GUIDELINES FOR PRODUCING CARTOGRAPHIC OUTPUT

M. Bunch, 2002, Faculty of Environmental Studies, York University

> Good design looks right. It is simple (clear and uncomplicated). Good design is also elegant, and does not look contrived. A map should be aesthetically pleasing, thought provoking, and communicative.
>
> – Robinson *et al.*, (1995) *Elements of Cartography, 6th Edition*. New York: John Wiley & Sons

Most of the assignments in GIS courses require students to produce cartographic output. Maps are a very important way to synthesize information and to communicate 'the whole picture' to one's audience quickly and succinctly. For students of geography and environmental studies, fields that are both analytic and synthetic and that are touted as interdisciplinary, the development of skills in the use of tools for integration (such as maps) is very important. For this reason, many lab assignments in GIS courses will include components that are aimed to develop and strengthen students' skills in map-reading and map-making.

GOALS OF MAP DESIGN

Students in GIS courses are directed to follow the 5 goals of map design outlined by Tyner (1992) in her book *Introduction to Thematic Cartography*.

These are:
- Clarity
- Order
- Balance
- Contrast
- Unity

Instructors marking lab assignments in this course will be evaluating how students deal with these design goals. An excerpt from Tyner's book is provided below. **Read it carefully and apply the principles to all maps you produce**. Another excerpt, from Ed Madej's book on *Cartographic Design Using ArcView GIS* is also included here. Madej gives examples using ArcView, and also provides a additional discussion relating to Clarity (legibility), Contrast (both visual, and figure-background), and Order (stereogrammic, extensional, and subdivisional hierarchy of map elements).

Students should pay attention also to the section on "Formulating the plan" in the excerpt from Tyner's book below. Consider the questions;

What is the purpose of the map?
Who is the audience?
What is the topic?
What are the format and scale?
How will the map be produced and reproduced?

These issues will have considerable impact on design choices such as the use of color, the scale of the map, the choice of projection, the size of the type face, the amount of ancillary information provided, and the method of symbolization.

MAP ELEMENTS

Students must also ensure that all maps they produce are complete – that they include all the necessary map elements. For simple maps all of the map elements listed below (with the exception of inset maps) should be present. In some cases certain elements might be left off – but this should be a considered choice based on sound design principles. Use the discussion of map elements below as a checklist for the maps you produce.

Figure, Theme, or Subject Area: This is the most important design unit of a map. It typically is placed in the visual centre of the map frame (demarcated by a border or neatline), and it's position in the visual hierarchy of map elements is emphasized. The readers eye should be drawn first to the theme. A useful 'rule of thumb' states that the theme should occupy about 70% of the space within the map frame.

Title: The title of a map should be descriptive but concise. Never include redundancies such as "Map of..." in the title. If the map is specific to a particular date, include the date in the title. The title is usually second highest in the hierarchy of map elements. The type face, size, colour and placement should be such that the reader's eye is drawn to the title second after the main figure. If

the title has two parts (title and subtitle), they are usually split and centred over two lines. The second line (subtitle) will have less emphasis (*e.g.*, smaller font size) that the main title. In placing the title, consider its position in the hierarchy of map elements and balance in the map.

Legend or Key: The legend is third in the visual hierarchy after the theme and the title. It should be placed with consideration for balance of the map. It may be set in a frame of its own and have a label. In a thematic map never label the legend "Legend." Rather, it should be labelled with a description of the theme which amplifies (if possible) the title. *E.g.,* if the map title is "Slums in Madras, 1986" the legend might be labelled "Size of slums by population" and correspond to symbols which represent slums in various population size categories. All symbols in the map that are not self-explanatory must appear in the legend. They must be represented exactly as they appear on the map.

Scale: The scale is low on the hierarchy of visual elements. The readers' eye should not be drawn to it, but it must be easy to find on the map when needed. All maps must have an indication of scale, whether this is provided by way of a scale bar, relative fraction statement, or a labelled graticule. Once again, balance is a consideration of the placement of this map element. One should also consider unity and harmony of the map in choosing the correct scale. For example, don't provide an overly ornate scale on a map with a simple design, and do not provide a scale which is more accurate that the map itself.

Orientation: Most maps provide some indication of their orientation. If no indication is provided, North is assumed to be at the top of the map. As with the scale, an indication of the orientation of a map is low in the hierarchy of visual elements, and should be included with consideration of balance, unity and harmony of the map. Use north arrows to indicate orientation only on maps which use projections that have straight, parallel meridians, or which present areas small enough that the curvature of the earth is not noticeable. *E.g.*, using a north arrow on a map of Canada which employs a conic projection would be misleading – the meridians converge at the north pole, so North would be indicated differently at different places on the map. Graticules and grid ticks can also be used to show direction.

Border or Frame, and Neatline: A border can add stability to the design of a map. It separates the map elements from the rest of the page and constrains the eye movement of readers, anchoring the map to the page, and a reader's attention to the map area. Neatlines are also sometimes included. These are lines that bound the detail of the map and separate it from marginal information (which may *bleed* off the page – extending to the edge with out a border).

Authorship: Maps which are not part of a larger publication, or which may be distributed in isolation from other identifying material, should always include a statement of authorship. This element is very low on the visual hierarchy, and is often included outside (*e.g.*, just below and justified to one side) of the map border. The authorship statement should include the name of the cartographer, the date or year the map was produced, and the location or institution it was produced. (*E.g.*, "M. Bunch, January 2002, York University"). The author might also wish to provide a statement of copyright.

Source Statement: Maps which employ data that was not collected or generated by the author of the map itself should always include an indication of the source of the data. This is similar to a bibliographic reference and should include the producer/author of the data, the year the data was collected or published, and any other pertinent information. Similarly, the base map used to create the map should also be cited, although in practice this is often neglected. (At the very least, students must state the source of their data). Source statements are very low on the visual hierarchy of map elements. They should be easy to find when the reader needs the information, but should not draw attention. Typically, such statements are provided in a small font near the bottom of a map, inside of the border. Examples of base map and data source statements are:

Base map after: 'Slums in Madras City, 1986.' (1986) 1:20 000. Madras: Tamil Nadu Slum Clearance Board.

Source: 'Survey of Slums in Madras Metropolitan Area' (1986) Madas: Madras Metropolitan Development Authority.

Inset maps: Inset maps may be used to gain an appreciation of scale, or to enlarge a portion of the map. Insets should be used sparingly and avoided if possible. Depending on the importance of the inset, it should be placed below the title and perhaps below the legend in the visual hierarchy of map elements. Its placement on the map should provide balance with the other map elements. Insets may require their own scales, legends, or titles depending on the complexity of the information presented and how self-explanatory that information is.

THE FOLLOWING EXCERPT IS FROM:

Tyner, Judith (1992) *Introduction to Thematic Cartography.* Englewood Cliffs, New Jersey: Prentice-Hall. pp 44-51.

DESIGN AS A PLAN OF EXECUTION

Goals of Design

Design is not a linear process. Although certain steps are followed (as outlined next), much of the creative design process is a right-brain activity and requires a holistic approach. Because language is limited to a serial progression, we cannot, in a textbook, consider all aspects of design at once, but must break the process into sections. Bear in mind that this is essentially artificial.

The goals of any design are clarity, order, balance, contrast, unity, and harmony. All these must be kept in mind simultaneously when planning a map.

Clarity

A map that is not clear is worthless. Clarity is achieved by carefully examining the objectives of the map and emphasizing the important points. At the same time, anything that does not enhance the map message should be eliminated. This means the map should not be overloaded with information, and the material that is included should be presented in a clear, unambiguous manner.

Order

Order refers to the logic of the map. Is there noise, clutter, or confusion? Are the various elements placed logically? Is the reader's eye led through the map appropriately? Since the map is a synoptic, not a serial communication, like reading or speech, cartographers cannot assume that readers will look first at the title, then the legend, and so on. Studies of eye movements show there is considerable shifting of view. The orientation of shapes seems to exert an attraction because the shape of the elements on a page creates axes that give direction.[2] That is, vertical lines lead the eye up and down on the map; horizontal lines lead the eye left and right.

Balance

Balance here refers to visual balance. Every element of the map has weight. These weights must be distributed properly about the optical center (a point slightly above the actual center), or the map will appear to be top heavy, weighted to one side, or unstable. The map in Figure 3-1 is poorly balanced.

Generally, visual weight within a frame depends on location, size, color, shape, and direction. Centrally located elements have less weight than those to one side; objects in the upper half or on the right side appear heavier than objects in the lower half or left side of the map. Weight appears to increase with increasing distance from the center, and isolated elements have more weight than grouped elements. Size, obviously, affects apparent weight; larger elements have greater visual weight. Certain colors appear heavier than others. Red is heavier than blue; bright colors are heavier than dark. Regular shapes seem heavier than irregular; compact shapes have more visual weight than unordered, diffuse shapes. Forms with a vertical orientation seem heavier than oblique forms.

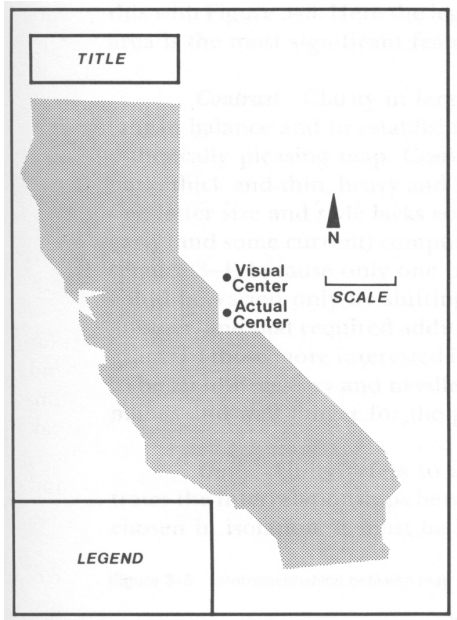


Figure 3–1 Poorly balanced map.

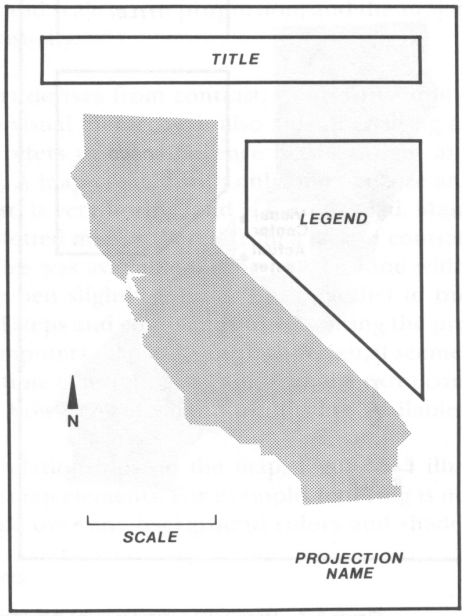


Figure 3–2 Map is too small for the format.

Closely tied to balance is the problem of white space. *White space* in this context is any area within the map border that is not taken by the map itself. Some white space is needed to set off the maps and avoid a crowded appearance, but normally it is desirable to place the largest-scale map possible within the borders while still allowing enough room for title; legend, and other necessary elements. Too often, a small map is used, and the remaining area is filled with oversized north arrows, bar scales, and the like, which overshadow the map (see Figure 3-2). In Figure 3-2, a larger-scale map could have been used and the scale, legend, title, and north arrow should be less prominent. In this illustration, the map has become the least important visual element within the borders. Contrast this with Figure 3-3. Here the legend and scale are in proportion, and the subject area is the most significant feature visually.

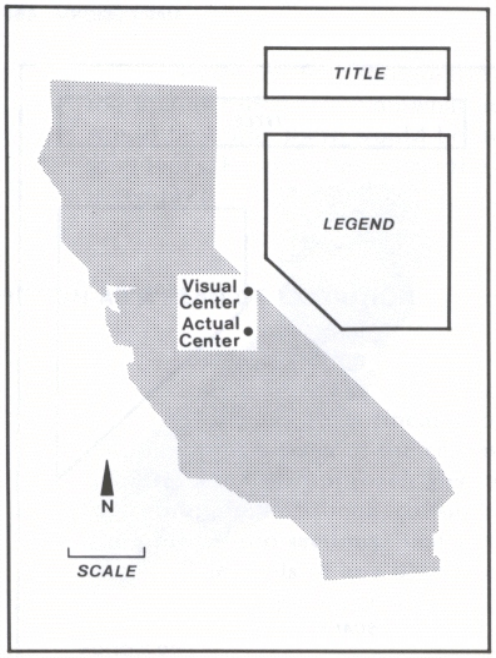


Figure 3-3 Good use of space.

Figure 3-4 Many early computer maps lacked contrast.

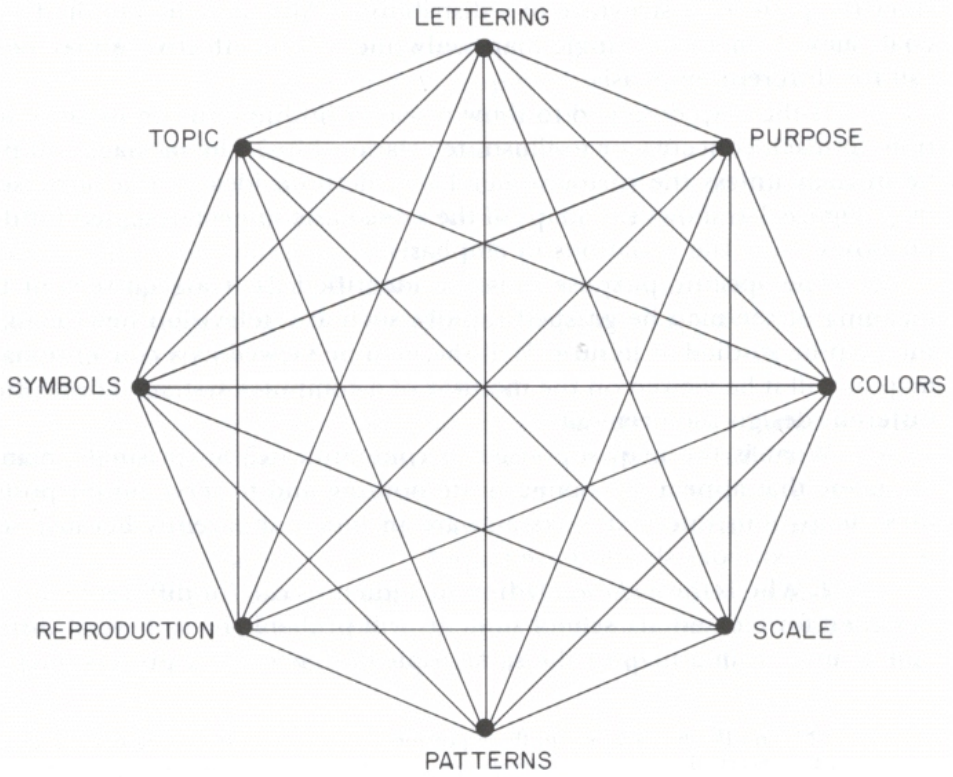
Contrast

Clarity in large part derives from contrast. Contrast is important in balance and in establishing a visual hierarchy; it also aids in creating an aesthetically pleasing map. Contrast refers to the difference between light and dark, thick and thin, heavy and light. A map created with only one pen size and one letter size and style lacks contrast, is very boring, and is hard to read. Many early (and some current) computer-plotted maps suffered from a lack of contrast (Figure 3-4) because only one pen size was available on the plotter. Line width could be varied only by shifting the pen slightly to draw lines parallel to one another, and that required additional steps and commands when writing the program. To those more interested in computers than cartographic design, it seemed to be an unnecessary and needlessly time consuming step to write the extra commands and wait longer for the plot. Now pens of varying widths are available.

Unity

Unity refers to interrelationships on the map. Figure 3-5 illustrates the interrelationships between map elements. For example, lettering is not chosen in isolation. It must be legible over any background colors and shades, and it must not conflict with the chosen symbols. Unity also means that the map appears to be a unit, not a series of unrelated bits and pieces.

Figure 3-5 Interrelationships between map elements.



Harmony
Do all the elements work well together? Are the letter styles in harmony with one another or is there a visual battle on the map? Do the patterns chosen create a pleasing appearance, or do they clash with one another in some manner? Does anything on the map jar the eye?

Formulating the Plan
Design begins with the concept of the map and defining the problem. The first of many decisions to be made is whether a map is the appropriate method to communicate the material. The cartographer must judge if the information is better presented in text or in a table rather than on a map. Normally, a map is the most suitable form of communication if the information is spatial in nature. If a map is the choice, the following questions are answered and, assuming the spatial information is available, the creative process begins.

1. What is the *purpose* of the map? Thematic maps have both a general and a specific purpose. In Chapter 1 we saw that thematic maps serve one of two general purposes: they may show locations and perhaps amounts, or they may show the pattern or structure of a distribution. Although, in a limited way, both goals may be met on a single map, only one will be effective, since these goals call for different emphasis.

Is the map designed to show research findings, to simply store information, to teach concepts, or to illustrate relationships? The message will probably be unclear unless the cartographer has a definite idea of the purpose of the map. Figure 3-6 shows two maps of the same basic subject designed for different purposes. Note the variations in emphasis.

The specific purpose must be identified. Is it a requirement that the meaning of the map be grasped rapidly, such as a television news map, or will the map be studied at leisure? Will the map be viewed as a conventional paper map or will it be viewed on the monitor of a computer system? These often have different design requirements.

What is the map supposed to communicate? Surprisingly, many maps are made that appear to communicate nothing and to serve no purpose. Often these maps illustrate textbooks and are included apparently because someone feels that textbooks should have maps.*

2. Who is the *audience?* Different audiences call for different maps. A map designed for elementary school students will probably be somewhat different in appearance from a map of the same topic designed for a professional journal.

*Barbara Petchenik refers to these purposeless, noncommunicating illustrations as "map- like objects."

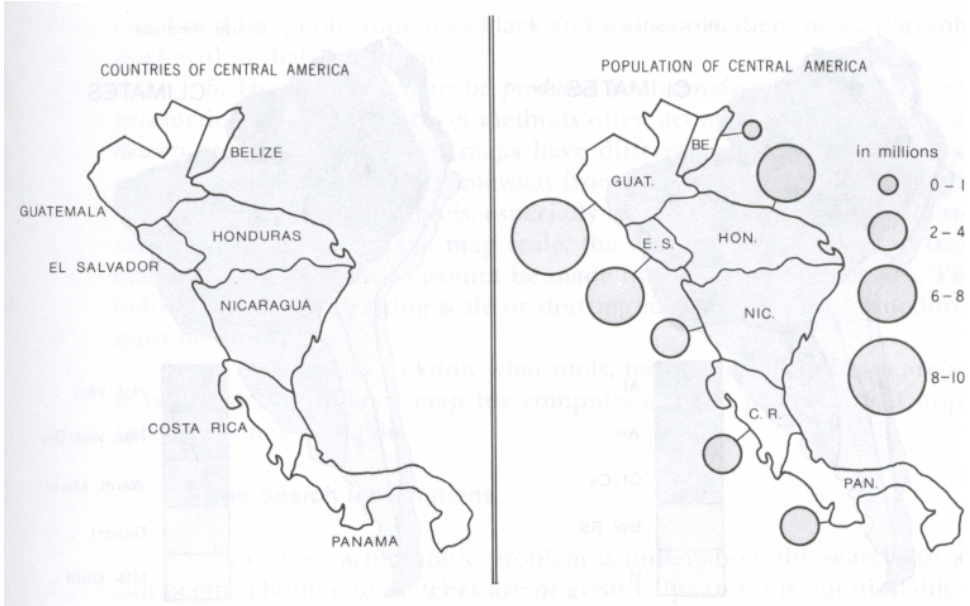


Figure 3-6 Both of these maps show Central America, but the one on the left is designed to show location and the one on the right to show population amounts.

Some information about the age and sophistication of the map users is helpful, as well as some knowledge of their map-reading abilities. These details must usually be inferred from the place of publication or other material. It is assumed that the audience of an academic journal, such as *The Annals* of the Association of American Geographers, has more map-reading sophistication than readers of elementary school textbooks. However, a clear explanatory legend should be supplied for any audience (Figure 3- 7).

The perceptual abilities of the map users are important. Do they have normal eyesight or are they visually impaired in some way, by having only partial sight or merely in being older and finding small print difficult to read. Again, this information must often be inferred.

Various environmental factors are involved. For instance, what type of lighting will be available? A map that will be viewed in a darkened airplane will have different design requirements than one that will be used in a brightly lighted planning office. Testing may be necessary to determine what colors and type styles work best.

Cartographers and map users should not be adversaries. Cartographers should design maps that will be of maximum use; maps should not be tests of the users' puzzle solving abilities and patience, although many published maps seem to be just that.

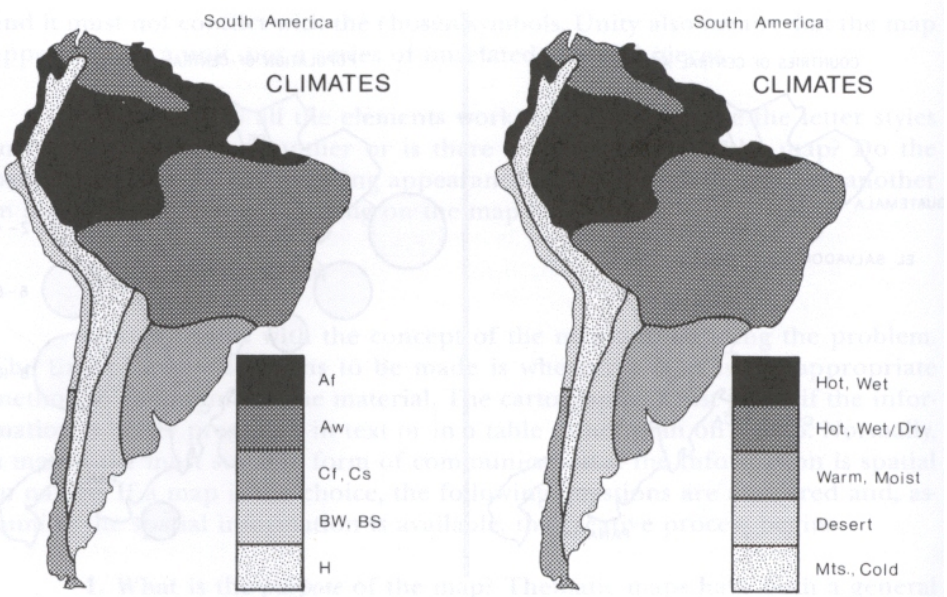


Figure 3–7 Both maps show climates of South America, but the one on the right is designed for elementary school and the one on the left for college level.

3. What is the *topic?* The theme and location have a bearing on the choice of projection, scale, and degree of generalization. Distribution maps require equal-area projections, a map of wheat distribution does not need a detailed coastline, and mid-latitude areas are better represented on conic projections than cylindricals, for example. Each of these will be discussed more fully in the relevant chapters.

4. What are the *format* and *scale?* Format refers to the size and shape of the pages and may also involve color and other elements. To make maximum use of the space, the largest-scale map that will fit without crowding within the given page dimensions should be chosen. If the format is not specified, it must be learned. Universities have specific requirements for theses and dissertations; as do publishers of books and professional journals. Size limits for journals are often specified in the journal or are available by writing to the editor for a copy of the guidelines. Table 3-1 gives the formats for some of the more common geographic and cartographic journals.

The use or nonuse of color is a part of the format. The addition of even one color greatly simplifies the task of representing several different phenomena, but if the publication uses black and white only, then the cartographer must work within that constraint.

Table 3-1

Annals of AAG	6 by $8^{5}/_{16}$ inches
Cartography and Geographic Information Systems	6⅞ by 9 inches
Geographical Review	5 by 7⅝ inches
Journal of Geography	7 by 9⅝ inches
Professional Geographer	4⅞ by 7⅛ inches

5. How will the map be produced and reproduced? The tools, techniques, production, and reproduction methods often act as limiting factors. Computer- drawn and manually drawn maps have different requirements. Similarly, pen and ink maps might differ somewhat from scribed maps in their requirements. For some production methods, especially those used for intermediate steps, it is not possible to change the map scale, the map must be drawn on translucent material, and corrections cannot be made by painting out mistakes. Therefore, before choosing a drafting scale or drafting medium, the reproduction method must be known.

It is necessary to know what tools, media, and techniques are available. It is pointless to plan a map for computer-assisted production if appropriate software is not available.

THE FOLLOWING EXCERPT IS FROM:

Madej, Ed (2000) *Cartographic Design Using ArcView GIS*. New York: OnWord Press. pp 26-32.

Cartographic Design Principles

There are four basic design principles to consider during the cartographic design process: legibility, visual contrast, figure-to-ground contrast, and hierarchical organization of layers. These principles come into play at different points in the process of constructing a map, as you are using different tools in ArcView's view and layout documents.

Legibility

If you are reading a book and have trouble understanding a paragraph, you can grab a dictionary and look up the meaning of a word or phrase, or ask another person to read the passage and get their interpretation. The author of the book may have written that paragraph poorly, but your failure to understand it does not necessarily ruin the entire book.

If you are reading a map, however, and cannot see the differences between geographic symbols or read the labels of some of the features, there is really no place to turn for help. If the mapmaker has symbolized one critical symbol poorly, the meaning of the entire map may be ruined. Maps are a unique form of graphic communication, in that their meaning hits the map reader all at once. If you have to work to understand the map's meaning, the map is worthless. This is especially true with thematic maps, but applies to general reference maps as well.

Map symbols must be legible to the reader. Lines representing roads need to be differentiated from lines representing rivers. Circular points symbolizing cities must be clearly different from points symbolizing sewage outfalls. Map feature labels should be readable by the map user under the conditions the map is designed for, whether in a book, on a wall in a large meeting room, or in a car while driving down the highway.

TIP: *Arc View's Pen and Fill palettes default to a line weight of .1 pt that is very difficult to see, even if it prints clearly on your printer. Change it to at least .5 pt to be visible for lines and polygon outlines. Arc View's Font palette defaults to the first font in your type list (Arial is common on Windows computers) at 14 pt, which is moderately large for type. 10-pt type is easily readable by most people when a map is hand held by the user, whereas 6-pt is getting too small for some.*

Special considerations regarding map legibility need to be addressed for map users that may have common visual impairments, such as color blindness. Studies show that 4 percent of the American public have trouble distinguishing red from green. The one color-blind board member that cannot tell the difference on the map you made of your company's sales figures can be a problem, but producing an unreadable map of fire evacuation routes in a building can be criminal. The mapmaker uses the visual variables of size, shape, and color to help with legibility.

Visual Contrast

With thematic maps, the map symbols that represent your data should have good contrast with the other map features. The map reader's eye is drawn instantly to contrasting shapes and colors. Your job as map-maker is to make sure the reader's eye is drawn to the features that define the purpose of the map, and is not confused with other less important information. There is less contrast between different classes of reference map features because no one feature should overpower another.

Figure-Ground Contrast

Thematic maps use visual contrast between classes of map features to establish figure-to-ground contrast. The layer or theme that contains the important data should stand out from the background layers of the map. Cartographers use several tools to trick the reader's eye into seeing the important data (the figure), which seems to "float" above the rest of the map (the ground). Figure-ground contrast is evident in the following illustration of interstate highways of the southwestern United States.

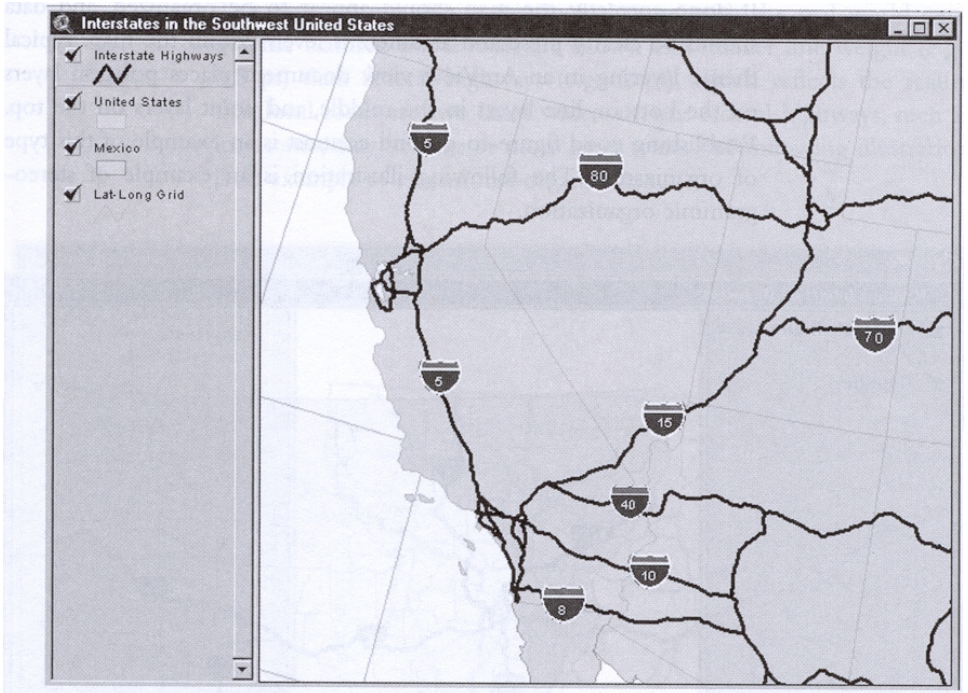
A theme used as a figure can be made darker than the rest of the map, using the visual tool of value. With size, smaller map features appear as the figure, whereas larger features constitute the ground. Map features that are closed polygons near the center of the map appear as the figure, whereas areas split by the edge of the map are discerned as ground.

Map features your audience are familiar with will tend to appear as the figure. For example, the outline of the state of Montana is readily recognized by people living in Montana, and will emerge as the figure. However, show the same map to visitors from the Far East and the state outline will disappear as the ground.

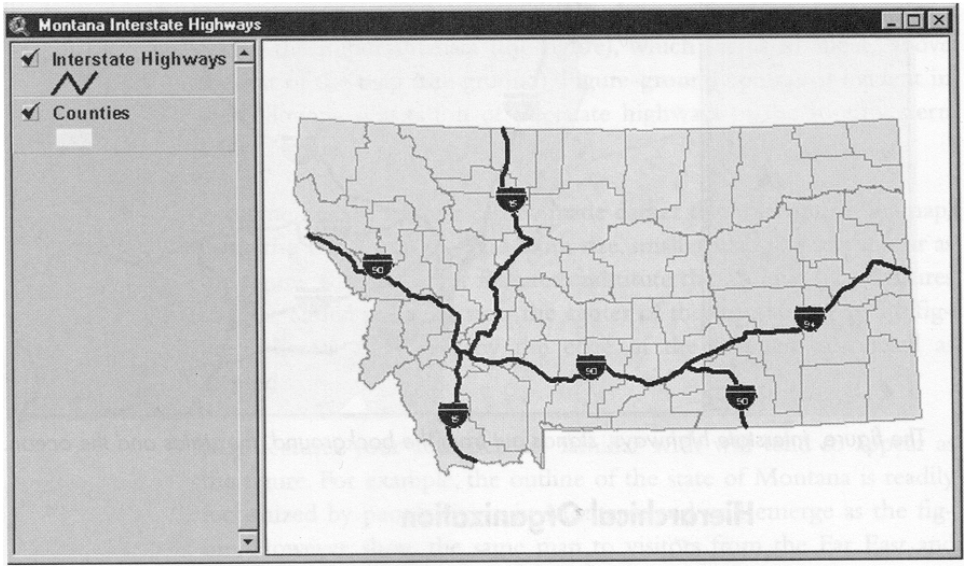
It takes some experimentation in ArcView, using a combination of Theme layering in the view and the Legend Editor to establish good figure-to-ground contrast, an example of which is shown in the following illustration. However, when you find it, you will know it. It should be easily visible!

Hierarchical Organization

A good map is not a jumble of features but an intentionally organized series of geographic data layers. The map maker establishes hierarchical organization of features between themes with Theme layering in the view's Table of Contents, and within themes using the Legend Editor. There are three main types of hierarchical organization: stereogrammic, extensional, and subdivisional.



The figure, interstate highways, stands out from the background, the states and the ocean.

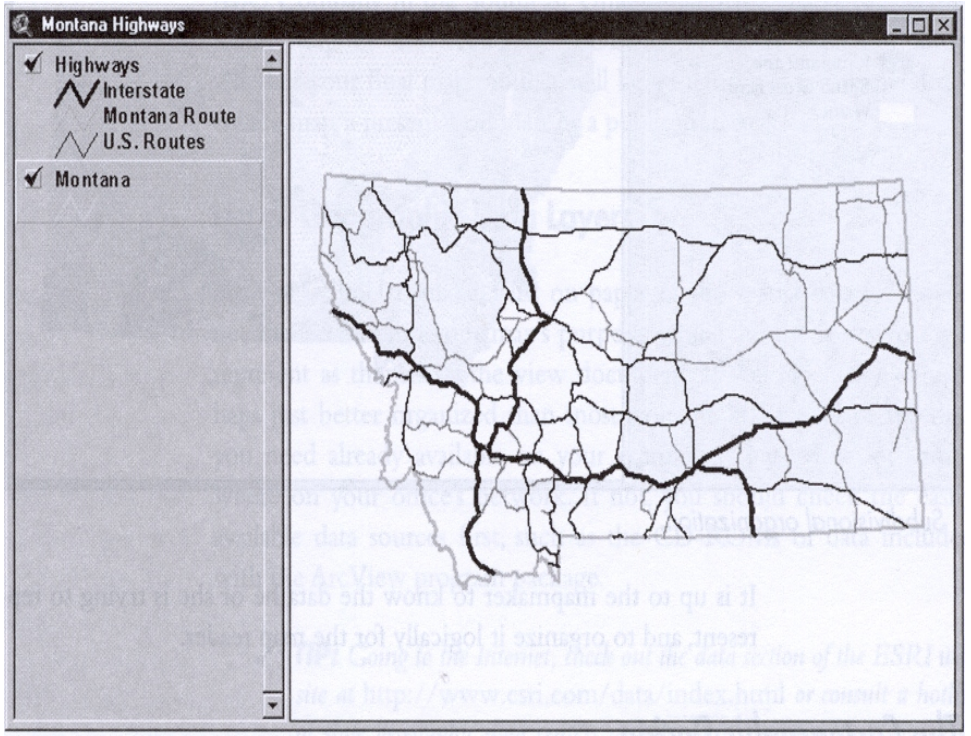


Stereogrammic organization.

Stereogrammic organization involves organizing the layering of several themes in order to emphasize the important features of a single theme. If done correctly, the map should appear to be organized, and data should be clearly presented at different levels within the map. Typical theme layering in an ArcView view document places polygon layers on the bottom, line layers in the middle, and point layers on the top. Establishing good figure-to-ground contrast is an example of this type of organization. The following illustration is an example of stereogrammic organization.

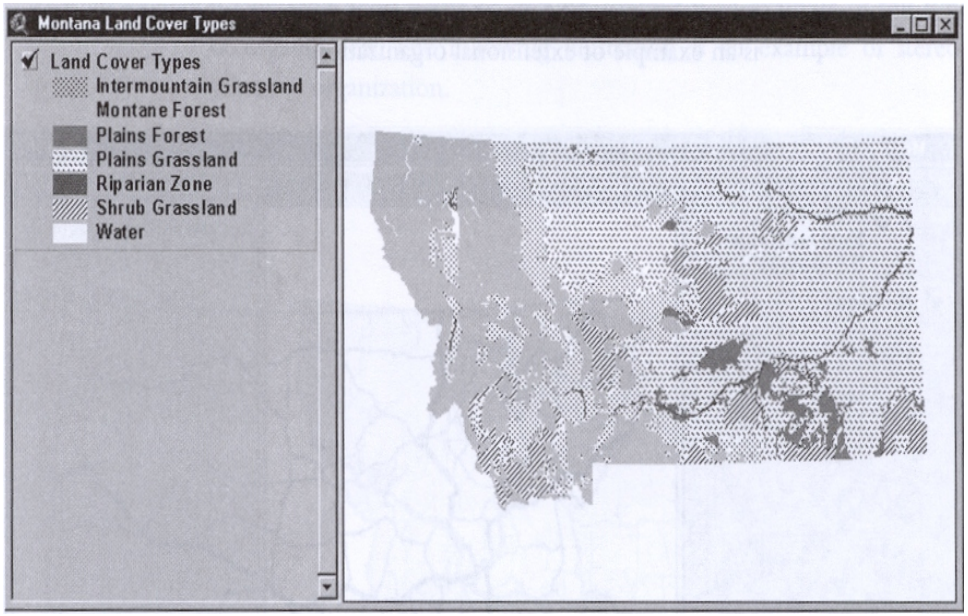
Extensional organization relies on the ordering of data within a single theme, such as classifying roads with different line sizes based on whether they are local, state, or federal highways. The organization is inherent in the data; that is, it is found in a field within a theme's Attribute Table, and the mapmaker shows the organization by using differences in line or point sizes.

The organization also makes logical sense with the real-world geographic features. Local roads are shown as a smaller line weight (e.g., 0.5 pt) than federal highways (e.g., 2 pt), which reflects the reality that local roads are two lanes wide, whereas federal highways, such as interstates, may be four or more lanes wide. The following illustration is an example of extensional organization.



Extensional organization.

Subdivisional organization is similar to extensional organization, but applies primarily to polygon themes. Land-cover mapping provides an example here: polygons representing types of evergreen forests can be shown in various shades of dark green, whereas grasslands might be portrayed in yellows. The map reader instantly recognizes the differences between forest and grasslands – something they could not do easily if the different types of evergreen forest were shown as greens, reds, and browns, and grasslands shown as yellows and blues. The following illustration is an example of sub divisional organization.



Subdivisiona/ organization.

It is up to the mapmaker to know the data he or she is trying to represent, and to organize it logically for the map reader.