**C H A P T E R**

1

Overview of SAS/GIS Software

Introduction to Geographic Information Systems

SAS/GIS software provides an interactive geographic information system within SAS. A *geographic information system* (GIS) is a tool for organizing and analyzing data that can be referenced spatially, that is, data that can be tied to physical locations. Many types of data have a spatial aspect, including demographics, marketing surveys, customer addresses, and epidemiological studies. A GIS helps you analyze your data in the context of location.

For example, if you need to evaluate population data for census tracts, you could view the information in tabular format. However, consider how much easier and more effective it would be to view the demographic information in the context of the geography of the tracts as in Figure 1.1 on page 4. When viewing information that has a spatial component, you might find it easier to recognize relationships and trends in your data if you view the information in a spatial context.

Figure 1.1 Evaluating Spatially Referenced Data
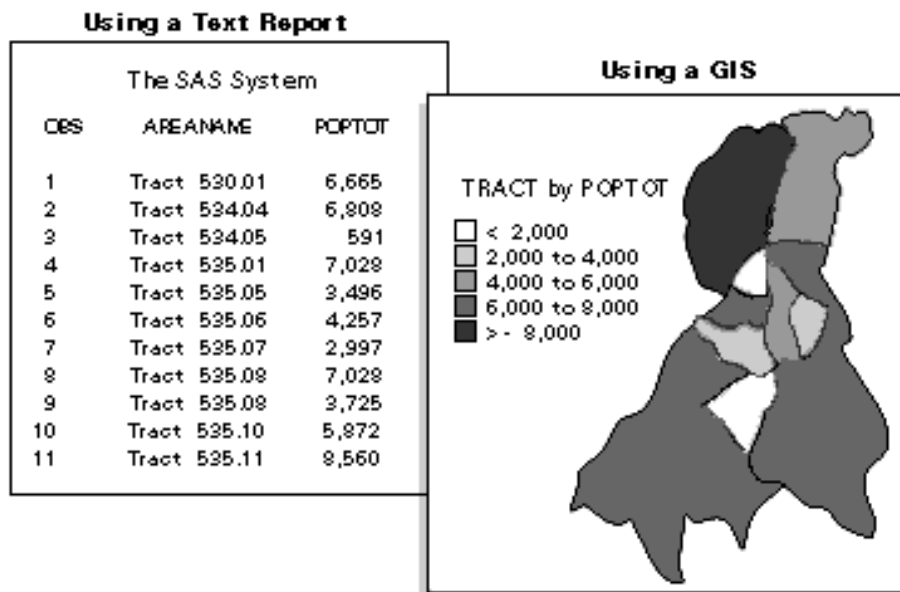
SAS/GIS software enables you to do more than simply view your data in its spatial context. It also enables you to interact with the data by selecting features and performing actions that are based on your selections. SAS/GIS software draws on the capabilities of SAS and enables you to access, manage, analyze, and present your data easily.

Features of SAS Software

SAS provides a powerful programming language with components called procedures that allow you to perform many different kinds of analysis and data management functions, as well as produce many different types of text-based and graphical presentation output. Combined with other features, the SAS language and its procedures make an immense variety of applications possible, including the following examples:

- □ Access raw data files and data in external databases and database management systems.
- □ Manage data using tools for data entry, editing, retrieval, formatting, and conversion.
- □ Analyze data using descriptive statistics, multivariate techniques, forecasting and modeling, and linear programming.
- □ Present data using reports and business and statistical graphics.

SAS is also portable across computing environments. SAS applications function the same and produce the same results regardless of the operating environment on which you are running SAS to process your data. However, some features, such as interactive windows, are not supported on all platforms.

For more information about SAS, please refer to *SAS Language Reference: Concepts*.

Data in SAS/GIS Applications

SAS/GIS software uses two basic types of data:

spatial data
  contains the coordinates and identifying information that describes the map
  features such as streets, rivers, and railroads.

attribute data
  is the information that you want to use for analysis or presentation. This
  information must be spatial in nature. Sales figures for each of your store
  locations, population data for each county, and total income for each household in
  a region are examples of information that is spatial in nature because the
  information applies to a specific geographic feature.

For example, the U.S. Census Bureau distributes both types of data:

TIGER Line files
  contain spatial information that you can use to build maps.

Summary Tape files
  contain population and other demographic information that you can link to the
  map features.

Attribute data provides the information that you want to analyze, and spatial data
provides the context in which you want to analyze it. For example, consider the
SAS/GIS map shown in the following display. Spatial data provides the boundaries for
the map areas, and attribute data provides the population information that is used to
color the map areas.

Display 1.1 Spatial and Attribute Data in SAS/GIS Maps
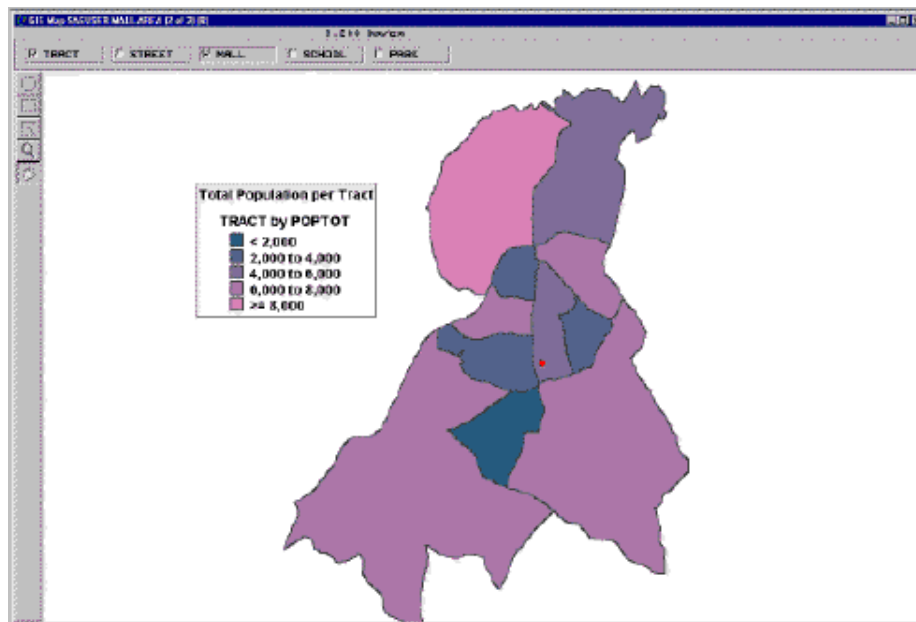
Spatial Data

Spatial data contains the coordinates and identifying information that are necessary
to draw maps. For SAS/GIS software, spatial data is stored in SAS/GIS spatial

databases, which consist of collections of SAS data sets and SAS catalog entries. The primary method for creating a SAS/GIS spatial database is through the SAS/GIS Import facility, either in batch or in interactive mode. You can also use the GIS procedure to create, modify, and manage the catalog entries in a spatial database.

Spatial Data Layers

Features in the spatial data are organized into layers. A *layer* is a collection of all the features in the map that share some common characteristic. The various physical aspects of the map—political boundaries, roads, railroads, waterways, and so on—are assigned to layers according to their common spatial data values. Some features can appear in multiple layers. For example, a street can also be a ZIP code boundary and a city boundary line. The street could appear in three layers: one containing the streets, one containing the ZIP code boundaries, and one containing the city boundaries.

Three types of layers can be represented in SAS/GIS maps: points, lines, and areas. For example, the collection of all the points in a map that represent park locations can be organized into a point layer for parks, the collection of all the lines in a map that represent streets can be organized into a line layer for streets, and the collection of all the areas that represent census tracts can be organized into an area layer for tracts. When the various layers are overlaid, they form a map, as shown in the following figure.

Figure 1.2 Layers Forming a SAS/GIS Map
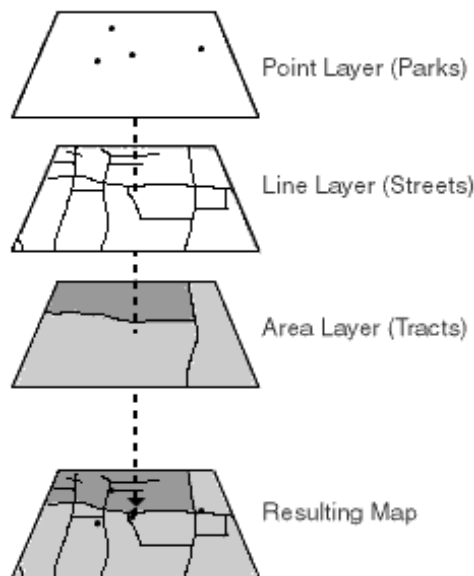
A layer can be displayed as either static or thematic. When a layer is displayed as static, it uses the same graphical characteristics (color, line, width, and so on) for all features in that layer. For example, a street layer could use the same color and line style to display all the streets. When a layer is displayed as thematic, it uses different graphical characteristics to classify the features in that layer. For example, a theme representing sales regions could use different colors to show the quarterly sales performance of each region. A theme in a layer representing highways could use different line widths to show the classes of roads. A layer can have multiple themes stored in it, and you can easily change which theme is currently displayed.

Spatial Data Coverages

In SAS/GIS software, maps display only the portion of the spatial data that falls within a given coverage. A *coverage* defines a subset of the spatial data that is available to a map. The coverage can include all the spatial data in the database, or only selected portions. For example, a spatial database might contain geographic data for an entire country, but a coverage might restrict the portion that is available for a given map to only one region. You can define more than one coverage for each spatial database, although a map uses only one coverage at a time.

Spatial Data Composites

Most operations in SAS/GIS software use composites of spatial data variables rather than the actual spatial data variables themselves. *Composites* identify the relationships and purpose of the variables in the spatial data.

For example, if the spatial data has the variables STATEL and STATER that contain the state ID codes for the left and right sides of each feature, then the spatial database could define a composite named STATE that identifies the relationship between these variables and specifies that they delineate state areas in the map. You would use the STATE composite, rather than the actual STATEL and STATER variables, to link state areas in the map to attribute data for the corresponding state.

See Appendix 2, "Details of SAS/GIS Spatial Databases," on page 161 for more information about the structure of SAS/GIS spatial databases.

Attribute Data

The second type of data that is used in a GIS is attribute data. In SAS/GIS software, your attribute data must be stored in either a SAS data set or a SAS view. SAS views allow you to transparently access data in other formats. For example, you can create a SAS/ACCESS view to access data in a database such as DB2. A DATA step view or an SQL view also allows you to access an external file, or any other type of data from which you can create a SAS view. Once your attribute data is accessible either as a SAS data set or through a SAS view, it can be linked to your spatial data for use in labeling, analysis, or theming. For example, your spatial data might represent a county and contain information for city boundaries, census tract boundaries, streets, and so on. An attribute data set with population information for each census tract can be linked to a map using the corresponding tract composite in the spatial data.

Some of the ways in which you can use attribute data in SAS/GIS software include the following:

- □ Use values in your attribute data as labels. For example, you could use attribute data containing population data to provide the text of labels for census tracts.

- □ Use the values in your attribute data as themes for layers. For example, you could use attribute data containing average household income data as a theme for a census tract layer.

    See Chapter 5, "Customizing Maps," in *SAS/GIS Software: Usage and Reference, Version 6* for more information about assigning themes to map layers.

- □ Define actions that display or manipulate the attribute data when features are selected in the map. This way, you can explore your attribute data interactively rather than simply view static results. The actions can range from simple, such as displaying observations from an attribute data set that relate to features in the map, to complex, such as submitting a procedure from SAS/STAT software to perform a statistical analysis.

You can define the following actions for your attribute data:

☐ Display observations from attribute data sets that relate to selected map features.

☐ Open additional maps that relate to selected map features.

☐ Display images that relate to selected map features.

☐ Interactively subset attribute data sets according to a subset of selected map features.

☐ Submit SAS programs.

☐ Issue SAS commands.

☐ Issue host commands.

☐ Display and edit information for the selected map features.

☐ Organize area features into groups that are based on your attribute data.

See Chapter 4, "Performing Actions for Selected Map Features" in *SAS/GIS Software: Usage and Reference, Version 6* for more information on defining and performing actions.

Designing a SAS/GIS Spatial Database

One of the first steps in a SAS/GIS project is determining the design of your SAS/GIS spatial database. The database will contain the following types of information:

Table 1.1   SAS/GIS Data Types

Type of Data	Database Contents
spatial	all of the spatial data that the user wants to see
attribute	all of the associated attribute data that the user needs to use for analysis or presentation purposes

Before you begin creating the spatial database, you should draw up an overview of the system goals and data requirements. The time you spend designing your database initially will save you time and expenses later in the project. A well-designed database is easier to maintain and document, and you can extend it for future GIS projects.

Use the following guidelines when determining the information you want to include in a database:

Table 1.2 SAS/GIS Spatial Database Guidelines

If you want to determine...	Then	
project objective	**1**	Identify the initial objective of the project and its ultimate goal.
	2	Consider any requirements that might have been imposed on it.
	3	Determine the feasibility of initial implementation and, as best as possible, the impact of any future demands.
attribute data	**1**	Identify the attribute data that is necessary to illustrate the project objectives.
	2	Determine whether you have this data or can obtain it.
spatial data	**1**	Identify the spatial features that you need to link with your attribute data, for example, states, cities, rivers, roads, railroads, airports, and so on.
	2	Determine whether you have this data or can obtain it.

Once you have determined a preliminary list of the data that you will need, use the additional factors in the following sections to help you evaluate and refine your list.

Enable Linking between Spatial Features and Attribute Data

To use attribute data for map actions, themes, or labeling, the attribute data set must contain the same identification information as the spatial feature that it describes so that you can link between them. For example, if your attribute data has Sales Revenue for stores, and Store ID Numbers, you probably want to include the actual location in longitude and latitude for each Store ID Number on your spatial data list. You can then place a marker at the store location and also visualize and analyze the corresponding attribute data for each store.

Use No More Details Than You Need

Use only the data you need for your project. For example, if you have store locations that request the customer ZIP code at the cash register, you should not assume that you need ZIP code boundaries on your map. ZIP code boundaries might be far too small for your purposes if you have stores nationwide. You might decide instead that the three-digit ZIP code boundaries provide fewer, yet more appropriately sized, areas for your analysis. You can summarize your attribute data to the three-digit ZIP code level and use it for your analysis, reducing both the amount of spatial data and attribute data that you need. As long as it is appropriate for your analysis, decreasing the amount of required spatial and attribute data reduces storage space and improves performance. Reducing the level of detail in the spatial data also saves money if you have to purchase the data.

Ensure a Common Level of Spatial and Attribute Data

If you plan to summarize your attribute data to a matching level of your spatial data, make sure that the two types of data have a common level that you can use. For

example, ZIP code boundaries can cross not only county boundaries, but also state boundaries, so there is usually not a one-to-one correspondence between ZIP codes and states or counties. If the only information that ties your attribute data to your spatial data is ZIP codes, you will have difficulties using your ZIP code level attribute data if you include only state or county boundaries in your spatial data.

For specific, smaller areas of the country, a one-to-one correspondence might exist that will allow you to summarize your attribute data to a higher level. However, ZIP codes can change frequently, and this correspondence might be lost. Also, because ZIP codes change, you must be able to account for these changes when performing a historical analysis. For example, if you are comparing sales in a specific ZIP code area over a ten-year period, make sure that the area remained constant during that period. The same is true for other spatial data.

Using the SAS/GIS Interface

Starting SAS/GIS Software

Use the following steps to start a SAS/GIS software session:

1   Open a SAS session.

2   From the SAS menu bar, select **Solutions ▶ Analysis ▶ Geographic Information System**

Or type **GIS** in the SAS Command Box or on any SAS command line.

Using Dialog Box Elements

In most places where you must supply a value in a SAS/GIS window, you will see a pull-out arrow, a drop-down arrow, or both, presented in conjunction with text boxes, as shown in the following display.

**Display 1.2**   Typical Dialog Box Elements

Clicking a drop-down arrow displays a list of valid choices for the option. Display 1.3 on page 11 shows the list that is displayed by clicking the drop-down arrow for the **Style** field in Display 1.2 on page 10.

**Display 1.3** List Displayed by the Style Drop-down Arrow

Clicking a pull-out arrow opens a new window in which you can interactively select appropriate values. The following display shows the window that is opened by clicking the pull-out arrow for the **Color** field in Display 1.2 on page 10.

Display 1.4 Window That Is Opened by the Color Pull-out Arrow
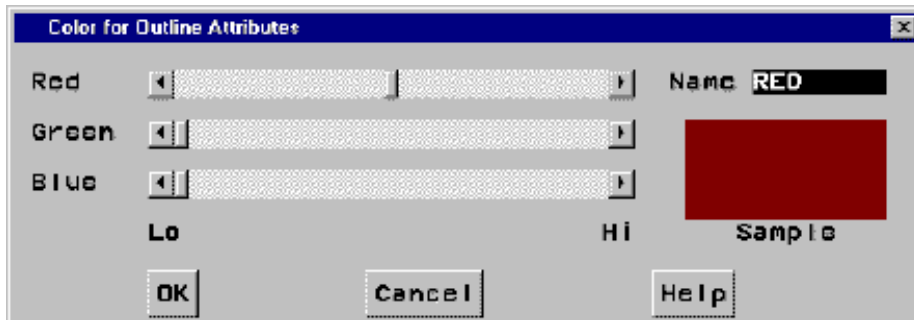
Selecting Maps and SAS Data Sets

Whenever you need to specify the name of a SAS data set or SAS catalog entry, SAS/GIS software opens an Open window like the one shown in the following display.

Display 1.5 Typical Open Window
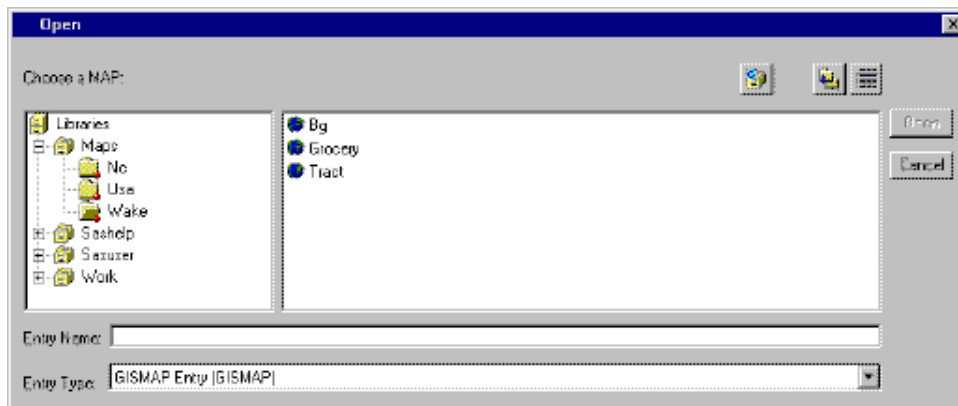
The window provides an intuitive way to find the SAS data set or catalog entry that you need. It also makes it impossible to enter an invalid name, since only those choices that are appropriate for the operation you are performing are presented for selection.

To select each level of the SAS name from the tree view, double-click your choice. Once you make a selection, the list of available choices for the next level of the name is displayed.

Accessing the SAS/GIS Tutorial

This book does not attempt to cover all of the fundamentals of using SAS/GIS software. For an introduction to the basic tasks that you can perform, see the online tutorial that is included in SAS/GIS software. To start the tutorial, make the following selections from the GIS Map window's menu bar:

Help ▶ Getting Started with SAS/GIS Software ▶ Begin Tutorial

The tutorial creates sample maps and attribute data and leads you step by step through the following tasks:

□ displaying maps

□ selecting the types of feedback that are provided about the displayed map

□ using the zoom tool to zoom in on selected areas of the map

□ using the pan tool to move the map within the window

□ modifying, adding, and removing layers in the map

□ using attribute data as a theme for a layer

□ adding legends that explain how features are represented

□ selecting features and using actions to explore the attribute data

□ saving changes to the map

□ geocoding addresses

□ adding points to a map

After you have used the online tutorial to become familiar with the basics of using SAS/GIS software, you can refer to *SAS/GIS Software: Usage and Reference, Version 6* for additional information about using SAS/GIS software and for detailed reference information about the features of SAS/GIS software.