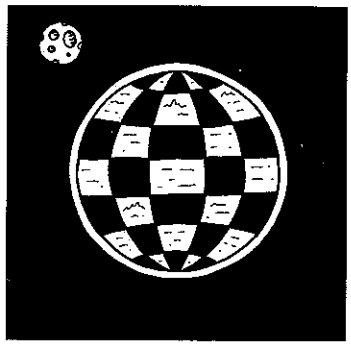
CHAPTER 7

Making Maps with GIS

"What is the use of a book," thought Alice, "without pictures or conversations?"
—Lewis Carroll, Alice's Adventures in Wonderland *(1865)*

Oh, the vision thing...
Some reporters said I don't have any vision. I don't see that.
—George Bush, quoted in Time, *January 26, 1987*

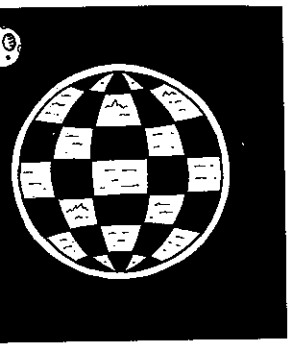
A map is a set of errors that have been agreed upon.
—Anonymous



Y3K. Cartographers team with geologists, and finally eliminate the problem of continental drift.

7.1 THE PARTS OF A MAP

A *map* can be defined as a graphic depiction of all or part of a geographic realm in which the real-world features have been replaced by symbols in their correct spatial location at a reduced scale. Maps, as we have already seen, are the paper storehouses of spatial information that we use as sources of data for GIS. They are also the final stage in GIS work, the means by which the information being extracted, analyzed, and reconstructed using the powers of the GIS is at last communicated to the GIS user or the decision maker who relies on the GIS for knowledge. Maps within a GIS can be temporary, designed merely for a quick informative glance, or permanent, for presentation of ideas as a substitute for a picture or a report. Whatever the map's context, as in Chapter 2, we must return again to the cartographic roots of GIS for a discussion of the critical information that the GIS practitioner needs to use the map display part of a GIS correctly.



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In either case, the map has a structure. Just as a sentence in the English language needs to follow grammar and syntax to be understood, so a map has to follow its own visual grammar. As a starting point, we cover in this chapter what the various parts of a map are called and which of them are essential. This is followed by a description of the methods used by GIS systems for displaying maps and how the choice of a type of map is sometimes made for us by the sorts of attributes and the geographic character of the data in the GIS. We then cover map design, summarizing some of the rules that cartographers have developed for selecting map symbols, such as colors, and then using them to assemble effective maps.

Just as a map has a structure, so that structure can vary according to which media we use for map display. GISs usually use the computer monitor to display a map, rather than the traditional paper. Only now, after many years of computer mapping, are cartographers beginning to understand how map design depends on the display medium. The GIS has been a major reason why this has become an important consideration.

First, however, we should define the terms used in describing maps. Figure 7.1 shows a set of cartographic *elements*. A cartographic element is one of the building blocks that make up a map and from which all maps are assembled. Each element should be present, although in some cases exceptions are possible. The two basic parts of the map are the *figure* and the *ground*. The figure is the body of the map data itself and is the part of the map referenced in ground coordinates. Almost all other parts of a map are located on the map using *page coordinates*, defining locations on the map layout itself rather than the piece of the world it shows. The *graticule* or *grid*, or often a *north arrow*, is the reference link between the two coordinate systems on the final map. Also part of the figure, the ground, and the legend are the *symbols*. The *legend* translates the symbols into words by locating text and the symbols close to each other in the page coordinate space.

The *border* is the part of the display medium (paper, window, computer screen, or other medium) that shows beyond the *neat line* of the map (Figure 7.1). In special circumstances, additional information can be provided in this space, such as the map copyright, the name of the cartographer, or the date. The *neat line* is the visual frame for the map and is usually a bold single or double line around the map that acts as a rectangular frame. From a design standpoint, the neat line provides the basis for the page (i.e., cartographic device) coordinate system, in display units such as inches or centimeters on the page.

Text information is an integral part of a map, and no map is complete without it. Text is contained in the *title* (whose wording sets the theme and the "feeling" for the map), in *place-names*, in the *legend*, and in the *credits* and *scale*. The scale is a visual expression of the relationship between the ground coordinate space and that of the map page space. Because representative fractions change as the map is projected or rendered onto different display devices or windows, a graphic scale is preferred. Place names follow a strict set of placement rules, both on the figure and related to features and within the map space. Point, line, and area features have different placement rules, and there are also rules for dealing with the overlap of names and feature symbols. Some of the rules are shown in Figure 7.2.

Finally, an *inset* is either an enlarged or a reduced map designed to place the map into geographic context or to enlarge an area of interest whose level of detail is too specific for the main map scale. An inset should have its own set of cartographic

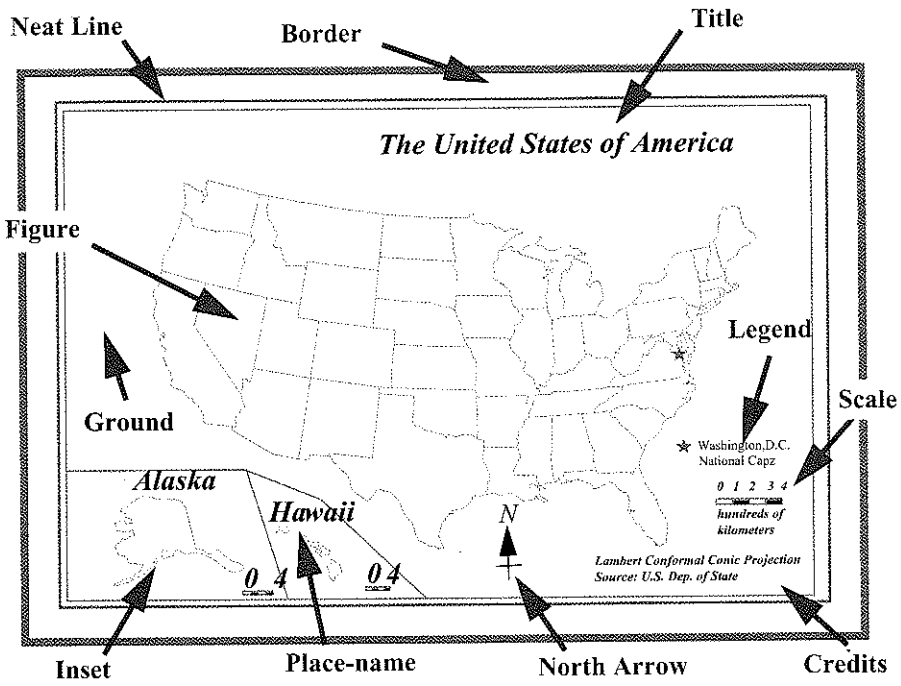


FIGURE 7.1: Cartographic elements.

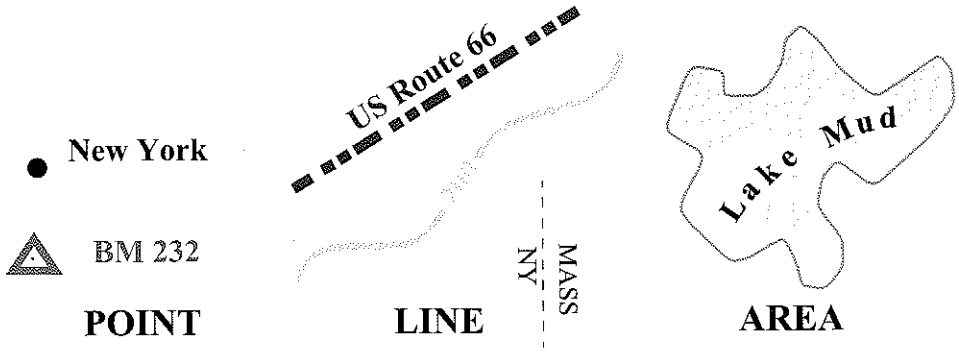
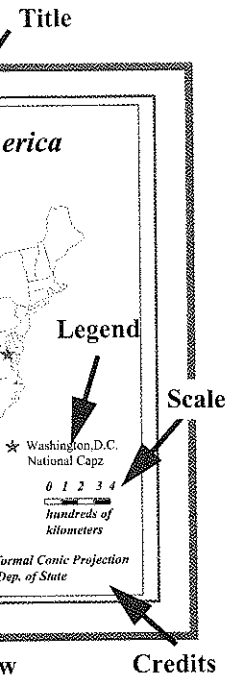


FIGURE 7.2: Some cartographic label placement conventions. Points: right and above preferred with no overlap. Lines: Following the direction of the line, curved if a river. Text should read up on the left of the map and down on the right. Areas: On a gently curved line following the shape of the figure and upright.

elements, although it is usually highly generalized and many elements may be omitted. To avoid confusing the main map with the inset, the inset should be clearly distinguishable from the figure and ground. Many Americans believe that Alaska and Hawaii are small islands off San Diego!



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7.2 CHOOSING A MAP TYPE

Over 3000 years of cartographic history, cartographers have designed numerous ways of showing data on a map. One way to divide up the methods is to look at those that show attributes by their geometric dimension, so that we can have point maps, line maps, and area maps, plus maps that show a three-dimensional view. Many maps show some or all of the types of features at the same time. These are often called *general purpose maps*. *Thematic maps* show just one or two themes or layers of information, often coded, colored, or grouped for convenience. In this section we take a look at the breadth of map types available.

A basic outline or *reference map* (Figure 7.3) shows the simplest properties of the map data. An example is a world outline map, with named continents and oceans. A general reference map, usually showing a suite of features including terrain, streams, boundaries, roads, and towns, is called a *topographic map* (Figure 7.4). Topographic maps are often used as reference information behind GIS map layers.

A *dot map* (Figure 7.5) uses dots to depict the location of features and may show a distribution such as population against a base map. A *picture symbol map* (Figure 7.6) uses a symbol, such as the silhouette of a skier, to locate point features such as ski resorts. The *graduated symbol map* (Figure 7.7) is the same, except that the symbol size is varied with the value of the feature. Typically, geometric symbols such as circles, squares, triangles, or shaded "spheres" are used.

A *network map* shows a set of connected lines with similar attributes. A subway map, an airline route map, and a map of streams and rivers are examples. The *flow map*

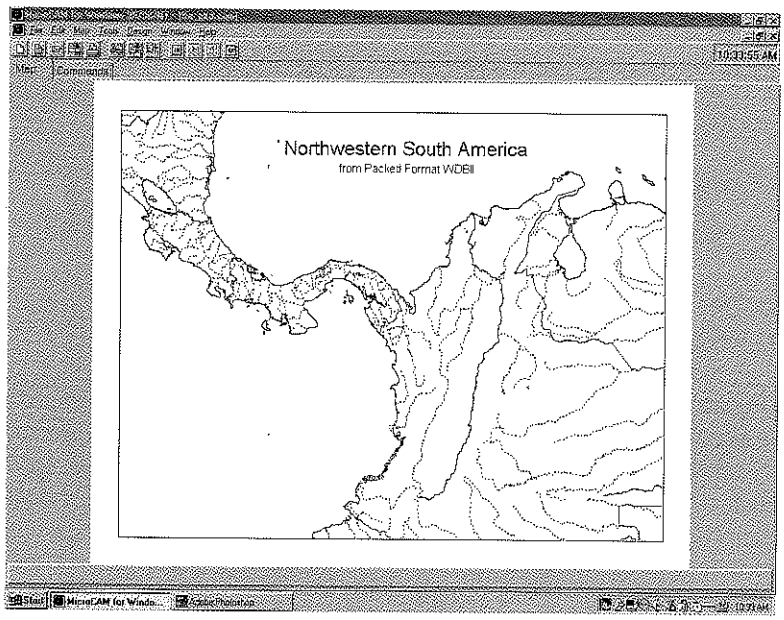


FIGURE 7.3: Reference Map. Central America from the Digital Chart of the World. Plotted from Microcam (`http://www3.ftss.ilstu.edu/microcam`)

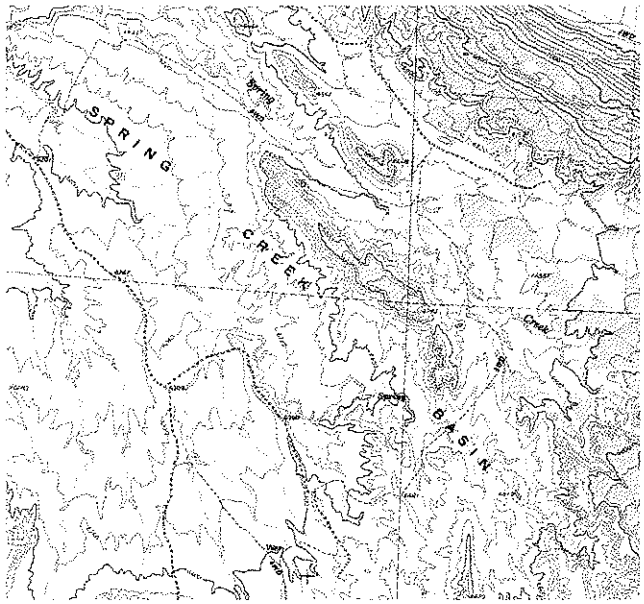


FIGURE 7.4: Topographic map. Section of USGS Digital Raster Graphic for the Dawson Draw, CO 1 : 24,000 quadrangle.

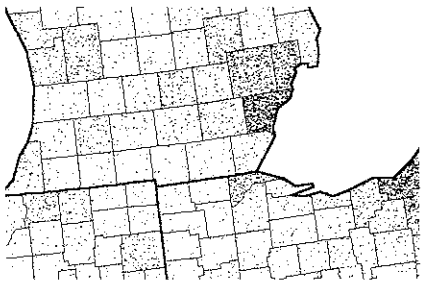


FIGURE 7.5: Dot map of population in the upper mid-west. Map by students of Sandra Arlinghaus, University of Michigan. (Used with Permission.)

(Figure 7.8) is the same, but it uses the width of the line to show value—for example, to show the air traffic volume or the amount of water flow in a stream system.

A *choropleth map* is the familiar shaded map where data are classed and areas such as states or countries are shaded or colored more or less densely according to their value. A variation on this, the unclassed choropleth, uses a continuous variation in tone or color rather than the steps that result from classes. An *area qualitative map* (Figure 7.9) simply gives a color or pattern to an area—for example, the colors of rock types on a geological map, or the land-use classes derived from image classification in remote sensing.

Volumetric data can be shown in several ways. Discontinuous data are often shown as *stepped statistical surface* (Figure 7.10), a block-type diagram viewed in perspective. The standard *isoline map* (Figure 7.11) is a map with lines joining points of equal value.

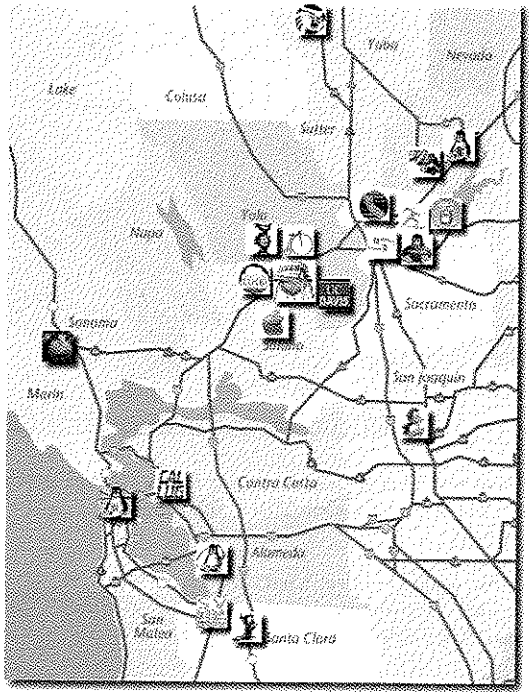


FIGURE 7.6: Picture symbol map. Image taken from Linux Users Group of Davis, CA web site `http://www.lugod.org`. (Used with permission.)

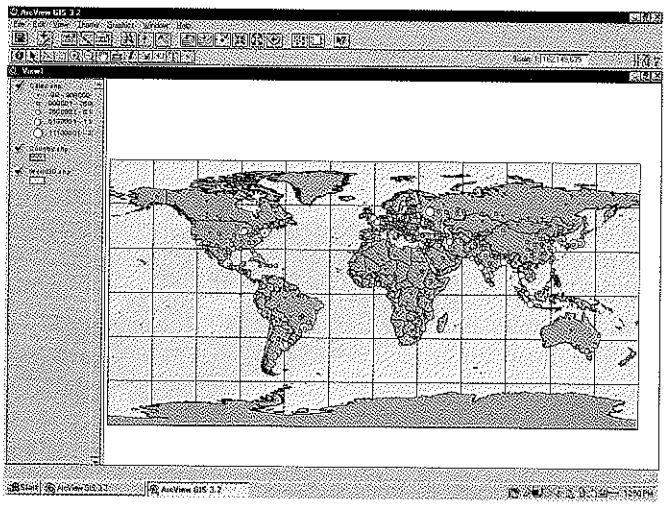


FIGURE 7.7: Graduated symbol map. Proportional circle map of world cities by population, 1995.

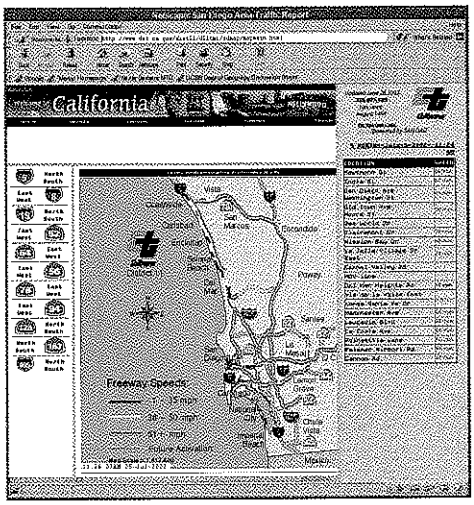
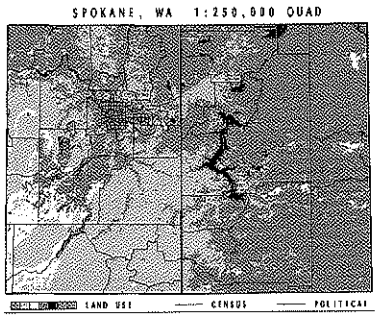


FIGURE 7.8: Flow map. Traffic speed in the San Diego, CA area as posted on the World Wide Web by the California Department of Transportation. (Used with Permission.)

FIGURE 7.9 Area qualitative map. Land use in Spokane, WA. Map by the USGS EROS Data Center. (Used with Permission.)



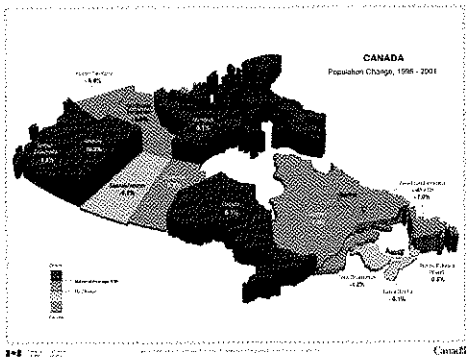


FIGURE 7.10: Stepped statistical surface. Map of population change in Canada, 1995–2001. Source: Statistics Canada. (Used with permission.)

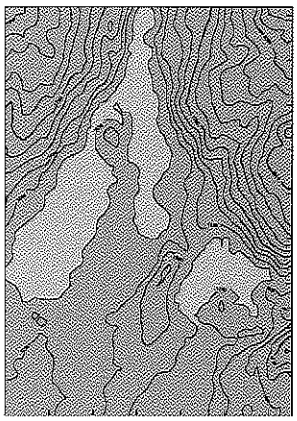


FIGURE 7.11 Isoline map. Contour map of part of the McCall, ID 1 : 24,000 quadrangle.

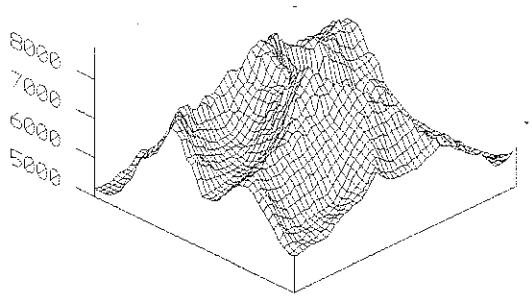


FIGURE 7.12: Fishnet or gridded perspective view. Area shown is the summit area of Mt. Everest. Source: Analytical and Computer Cartography, 2 ed. by the author.

Surface continuity is assumed, meaning that sharp breaks are usually smoothed. The terrain equivalent is the contour map, with its characteristic datum and *contour interval*. A variant is the *hypsometric map* in which the space between contour lines is filled with color using a sequence designed to illustrate variation. Image maps and schoolroom topographic maps use this type.

Three-dimensional views of surfaces rendered in perspective can be either a *gridded fishnet* (Figure 7.12), where a grid is distorted to give the impression of three dimensions, or a *realistic perspective* (Figure 7.13), when an image or shaded map is draped over the surface rather than a grid. The latter technique is often used in animations. Map views of terrain are often represented using *simulated hill shading* (Figure 7.14), where illumination of shadowing is simulated by the computer, and a gray scale or a colored map is used to show the surface. A variant is *illuminated contours*, in which the shading algorithm is applied only to the contours themselves. The final map type considered here is the *image map* (Figure 7.15), in which a value is depicted as variation in tone on a color or monochrome grid. Most raw and false-colored satellite image maps fall into this category, as does the orthophoto map.

So far we have covered the various map types. The GIS user should think of these as a set of possible methods, to be used when the GIS data to be shown have a given

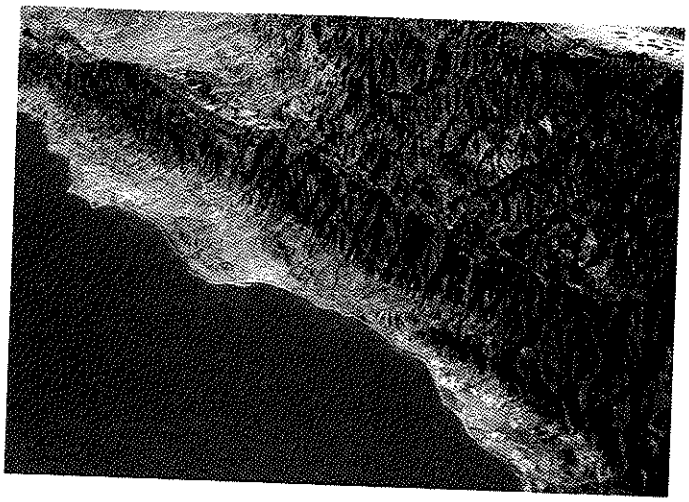


FIGURE 7.13: Realistic perspective view. Image is Landsat Thematic mapper data draped over the USGS DEM data. Image by Martin Herold and Jeff Hemphill. (Used with permission.)

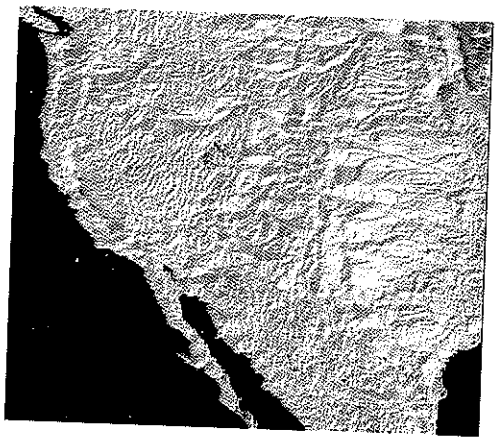


FIGURE 7.14: Hill-shaded relief map. Western United States. Source: the author.

set of characteristics. Earlier in the book we classified features on a map into those that are points, lines, areas, and volumes. Obviously, the nature of the map data in the GIS is different for each of these. A three-dimensional location, for example, usually needs latitude, longitude, and elevation. In addition, the type of attribute information determines what mapping methods can be used.

Figure 7.16 places the mapping methods covered in this section into a framework of a division of the number of dimensions of the GIS features being shown. Similarly, the types of maps make certain assumptions about the nature of the attributes themselves, not just their graphic representation. For example, a reference map that shows cities has point information and text attributes—the names of the cities. The proportional circle map requires that for every point the attribute must be an integer or a floating-point number. A choropleth map requires a floating-point number that has been grouped into shade categories. These data requirements are also given in Figure 7.16.

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FIGURE 7.15: Image map. Digital orthophoto quad. (Courtesy of USGS.)

POINT	LINE	AREA	VOLUME
Dot Map [1] Picture Symbol Map [1] Graduated Symbol Map [2]	Network Map [1] Flow Map [2]	Choropleth Map [2][3] Area Qualitative [3] Stepped Statistical Surface [2] Image map [1]	Isoline Map [2] Hypsometric Map [2][3] Gridded Fishnet [2] Realistic Perspective [2] Hill Shaded Map
← Reference Map [1][4] →			
Topographic Map [1][2][3][4]			

FIGURE 7.16: Types of maps sorted by dimension of features and type of attribute. [1] Feature present, [2] number attribute, [3] categorical attribute, [4] text present.

Particularly common mistakes in choosing mapping methods are choosing choropleth maps for data that are simply "counts," such as population totals, rather than values, rates, or percentages (instead, proportional symbol mapping should be used at the area centroids) because larger areas look like "more" simply because of their geographic size; choosing methods that classify attributes when it is unnecessary; or using too many classes for symbolization. Most other problems are problems of design and are covered in Section 7.3.

7.3 DESIGNING THE MAP

The last stage in the mapping process is the conversion of the GIS data into a map design. Note that for any map type we can have an almost infinite number of choices of symbols, fonts, colors, line thicknesses, and so on. Selecting the "best" design can make an enormous difference in the effectiveness of the map. If a map has taken a large amount of work to generate, it is well worth the GIS user's effort to make doubly sure that the design is sound.

7.3.1 Basics of Design

Some characteristics of the design are predetermined by the choice of the type of map. Primarily, the design stage consists of devising a balanced and effective set of cartographic elements to make the map. A trial-and-error interaction between a map design and a set of symbols or colors comes into play, called the *design loop*. The GIS makes this process possible in the first place by supplying the tools to create, modify, and re-create the map.

It is important to place the map elements correctly. Placement of the elements is usually in one of two ways: first, by having the GIS draw a map, then passing it to a graphic design program and interacting with the map in a design loop; and second, especially in a GIS, by editing a set of macro-like commands that move elements to specific places in the map space. This technique is less efficient and involves many traverses through the design loop.

Most cartography texts state that the cartographer should aim for harmony and clarity in the composition—visual balance and simplicity. This comes from experience and an aesthetic sense that can take years to perfect. For the beginner in GIS, MacEachren (1994) and Dent (1996) give fine summaries of the design experience of professional cartographers.

Text is an important design element. Map text should be clear, correctly and tersely worded, and the words should be positioned as the graphic elements they are. It is easy to make a map title or legend labels either too small or too big, unnecessarily grasping the map reader's attention. Map text should be edited carefully. Many a map in final form has retained a typographical error that should have been eliminated at first glance, or has misspelled a foreign name that should have been checked.

Facts to bear in mind to balance the map elements are (1) that the "weight" of the elements can change when a symbol set (line widths, colors, text fonts, etc.) is chosen; (2) that the elements act in concert with each other in a visual hierarchy, that is, some of the elements naturally stand out from or "above" others, and that using deliberately exaggerated contrast to enhance this hierarchy is usually most effective; and (3) that the combined effect of all the elements is to draw the eye to the center of gravity of the elements. Theory implies that the "visual center" of the map be placed 5% of the map height above the geometric center.

7.3.2 Pattern and Color

The symbolization aspect of design has been studied by cartographers in detail, and more than a few rules of thumb exist. Some symbolization methods are simply not suitable for certain types of maps and certain map data configurations. For example, a frequent misuse of color is on choropleth maps, especially when the computer gives access to thousands of possible colors. Choropleth maps usually establish value by shading, pattern, or color intensity, but rarely by color as such. Thus a sequence from light yellow to orange with a slight color change looks right, but a sequence from red to blue across the rainbow makes the map look like a decorated Easter egg! Color changes are appropriate to distinguish between opposites on the same map, such as a surplus/deficit, above/below a statistical average, or two-party election results.

When only monochrome is to be used, the equivalent applies. Shade sequences should be even, flowing from dark to light, with dark usually being high, and light being

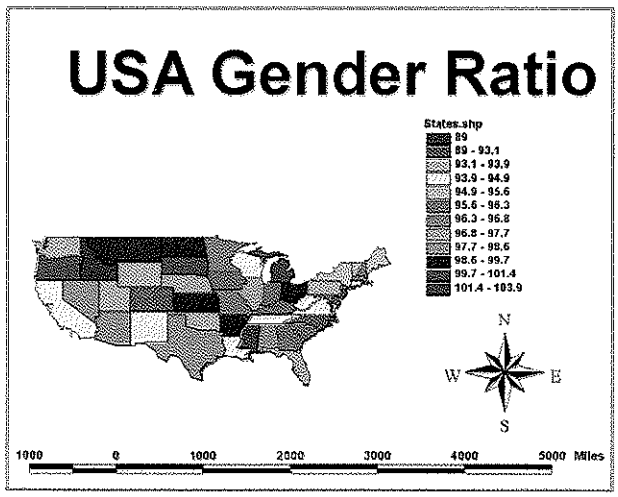

FIGURE 7.17: Some typical map symbolization errors with a GIS. These are: map title too large; map elements unbalanced within neat line; figure too small; too many classes (5 to 7 is best); class shades should not vary in hue; class shades should follow light to dark in sequence; class breaks should not overlap; compass rose adds nothing; and the scale bar is too long. Worst of all, it is impossible to see the spatial pattern in the data!

low. Don't forget that white or blank can be a shade tone, leaving the map looking less cluttered as a result. Another issue is pattern. Combinations of crosshatching, dot patterns, and so on can be extremely confusing to the map reader (Figure 7.17). Combining unmatched patterns can create undesirable optical illusions.

Even on general-purpose maps, color balance is essential. Computer displays use pure color, to which the eye is not usually subjected. Less saturated colors, if available, are more suitable for mapping. In addition, *cartographic convention* should be followed. Ground colors are usually white, gray, or cyan, not black or bright blue. Contours are frequently brown, water features cyan, roads red, vegetation and forest green, and so on. Failure to follow these conventions is particularly confusing to the map reader. Imagine, for example, a globe with green water and cyan land! Map colors can also look completely different on a white rather than a black background, and even on different monitors and plotters.

Color is a complex visual variable. Colors are often expressed as red, green, blue triplets (RGB) or sometimes as *hue*, *saturation*, and *intensity* (HSI). These values are either determined by the hardware device (e.g., 8-bit color allows a total of 256 colors from any of $256 \cdot 256 \cdot 256$ combinations of individual values of RGB) or are decimal values of HSI between zero and one. For example, in RGB, a mid-gray would correspond to [128,128,128]. It is possible to translate directly between the RGB and HSI representations of color. Whereas RGB values are simply the degree to which the respective colored phosphors of the monitor emit light, HSI is closer to the way in which people perceive color.

Hue corresponds to the wavelength of light, going from red at the long-wave end of the visible light spectrum to blue at the other end. *Saturation* is the amount of color per unit display area, and *intensity* is the illumination effect or brightness of

the color. Cartographic convention dictates that hue is assigned to categories and that saturation or intensity is assigned to numerical value. When several hues appear in juxtaposition on a map, the colors are perceptually altered by the eye, a phenomenon known as *simultaneous contrast*. Thus maps that use several hues, even as background and line color, should be designed with caution. In addition, the eye's ability to resolve contrast varies significantly with hue, highest in red and green and lowest in yellow and blue.

7.3.3 Summary

The design of a map is a complex process. Good design requires planning, achieving visual balance among map elements, following conventions, employing the design loop, and correctly using symbols and map types. Without consideration of design, and certainly without having all the required map elements, however impressive it may look on a computer screen, the product is just not as effective. If the map is the result of a complex GIS process, good design is even more important to the person who will have to interpret the map. As we have seen, the relationship between cartography and GIS is a close one. While making a map is often given little thought in the GIS process, it is nevertheless an important stage because it is using maps that particularly distinguishes GIS as being a different scientific approach, and it is the map that has the primary visual impact on the GIS user or decision maker using GIS. Just a little extra care and attention to detail at this final stage can lead to immense improvements in the finished GIS product and to the perception that the entire information flow used in the GIS process is professional and complete.

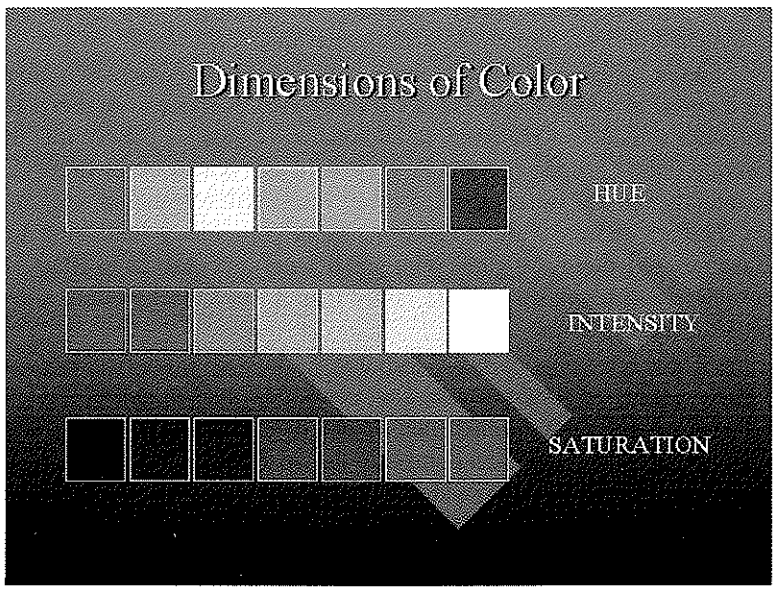

FIGURE 7.18: The dimensions of color. Hue or chroma defines the wavelength of the light reflected or transmitted by the map. Intensity is the level of brightness associated with the color. Saturation is the density of the color on the map surface, expressible as the proportion of the surface area covered in the color. Hue communicates different classes and things, while saturation and intensity communicate numerical level or value.

7.4 STUDY GUIDE

7.4.1 Summary

Chapter 7: Making Maps with GIS

The Parts of a Map (7.1)

- A map is defined as a graphic depiction of all or part of a geographic realm in which real-world features have been replaced with symbols in their correct spatial location at a reduced scale.
- In a GIS, maps can be produced as temporary output; to check a result, answer a query, and so on; or as permanent output as a fully featured cartographic product.
- To appear professional and avoid errors, GIS maps should reflect cartographic knowledge about map design.
- A map has a visual grammar or structure that must be understood and used if the best map design is desired.
- The selection of a map type is often determined by the geographic properties of the data and the attributes.
- A map is composed of a set of basic cartographic elements, including the neat line, scale, border, figure, ground, labels, insets, credits, legend, and title.
- The figure is that part of the map shown in ground coordinates rather than laid out in page coordinates.
- Map text, especially labels on features, follows a set of placement rules that are specific to the dimension of the feature and properties of the map.

Choosing a Map Type (7.2)

- There are many different types of maps, divided by purpose into thematic and general purpose, and by dimension.
- Types of point maps found in GIS software are dot maps, picture symbol maps, and graduated symbol maps.
- Types of line maps common in GIS systems include network maps and flow maps.
- Some types of volume maps that GIS can produce are isolines, hypsometric maps, gridded fishnet, realistic perspectives, and hill-shaded maps.

Designing the Map (7.3)

- A GIS map is designed in a process called the design loop.
- Good map design requires that map elements be placed in a balanced arrangement within the neat line.
- Visual balance is affected by the "weight" of the symbols, the visual hierarchy of the symbols and elements, and the location of the elements with respect to each other and the visual center of the map.
- Symbols, especially colors, are subject to the constraints of cartographic convention (e.g., forests should be green).
- Color is a complex visual variable, and in a GIS is specified by RGB or HSI values.

- **Design errors are common with GIS use, and these include incorrect selections of map type and symbolization errors.**
- **When a GIS map is the result of a complex analytical or modeling process, good design is essential for understanding.**
- **The map is what distinguishes GIS as a different approach to the management of information, so extra care should be taken to improve the final maps that a GIS generates in a GIS task.**

7.4.2 Study Questions

The Parts of a Map

Using a map that you have found in a newspaper or magazine, identify the map elements listed in Figure 7.1 and label them on the map. Are any of the elements missing? Could the map have been improved by adding any of the elements listed in the figure?

Using a USGS topographic quadrangle or any other general reference map such as a wall map, a road map, or an atlas map, copy onto a diagram examples of label placement for point, line, and area features. Are there any examples where the "rules" of text placement have been violated? How has the cartographer dealt with the problem that in dense label areas, features names would overlap?

Name six items that could legitimately be found within a map's border and outside the neat line (not coffee stains!).

Choosing a Map Type

Make a list of the different types of maps listed in Section 7.2. Using Figure 7.16, verify that the classification of feature dimension is correct. Which map types cross categories? Can you find examples of cartographic methods that cross the boundaries of these types?

Make a set of conditions for data to be suitable for display on a choropleth map.

Designing the Map

Give three simple rules for a complete GIS novice to keep in mind when using a GIS to produce a map.

What design issues should be kept in mind when making a choropleth map?

Annotate Figure 7.17 with each of the mistakes labeled in the caption. Can you see any other mistakes? Can you find any mistakes in other figures in the book?

7.5 EXERCISES

1. *Carefully read the documentation for a GIS to which you have access, and compile a list of what map types the software is capable of producing, compared to the map types listed in Section 7.2. Is the subset of map types suited to a particular dimension of data attributes, such as areas?*
2. *Use your GIS package to draw a simple choropleth map. What tools are available within the GIS to assist in the choice of classes for the choropleth data? Does your GIS allow you to make choropleth maps using values other than ratios or percentages? Is there any guidance for choice of colors, shades, or a map layout? How might the documentation for the system be improved to guide the new cartographer better?*

3. *Make two different maps with your GIS of the same data, one in which you choose a design to enhance differences in the data and one where you try to hide them. Show the maps to some friends or colleagues and ask them about the distributions. Can their opinions about the data be shaped by the choice of symbols for a single map type? Repeat the task using the same data and two sets of symbols, say gray tones versus shading, or red hues versus green hues.*
4. *Using a topographic map or any map you choose, perhaps from the documentation for your GIS, analyze the placement of labels on the maps. Check a cartography textbook for the conventional cartographic rules of label placement. Can the GIS change placement of the labels?*

7.6 BIBLIOGRAPHY

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7.7 KEY TERMS AND DEFINITIONS

area qualitative map: A type of map that shows the existence of a geographic class within areas on the map. Colors, patterns and shades are generally used. Examples are geology, soils, and land-use maps.

border: The area between the neat line and the edge of the medium or display area on which a map is being displayed. Occasionally, information can be placed within the border, but this area is usually left blank.

cartographic convention: The accepted cartographic practice. For example, water is usually cyan or light blue on a world map.

cartographic elements: The primitive component part out of which a map is assembled, such as the neat line, legend, scale, titles, figure, and so on.

choropleth map: A map that shows numerical data (but not simply "counts") for a group of regions by (1) grouping the data into classes, and (2) shading each class on the map.

clarity: The property of visual representation using the absolute minimum amount of symbolism necessary for the map user to understand map content without error.

color balance: The achievement of visual harmony between colors on a map, primarily by avoiding colors that show simultaneous contrast when adjacent to each other.

contour interval: The vertical difference in measurement units such as meters or feet between successive contour lines on a contour map.

contour map: An isoline map of topographic elevations.

credits: A cartographic element in which the sources, authorship, and ownership of the map and the map attributes are cited, often including a date or reference.

design loop: The iterative process in which a GIS map is created, examined for design, improved, and then replotted from the modified map definition until the user is satisfied that a good design has been reached.

dot map: A map type that uses a dot symbol to show the presence of a feature, relying on a visual scatter to show spatial pattern. Most often used where point features are the GIS data, but dots can be scattered at random throughout areas.

figure: The part of a map that is both referenced in the map coordinate system rather than the page layout coordinates and that is the center of the map reader's attention. The figure is contrasted against the ground, or background. For example, on a map of New York State, the state is the figure, and surrounding states, though shown and labeled, are part of the ground and may be toned down.

flow map: A linear network map that shows, usually by proportionally varying the width of the lines in the network, the amount of traffic or flow within the network.

fonts: A consistent design for the display of the full set of English or other language characters, including special characters such as punctuation and numbers.

graduated symbol map: A map type that varies the size of a common geometric symbol to show the amount of an attribute at points or at centroids of areas. For example, cities could be shown with circles of area proportional to population, or census tracts could have a proportional circle divided as a pie chart at a representative point inside the tract.

gridded fishnet map: A map of a three dimensional surface showing a set of profiles, often parallel to the x, the y, or the viewer's axis so that the surface appears three dimensional, as a raised fishnet viewed in perspective.

ground: The part of the body of the map that is not featured in the figure. This area can include neighboring areas, oceans, and so on. The ground should fall lower than the figure in the visual hierarchy.

harmony: The property by which the elements of a map work together to create a balanced aesthetic whole.

HSI: A system for color, specified as values for hue, saturation, and intensity, respectively.

hue: A color as defined by the wavelength of the light reflected or emitted from the map surface.

hypsometric map: A map of topography involving a color sequence filling the spaces between successive contours, usually varying from green through yellow to brown.

image map: A map that in two dimensions shares many of the characteristics of a map, that is, cartographic geometry, some symbols, a scale and projection, and so on, but is a continuous image taken from an air photo, a satellite image, or a scanner. A scanned paper map used as a backdrop in a GIS becomes an image map.

inset: A map within a map, either at a smaller scale to show relative location, or a larger scale to show detail. An inset may have its own set of cartographic elements, such as a scale and graticule.

intensity: The amount of light emitted or reflected per unit area. A map that has high intensity appears bright.

isoline map: A map containing continuous lines joining all points of identical value.

label: Any text cartographic element that adds information to the symbol for a feature, such as the height number label on a contour line.

label placement rules: The set of rules that cartographers use when adding map text, place-names, and labels to features. Some rules are generic to the map as a whole, while others relate to point, line, and area features specifically. Well-designed maps follow the label placement rules and use them to resolve conflicts between the labels, as labels should never be plotted over each other.

legend: The map element that allows the map user to translate graphic map symbols into ideas, usually by the use of text.

line thickness: The thickness, in millimeters, inches, or other units, of a line as it appears on a map.

map: A graphic depiction of all or part of a geographic realm where the real-world features have been replaced with symbols in their correct spatial location at a reduced scale.

map design: The set of choices relating to how a map's elements are laid out, how symbols such as colors are selected, and how the map is produced as a finished tangible product. The process of applying cartographic knowledge and experience to improve the effectiveness of a map.

map title: Text that identifies the coverage and content of a map. This is usually a major map element and can be worded to show the map theme or the map's content.

map type: One of the set of cartographic methods or representation techniques used by cartographers to make maps of particular types of data. Data, by their attributes and dimensions, usually determine which map types are suitable in a map context.

neat line: A solid bounding line forming the frame for the visually active part of a map.

network map: A map that shows as its theme primarily connections within a network, such as roads, subway lines, pipelines, or airport connections.

orthophoto map: An image map that is an air photo, corrected for topographic and other effects. A specific type of mapping program, at 1 : 12,000, by the USGS.

page coordinates: The set of coordinate reference values used to place the map elements on the map and within the map's own geometry rather than the geometry of the ground that the map represents. Often, page coordinates are in inches or millimeters from the lower left corner of a standard-size sheet of paper, such as A4 or $8\frac{1}{2}$ by 11 inches.

permanent map: A map designed for use as a permanent end product in the GIS process.

picture symbol map: A map type that uses a simplified picture or geometric diagram at a point to show a feature type. For example, on a reference map, airports could be shown with a small airplane stick diagram, or picnic areas by a picnic table diagram.

place-name: A text cartographic element that links text for a geographic place to a feature by placing it close to the symbol to which it corresponds, such as a city name as text next to a filled circle.

realistic perspective map: A map of a three-dimensional surface showing a colored or shaded image draped over a topographic surface and viewed in perspective.

reference map: A highly generalized map type designed to show general spatial properties of features. Examples are world maps, road maps, atlas maps, and sketch maps. Sometimes used in navigation, often with a limited set of symbols and few data. A cartographic base reference map is often the base layer or framework in a GIS.

RGB: The system of specifying colors by their red, green, and blue saturations.

saturation: The amount of color applied per unit area. Perceptually, saturated colors appear rich or solid, whereas low-saturation colors look washed out or pastel-like.

scale: The part of the map display that shows the scale of the map figure as either an expression of values (the representative fraction as a number) or as a graphic, usually a line on the map labeled with an equivalent and whole-number length on the ground, such as 1 kilometer or 1 mile.

simulated hill-shaded map: A map in which an apparent shading effect of raised topography is produced by computer (or manually) so that the land surface appears differentially illuminated, as it would in low sun angles naturally.

simultaneous contrast: The tendency for colors at the opposite ends of the primary scale to perceptually "jump" when placed together; for example, red and green.

stepped statistical surface: A map type in which the outlines of areas are "raised" to a height proportional to a numerical value and viewed in apparent perspective. The areas then appear as columns, with a column height proportional to value.

symbol: An abstract graphic representation of a geographic feature for representation on a map. For example, the feature could be a canal, the symbol a blue line of a given thickness.

symbolization: The full set of methods used to convert cartographic information into a visual representation.

temporary map: A map designed for use as an intermediate product in the GIS process and not usually subjected to the normal map design sequence.

topographic map: A map type showing a limited set of features but including at the minimum information about elevations or landforms. Examples: contour maps. Topographic maps are common for navigation and for use as reference maps.

visual center: A location on a rectangular map, about 5% of the height above the geometric center, to which the eye is drawn perceptually.

visual hierarchy: The perceptual organization of cartographic elements such that they appear visually to lie in a set of layers of increasing importance as they approach the viewer.