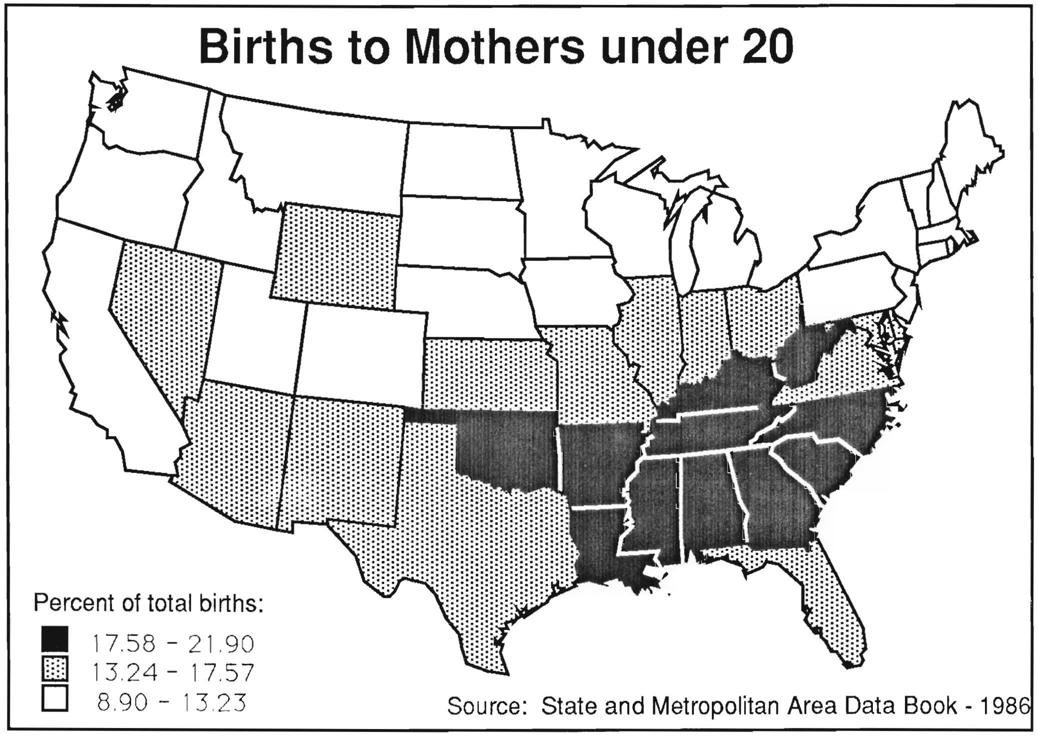

Births to Mothers under 20
Percent of total births:
17.58 - 21.90
13.24 - 17.57
8.90 - 13.23
Source: State and Metropolitan Area Data Book - 1986

FIG. 27

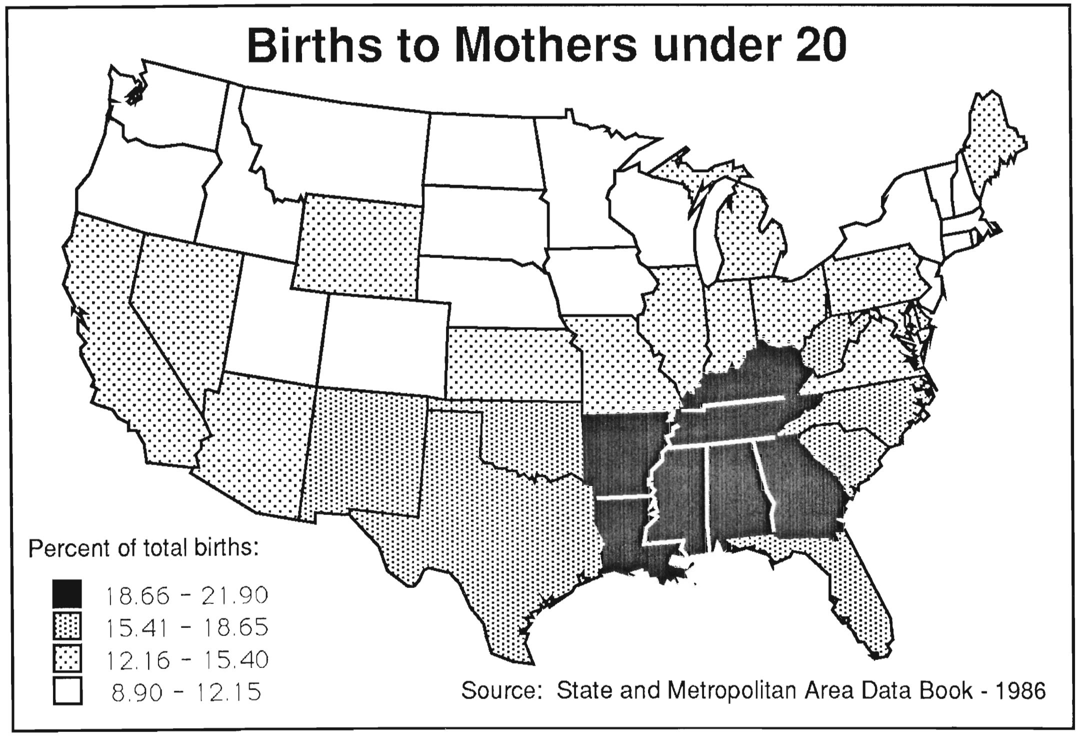

Births to Mothers under 20
Percent of total births:
18.66 - 21.90
15.41 - 18.65
12.16 - 15.40
8.90 - 12.15
Source: State and Metropolitan Area Data Book - 1986

FIG. 28

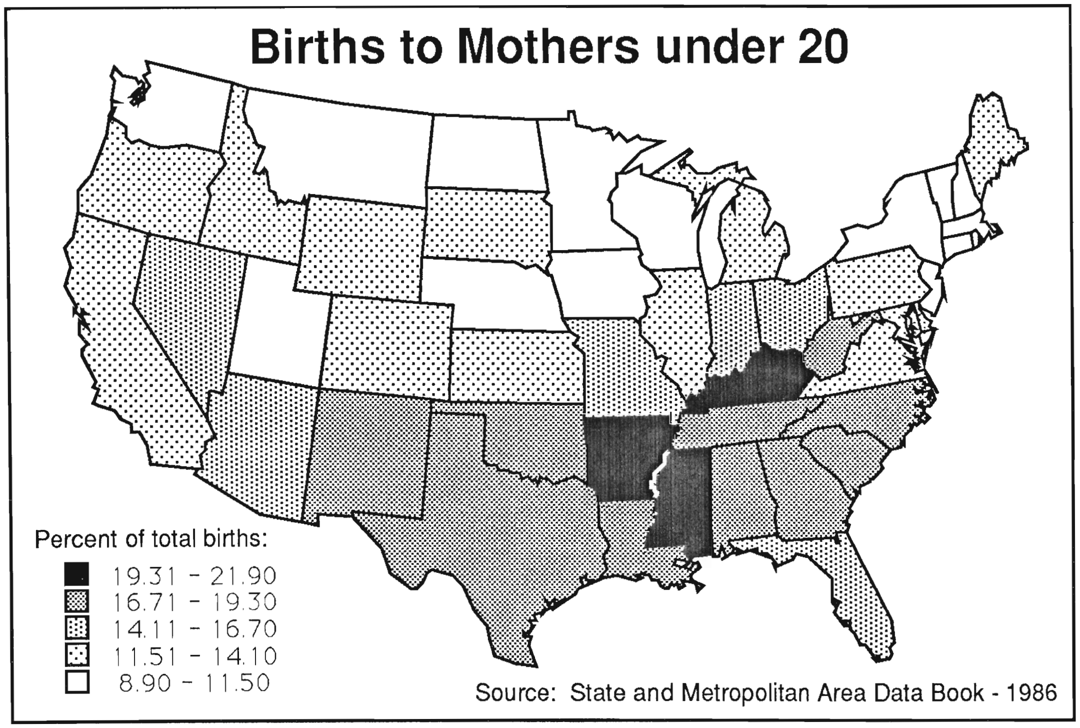
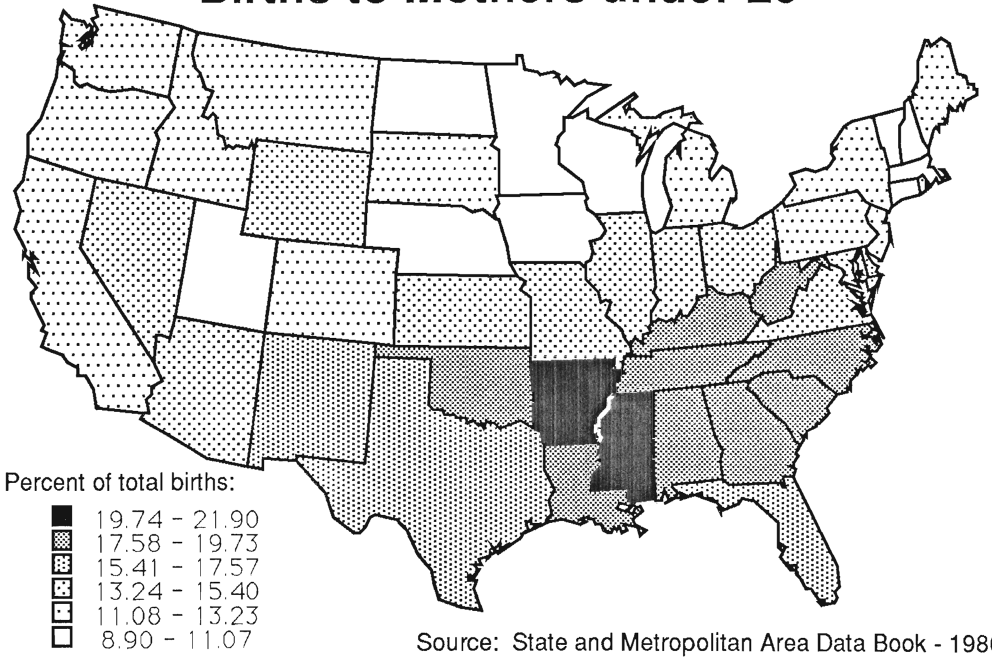

Births to Mothers under 20
Percent of total births:
19.31 - 21.90
16.71 - 19.30
14.11 - 16.70
11.51 - 14.10
8.90 - 11.50
Source: State and Metropolitan Area Data Book - 1986

FIG. 29

Births to Mothers under 20



Source: State and Metropolitan Area Data Book - 1986

FIG. 30