CHAPTER 1

THE BIG PICTURE ON DESIGN

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Every professional knows that communication skills are crucial to their work. Verbal skills are not enough when presenting geographic information—you also need graphic skills. This book helps you develop the graphic skills needed for mapmaking. Cartographic expertise allows you to communicate geographic information clearly with maps. Amateur-looking maps, on the other hand, can undermine your audience's ability to understand important information and weaken the presentation of a professional data investigation.

Designing better maps means thinking carefully about each aspect of the map design process. When creating a page layout, you should size each map element relative to its importance for the map purpose. The positions and sizes of empty spaces between elements are as important to layout as the elements themselves. Designing maps for specific display media and building a polished layout with visual emphasis on key elements of the design will ensure that your audience can read the map and understand your message.

Additionally, being able to transfer map files—to enable other people to build on your hard work or export maps to other software for final production—is the last step in completing a professional design. This chapter presents map design essentials that will help you produce clear, meaningful maps that invite reading.

The essentials of designing better maps are the following:

- designing for map purpose and medium, considering audience, media resolution, viewing distance, and color quality
- linking layout to map purpose, using visual hierarchy, editing decorative design elements, and selecting map projections
- planning a layout, balancing empty spaces, refining alignments in layout, and valuing experimentation and critique
- choosing appropriate export options, including raster formats, vector formats, and maps for the Web
Designing for map purpose and medium

The impetus to design better maps comes from a desire to make maps that are clear and convincing. A successful design begins with knowing why the map is being made. Cartographers begin planning maps by asking themselves and their clients several questions:

- What information is being mapped?
- Who will be reading the map?
- Is the map content coordinated with written text or other graphics?
- What size and medium will be used to display the map?
- What are the time and budget constraints on map production?

The topic and intended audience will dictate many of a map's characteristics. It may be necessary to refer to related research or to other maps in the same field to gauge the amount of detail and relevant symbol conventions suited to the project. Researchers who make their own maps have the advantage of familiarity with their data and how it is typically portrayed. They will still benefit by asking themselves the same set of questions before they begin design work.

Audience

If you are laboring over map design, you are probably making a map for people beyond your immediate work group. Who are these map readers? If the audience is new to the information mapped, they may require a simpler presentation.

Likewise, if they are people who are too busy to spend much time reading, they will also need a simple map that summarizes the information. Maps that have a simple purpose, such as an in-car navigation display showing an address location, demand a simple design. Maps for nonexpert or busy people will have a similar look. They should have a single message that focuses the attention of the reader.

In contrast, maps for people who already know about the topic can be more complex. If they are experts with the data that is mapped, they will expect a rich and multilayered presentation of information that adds to their knowledge or thoroughly supports your (the mapmaker's) contention. The more knowledge and time the map reader brings to the task of reading your map, the more information you will be able to include. More complex maps will motivate advanced map readers to spend more time examining a map on a topic of interest. Detailed information on the map will support their map reading rather than distract from it.
When designing a map, you should also consider your audience's physical ability to read. If the map will be used by older people and others likely to have reduced vision, keep the map text large enough to be legible. If the map will be read in dim or otherwise difficult viewing conditions, use exaggerated lightness contrasts. You may even choose to design your maps to accommodate color-blind readers, who comprise 4 percent of the population.

A map can be tailored to the knowledge level of its audience by reducing the number of categories of data shown. Figure 1.1 shows two municipal water maps made for different purposes. The example on the left shows water mains along with hydrants, meters, fittings, valves, laterals, road centerlines and edges, and sewage mains. This level of detail is suitable for a knowledgeable map reader. The example on the right uses portions of the same dataset, but the map has been simplified to show just the water mains and hydrants. This map would be suitable for a lay audience or a busy city mayor.

Figure 1.1 Two maps of city water mains. The map on the left includes detail suitable for an expert audience, while the map on the right, with fewer symbols, is appropriate for a novice or busy audience. Source: New Mexico Bureau of Mines and Geology, Placitas Quadrangle.
The same set of data can be used to make two maps with different purposes by emphasizing different categories of features. The two maps shown below are derived from the Placitas Quadrangle geologic map in New Mexico. The example on the left emphasizes the road to a recreation site, nearby mines, and the network of faults in the area. This map would be suitable as a location map for a group who wanted to plan a field trip to the area to examine these mines. The map on the right would be suitable for a more expert group who is familiar with geologic mapping conventions, the names and ages of geologic formations, and information on strike and dip (figure 1.2).

Maps for different purposes may also have similar levels of detail. The two maps shown below are designed from the same data, but they have different purposes, and so they should have different emphases. They show the same set of lines from a map of Joshua Tree National Park in Southern California symbolized two different ways. In the example on the left, the emphasis is on physical features adjacent to Joshua Tree: the San Andreas Fault (dashed), the transition zone between the Mojave and Colorado Deserts (brown), and sea level (blue). The map on the right emphasizes cultural features adjacent to the park: roads (thin red), the interstate highway (thick red), and populated places (yellow) (figure 1.3).

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**Figure 1.2** Two maps showing a portion of the Placitas Quadrangle, New Mexico. The map on the left simply shows faults as well as mining and recreation sites. The map on the right is designed for an expert audience. Source: New Mexico Bureau of Mines and Geology, Placitas Quadrangle.

**Figure 1.3** Two maps of Joshua Tree National Park emphasizing physical features (left) and cultural features (right). Source: National Park Service, www.nps.gov/jorto.
Resolution and viewing distance
Choosing how to present a map is part of the design process. Maps are designed for multiple and varied contexts. Each context will be best served by a different map design. Consider a few places we commonly find maps:

- full computer screen viewed at the reader’s desk
- computer-projected display presented to hundreds of people at once
- color laser prints distributed to a working group
- black-and-white print for a report that concerned citizens will photocopy at the library
- large plot pinned up at a planning meeting for viewing from across the room
- page in a glossy magazine or book that is professionally printed on an offset color press
- huge backdrop at a trade show
- supporting information in a documentary television show
- black-and-white fax to an emergency response team
- two-inch display on a personal digital assistant (PDA) for route planning
- part of an online interface for Web-based data dissemination

Each of these modes of display places significant constraints on how a map can be made and what it can contain while still being legible. Rather than complain about (or worse, ignore) these constraints, your job as the mapmaker is to use good design to master them. Many of us have attended a talk where the presenter declares that the projector is at fault for the illegibility of the maps. Wrong. The error is made by the presenter who borrowed a design suited for another context or by the map designer who did not account for the final display constraints.

If you need a map in a projected presentation, redesign it with bolder color differences, larger type, and simpler lines to be sure the main messages hold up at coarse screen resolution, bleached by the projector and the room lights, and viewed from a distance. If that map is printed in a book, you can use fine lines, small type, and subtle color differences. If that map will be placed on a Web site and viewed on a computer screen, design the map for screen resolution.

Resolution measures the smallest marks we are able to create within a display. It varies widely among the media on which we display maps. A computer screen may show us 72 dots of light per inch (dpi) across its display. A regular household television has poorer resolution, about 26 dpi for a 27-inch TV (dpi varies with television size; you would need an 8-inch TV for resolution comparable to a computer screen). A laser print may squeeze 600 dots of toner in an inch to build the image. A litho plate on an offset press can reproduce 12,000 dpi from an image-set negative.
The following maps show land use in a portion of Clark County, Washington (figure 1.5). A redesigned enlargement of the first map’s inset area (the blue rectangle) is shown on the right. The enlarged map uses fine lines and small type that would be suitable for reproduction in print.

Map features and type need to be much larger to build them with the emitted spots of light on the computer screen than to reproduce them in ink on a press. A map designed for screen display will look clumsy in a magazine, and a map designed for print may be illegible on screen. There are no bad media, just maps that are not designed appropriately for their media. Your map designs must change to accommodate each medium you are using.

Viewing distance affects map design just as resolution does. Features need to be enlarged to be visible from a distance. Letters two inches high that are seen at a distance of fourteen feet are approximately the same size as 10-point type seen at a reading distance of one foot. A line 2 points wide is practically invisible from across the room, so line widths also need to be increased to retain visibility. (Points are a small unit of measurement used in graphic design; one inch contains 72 points.) Similarly, color differences need to be stark to make small features clear, whether they are small in measured dimensions or small because of the viewing distance.

Simply reducing the enlarged inset to its original size demonstrates how the labels become unreadable with coarse resolution. There are not enough dots per inch to represent the small letter forms on this map at screen resolution, and lines have lost their detail and smoothness.
The odd-looking map (figure 1.7) shows the reduced version (figure 1.6) enlarged back to its original size with no redesign. You can see how poorly the type and lines are represented. You can also see how much information is lost at the coarse resolution.

![Figure 1.6 Poor readability results when the enlarged inset is reduced in size and viewed at screen resolution. Source: Clark County land use. Clark County Office, Washington State.](image)

Figure 1.7 The reduced map has been enlarged to demonstrate the pixilation that makes it unreadable. Source: Clark County land use. Clark County Office, Washington State.

Figure 1.8 The design has been improved for the small size. The inset is shown at the same scales as figures 1.6 and 1.7. Source: Clark County land use. Clark County Office, Washington State.

Figure 1.9 This design is suitable for viewing at a distance. Source: Clark County land use. Clark County Office, Washington State.

Figure 1.8 is a redesigned version of the inset map made to display at this smaller size. Both lines and type have been enlarged, improving the legibility of a map this size (compare to the finer lines in figure 1.5).

The larger version is redesigned again with large type and shown at a finer resolution (figure 1.9). This design would be awkward printed in a book to be read at close range, but it would work well for a poster intended to be viewed from across a room.

Both resolution of the media and viewing distance determine map design. These examples emphasize how type size and line width must change as a small part of a land-use map is resized and redesigned.
Color quality

Thousands of colors can be produced in print and display environments. Printed pages and cathode ray tube (CRT) screens do a good job of presenting color nuances. Maps designed for display on some liquid crystal display (LCD) screens and projectors require greater color contrast, especially when they include very light colors.

The flexibility of color selection varies widely with media. It is a good practice to test maps in the final media you intend them to be displayed. If the map needs to be readable in widely different media, produce different designs suited to these different contexts. If you want people to be able to make photocopies of a map you are designing in color, test it out on a copier of moderate quality before you finish it. If you want a map to support a presentation, test it with a variety of brightness settings on a projector and look at it from far away with the overhead lights on. Make time to iteratively adjust colors and recheck laser prints of a map before including it in a report to a client. If you are going to spend $50,000 printing a book using professional offset lithographic printing, spend $1,000 on proofs early in the design process to check color sets used in the book. Looking at map colors on a color laser print is not an adequate check of how the offset printed colors will look. You do not want to leave readability of your important maps to chance. Therefore, testing how maps will look in their final form will help prevent many design disappointments.

The maps shown in the next three figures were prepared from the same set of data and base information. They show the change in number of crimes for local police beats in Redlands, California. Each map has a different purpose and thus has different constraints on color use. The first map has six color classes ranging from dark to light to dark, through two hues (figure 1.10). This choice of colors emphasizes the highs and lows and provides details of change between the extremes. The two hues, blue and orange, represent decrease and increase respectively. The gray roads and white police beat outlines are base information that is readable but does not distract from the main message of change in crime. The readability of the white beat numbers relies on high-quality viewing or reproduction.

The second version of the crime map is designed for presentation using an LCD projector (figure 1.11). To anticipate differing qualities of projectors and different room lighting conditions, the map has been simplified to emphasize the highest increase and decrease in the area shown. This emphasis on extremes is supported with added text boxes that label the extremes. The beat outlines are also emphasized with a more intense color to be sure they retain readability.
If the presentation graphics needed to be photocopied in black and white, the dark orange and blue used above would reproduce to grays that were too similar to distinguish. The same map redesigned once more uses only differences in lightness to differentiate between increase and decrease in crime. It is suitable for black-and-white photocopying or laser printing (figure 1.12).

The segment of the Placitas Quadrangle geology map, which you saw earlier as figure 1.2, is shown again (figure 1.13). It has been redesigned here for grayscale presentation.

Design for black-and-white display relies heavily on differences in lightness and variation in pattern. Design constraints for black-and-white media that are unable to reliably produce shades of gray are particularly restrictive. Photocopying and faxing often restrict the mapmaker to black, white, and one or two middle grays for reproduction.
Linking layout to map purpose

The purpose of your map will determine what parts of it are most important. Which elements of your map do you want people to notice first and remember after they finish reading the map? This ordering of importance—or visual hierarchy—is created by designing some parts of the map to appear as background information and others to take prominence in the foreground. You should design map elements that supply supporting information with decreasing visual importance, echoing their role in understanding the mapped information.

Choosing a map projection is also a design decision that is dependent on the purpose of the map. Projecting the round earth onto the flat page creates unavoidable distortions in the geography of your map. By choosing an appropriate map projection, you can manage the distortion so that it has minimal impact on the message and purpose of your map. The choice of projection partly determines the shape of the map and its layout as well.

Visual hierarchy in layout

A map’s purpose determines which of its elements are the most important and should be displayed most prominently in the visual hierarchy. The title and key features on the main map are highest in the visual hierarchy. Supporting information, such as source notes, should be lowest in this hierarchy. Map design is largely a process of deciding how prominent to make each element of your map layout.

Numerous graphic effects can be produced using GIS software. Your decisions whether to use them or change them are guided by the visual hierarchy of information in your map. A clear understanding of the hierarchy of the map’s elements to suit its purpose is the essence of good design. Designs that do not follow a logical hierarchy are cluttered, confusing, and hard to read. Map designs that do are crisp, organized, inviting, and to the point.
The list of elements to consider can be extensive for a complex project, though most maps will not include every element:

- main map
- smaller-scale inset maps showing location
- larger-scale inset maps showing detail
- insets of locations outside the area of the main map
- title
- subtitles
- legends
- scale indicators
- orientation indicators
- graticule (lines of latitude and longitude)
- explanatory text notes
- source note
- neatline
- photos
- graphs

Hierarchy is established by an element’s position in the map layout, its size, and the amount of open space around it. A note in small text in the lower left corner will be lower in the hierarchy than a title in large text that is centered across the top of the map. Contrasting colors, line weights, and line detail also establish hierarchy.

The elements of a vegetation map of the Democratic Republic of Congo in figure 1.14 are not arranged in any particular order within the layout. This lack of planning produces a cluttered and unclear product. From top to bottom, the elements are the following:

- title and location inset map
- source note and subtitle for detailed inset map
- legend and detailed inset map
- scale for main map
- orientation indicator (north arrow) and main map with graticule

![Vegetation: Democratic Republic of Congo](image)

**Figure 1.14** Example map with a set of basic map elements haphazardly arranged. Source: World Conservation Monitoring Centre basemaps from Digital Chart of the World: DR Congo: ESRI and WRI.
Below are two organized layouts of the same vegetation map. In addition to the different arrangement of the elements, the visual hierarchy of these layouts is also different. The first map (figure 1.15) emphasizes vegetation distributions for the entire country, while the second emphasizes parks located in one forest type. The difference in visual hierarchy between the two maps is established mainly by changing the sizes of elements and repositioning them within the layout.

In the second example, the country vegetation map is an inset rather than the main map. It is smaller and positioned in a less prominent location than in the previous layout. Since this difference changes the apparent purpose of the map, it has been suitably retitled in the map below (figure 1.16).

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**Figure 1.15**  *Layout emphasizing Congo vegetation. Source: World Conservation Monitoring Centre; basemaps from Digital Chart of the World: DR Congo; ESRI and WRI.*

**Figure 1.16**  *Layout emphasizing parks in Congo forest. Source: World Conservation Monitoring Centre.*
Even small elements can vary widely in their design and their level in the visual hierarchy of a map. A set of scale bars with increasing visual prominence is shown in figure 1.17.

The first three scale bars are better suited to thematic maps while the next three are better suited to reference maps. The simple scale bars encourage approximate distance estimates (for example, 10 or 20 km), and they do not distract attention from the map message. The detailed scale bars have sufficient length and segmentation that they let the user calibrate distances and make measurements across the map. A scale bar that is dark, wide, and detailed with many segments (such as the bottom scale bar) is too dominant for a simple thematic map that will not be used for detailed distance measurements. However, the same scale bar may be appropriate for a detailed reference map where its prominence supports a primary use of the map—measuring distances with relative precision between points on the map.

Figure 1.17  Example scale bar designs.
Decorative design elements
Many graphic elements and effects can be used to enhance the primary components of a map layout:

- drop shadows
- line styles for frames
- background patterns
- full compass rose
- zoom lines
- colorful logos
- decorative type fonts
- geometric shapes

An example map of Joshua Tree National Park includes many decorative elements (figure 1.18). They compete for the reader's attention and distract from the main message of the map—ecological zones. They also look fairly silly.

The same map has been redesigned in figure 1.19. The important map content stands out, and supporting information is pushed into the background where it belongs.

Any decorative element can be an effective addition to a map, but only if it is used purposefully. For example, a drop shadow may either attract too much attention away from the map itself, or it may effectively elevate a small, yet important, element to the foreground. Zoom lines that sweep across the page to connect an enlarged area to its location on a smaller-scale map may be vital for one map's purpose, but they may confusingly obscure other

Figure 1.18  Excessively decorated elements on a map of Joshua Tree National Park in Southern California. Source: National Park Service, www.nps.gov/jotr

Figure 1.19  An improved visual hierarchy for the Joshua Tree map elements. Source: National Park Service, www.nps.gov/jotr
data on a map with a different goal. A simple tiny label, such as "Enlarged area," next to the location on the smaller-scale map may be a better solution if the zoom lines will be too prominent in the map’s visual hierarchy.

The enlargement of the northeastern portion of a population density map is elaborately portrayed in figure 1.20. The zoom lines interfere with a portion of the northern megalopolis, which is an important part of understanding population density in the northeast.

The map is redesigned in figure 1.21 with a more subdued cue to the enlargement. Small text explains the relationship between the two areas. The white box and darker blue water link the inset map to its extent, outlined on the main map. Scale bars are included to further emphasize the difference in scale between the two mapped areas.

A background may seem like the one element that should always be lowest in the visual hierarchy, a background in the true sense of the name. But consider a television sportscast—whirling, flashing, colorful, and detailed designs form the background for the information on screen. Should we conclude that colorful and busy backgrounds are the modern way to design information displays? Well, think about how much information is on that display—perhaps four final scores or three performance statistics. Broadcast designers use all that background activity to keep you looking at a screen that has a small amount of information on it. You should be confident that your map contains enough information to attract your reader. Color and detail should be used to make your mapped information stand out, rather than its background. Do not let your background become too high in the visual hierarchy of your map; it is definitely not the most important element of the layout.
Map projections in design

Many mathematicians have been entranced by the interesting puzzle of projecting the spherical globe onto the flat page. My students and I had fun physically acting this out using an old globe that I found on the roadside one day. We stomped and pulled and tore this poor old carcass into a flat surface. We illustrated that all projected maps are distorted in some way (and more kindly). Your job as a mapmaker is to choose a projection that relegates those distortions to places on the map that are not important for your message. This challenge makes projection selection a design decision because it depends on the purpose of the map.

If you are making a detailed map of a small amount of land (a large-scale map), the particulars of map projection will not be crucial unless map readers will be taking detailed measurements from the map. If you are mapping larger areas—all the U.S. states, for example—you should put more thought into the map projection. For continental, oceanic, or hemispheric mapping, projection becomes a critical decision. If you see a map of the United States that looks like a rectangular slab, with a straight-line U.S.–Canada border across the west, be suspicious of the mapmaker’s knowledge of map projection and of interpretations of the mapped data.

For example, if you want to understand the road network on a map with a poorly chosen map projection, you will not know whether roads look sparse in an area because it is underdeveloped or because the map is distorted in a way that happens to expand that part of the map. Likewise, maps of point patterns or area densities need equal area basemaps for accurate interpretation.

The map of western Canada below was produced with a plate carrée projection (Figure 1.22). The length of one degree of latitude on the page is equal to the length of one degree of longitude, forming a square grid. This projection is sometimes misnamed “no projection.” Plate carrée seems like a fine idea until you remember that the length of degrees of longitude get smaller as you near the poles. (The length of one degree of longitude is half the length of a degree of latitude at 60 degrees north.) The provinces and especially the northern islands of Canada appear stretched horizontally because they are distorted by the projection. East-west scale (degrees of longitude) gets larger as you go north on this map. Judging the density of roads or the size of national parks is difficult with a projection that results in such distortions.

Figure 1.22 The plate carrée map projection distorts this portion of Canada.

Source: DMTI Spatial, Inc.
A more suitable projection of the same area of Canada is shown in figure 1.23. This map is made using an Albers Equal Area projection with two standard parallels (lines of true scale) running through the area of interest at 52 degrees and 60 degrees longitude.

The provinces are proportioned quite differently on this map compared to the map in figure 1.22. Wood Buffalo National Park is correctly shown much larger than the parks to the south, as is the openness of the northerly road network. Areas are correct all over this map, so density of features, such as roads and small lakes, can be accurately judged.

Projection affects the shape of geographic areas, which in turn constrains the size and layout of the map. You can see how much of northern Canada is not shown in figure 1.23 that was present on the first example. If northern Canada was relevant for this map, a larger frame or a smaller scale would be needed to suit the map purpose.

If you are making thematic maps—special purpose or statistical maps of geographic phenomena such as population density—employ an equal area map projection for most topics. Despite all the fun we could have with projection distortions, this is the important piece of information to remember: If you are mapping data distributions, choose an equal area projection.

If you are mapping the continental United States, the Albers equal area projection, which is customized to the United States, is a common projection choice. You should also make use of the customized Albers projections for Alaska and Hawaii. Each projection has repositioned standard parallels so that no part of the area of interest gets far from these lines where there is no distortion.

Large-scale reference maps often use another category of projection called conformal projections. These projections are better for showing routes and locations because they preserve angles and shapes at points. These advantages come at the expense of preserving areas, and they will misrepresent densities of features in parts of the map distorted by the projection.
**Planning a layout**

When you are creating a page layout, you should size each map element relative to its importance for the map purpose. Think about the logic of the position of each element relative to other elements. Then step back, squint your eyes, and look at the arrangement of empty spaces on your page. Designing the positions and shapes of those empty spaces is a key to good page layout.

Geographic areas are often irregularly shaped, and a novice designer may be tempted to fill the corners and voids in a display with the remaining elements of the map. Unfortunately, some designs evolve like this—a map designer says, “I see a big hole in a lower corner of my map, so I will use a large compass rose to fill in that problem area.” If that sounds like familiar thinking, your future maps will benefit from design practice. The problem with the “fill in” strategy is the resulting overly large or bold map elements that are at the wrong level in the visual hierarchy of the map.

Experimenting with design can reveal new and more effective arrangements of elements in a map layout. Also, knowing how to get the most out of others’ critiques lets you finish a project with confidence.

**Balancing empty spaces**

If the goal of page layout is not consistent filling in, what is it? Page layout is an act of balancing empty spaces. If you have an empty space on the page in one corner, you can position other map elements to produce empty spaces that are similar in size in other parts of the page to balance that gap. These open areas are useful too; they offer a welcome break from the visually dense information of your map and text blocks. They can open up a complex page by separating groups of elements so that their relationships can be better understood.

Two maps of transportation and land use in Prince George’s County, Maryland, provide examples of a densely arranged layout and a more loosely arranged layout. Both layouts are suitable for the elements and purpose of the map (figures 1.24 and 1.25).

The same maps are marked up to encourage you to focus on the empty spaces in the layouts (figures 1.26 and 1.27). In the first layout, the blue highlights are small and similar in size throughout the map. In the second layout, the blue highlights are larger but are still balanced in their arrangement on the page. You can improve your map layouts by learning to see these empty places, create them, move them around, and use them as design elements.
Drawing boxes around map elements makes designing with empty space more difficult. A box is not a "bad" design choice for a map, but it can dissect empty space into distinctive shapes—inside the box and outside the box—that become difficult to incorporate into a design. The shape of the empty space outside the box may crowd adjacent parts of the map. Inside the box, the gaps between text and the edge of the box can create shapes that are distracting and difficult to work with. With no box, these shapes coalesce to form a looser space around the text, which has a less distinctive shape and is easier to balance with other empty space in the design.

The top portion of a third layout of the Prince George's County map uses boxes around the inset map, the legend, and the title (figure 1.28). Compare this design to the two previous designs.

Purple highlights have been placed in the many crowded and tight spaces created by these boxes in a marked-up version of this same design. These tight spaces can be arranged, but it will be harder to produce a balanced layout (figure 1.29).

The purple highlights in the map (figure 1.30) emphasize the empty spaces inside and outside the boxes. Notice how little control the designer has over the shapes of these spaces because they are dictated by the boxes.
In this next example, the boxes create a difficult and distracting set of pinched angles near the center of the detailed inset map from the bottom part of the map layout (figure 1.31).

![Map with boxes](image1)

![Map with improved layout](image2)

Figure 1.31 Boxy layout within inset map of transportation details. Source: Maryland State Highway Administration, Prince George's County.

Figure 1.32 The layout of the inset map is much improved when the boxes are removed. Source: Maryland State Highway Administration, Prince George's County.

Empty spaces that flow into each other are much easier to work with when the boxes are removed from the design. Notice also that removing the strong geometric box shapes pushes the legend back in the visual hierarchy where it belongs as supporting information. Strong geometric shapes like rectangles can unintentionally elevate an element in the visual hierarchy of the layout (figure 1.32).

Learn to see and use the empty spaces between elements when you are designing a page layout. Unnecessary boxes around map elements produce gaps and spaces that interfere with the design of an attractive and balanced layout of map elements. It is better to group elements with effective manipulation of empty space rather than by containing them in restrictive and visually dominant boxes.
Refining a layout
A map layout works best when elements that are conceptually related are placed physically near one another. This seems obvious, but in a layout with many map elements, it can be difficult to accomplish. For example, a confusing association can result if a scale bar is placed closer to an inset map than the main map to which it refers.

A layout with many maps, each with explanatory text, is designed well if surrounding empty space unambiguously groups each text block with the map it describes. A general explanation for the entire layout functions well if it stands on its own; not necessarily isolated, but not visually associated with one particular element through proximity.

The location of the scale bar in figure 1.33 is confusing because it is close to three maps, each at a different scale. This layout fails because the importance of proximity is not considered.

An enlargement of a portion of the Congo map, redesigned, shows a scale bar positioned within the main map (figure 1.34). The scale bar is still quite close to the inset map, and therefore might be misconstrued as pertaining to it.

![Figure 1.33](image1.png) **Figure 1.33** Ambiguous scale bar position between three maps of different scales.  
*Source: Maryland State Highway Administration, Prince George's County.*

![Figure 1.34](image2.png) **Figure 1.34** The scale bar is ambiguous because of its close proximity to the inset.  
*Source: World Conservation Monitoring Centre; basemaps from Digital Chart of the World (DCW).* DR Congo, ESRI and WRI.*
As you decide how adjacent objects will be positioned, examine the details of how they align both vertically and horizontally. Look for linear elements that are almost aligned. Do you want them to be perfectly aligned or do they need to be placed intentionally out of alignment? You do not want to unthinkingly align everything; that strategy may produce a display that is more structured and static than is suitable for your map's purpose. Adjusting alignments to be either perfectly aligned or obviously not aligned confirms that your positioning is intentional, not accidental. Ambiguous alignments look like errors.

The portion of the Congo vegetation map (figure 1.35) has many elements that are only slightly out of alignment. Though the elements have been positioned reasonably, the map has a messy appearance because these details are not purposeful in their organization. The missed alignments are highlighted in purple in the second map (figure 1.36).

Figure 1.37 pulls the elements into an organized arrangement with intentional alignments. The result is a clear, professional presentation.
Careful alignment can also remedy extraneous or distracting shapes where geographic data coincides awkwardly with graphic frames. These intersections can misleadingly connect the geography to its frame to produce geometric shapes that draw the reader's attention away from the intent of the map. For example, if a state line runs directly to the corner of the frame, the three lines radiating from that one point become visually dominant. Because you can control the position of the geography within its frame, a slight adjustment will usually solve the problem. Choosing different line styles for frames and geographic features can also reduce these effects.

Figure 1.38 shows a few problem intersections between the orange graphic frame and the brown geographic state lines. The problems (highlighted in blue in figure 1.39) include state lines that run along the frame and one that runs directly into the lower left corner. The small tip of Cape Cod that pokes into the inset area at the lower right erroneously resembles an island rather than a peninsula.
The geography is not wrong, but the frame positioning is sloppy. Figure 1.40 shows that a slight shift in the frame position relative to the geography solves these problems without compromising the intent of the frame—to show the population density of New Hampshire.

Alignment adjustments are the finishing touches that allow you to create a professional looking page. You can fiddle with them endlessly, so seeing potential problem areas at the start of a project and using guides onscreen and other alignment tools can help you complete your design work efficiently.
**Experimentation and critique**

In addition to planning hierarchies and balancing empty spaces, a good dose of experimentation often improves a map design. Novice designers tend to place map elements in positions that seem obvious and workable. They may adjust these positions or change the sizes of elements slightly to improve the layout, but they do not question the initial arrangement of elements on the page.

Before you start making small adjustments to improve a layout, push yourself to think of some arrangements radically different from the first one you are assuming will work. Change the page orientation from portrait (tall) to landscape (wide) and see how elements fit together. Move elements from the top of the page to the bottom. Try pulling them into a more compact arrangement with overlapping elements. Overlay titles and text blocks on some conveniently open areas within the map. You may come back to the first layout in the end, but this experimentation is an important first step in map design.

The vegetation map seen in previous examples is shown in portrait and landscape orientations (figures 1.41 and 1.42). Both arrangements are well-balanced with similar visual hierarchies.

Equally important to experimentation is asking other people to judge your draft map layout. When you ask a person to critique your work, your job is to be quiet and let them do what you've asked. A critique is not an opportunity to explain or defend your decisions. You may adjust or discard many of their suggestions, but do that only after you hear them out. During the critique, ask them to elaborate on reasons behind their ideas and interpretations, but do not spend time debating them.
A draft map usually has unfinished aspects, such as incomplete text, nonsense colors, or errors. The person doing the critique will often zero in on these details first. Acknowledge that the work is a draft and encourage them to look at the big picture, the overall layout. Help them get past the details; details are easier to critique than the larger scope of a project.

You should ask a few people for suggestions and balance their critiques. Pay attention to their reasoning and recommendations, but be aware that points of confusion can sometimes be improved by making changes other than the ones suggested. For example, one critic may suggest that legend boxes be made larger so they are more visible and another may suggest spacing the boxes. You may decide that changing the position of the legend so the boxes are not as close to the colorful main map makes them more visible, addressing both concerns without making either suggested change.

A critique is raw material that pushes you to experiment and to refine your decisions. It also keeps you honest—it prevents you from going forward with convoluted adjustments when the overall layout (which at first seemed perfect) has become unwieldy and is ill-suited to the project's current goals.
Choosing appropriate export options

Choosing appropriately among many export options lets people without GIS software view and manipulate your map files. This more general concern, which goes beyond the details of mapmaking, allows a wide audience to see the maps you work hard to design.

A map is sometimes only one part of a larger presentation. In order to use a map in a Web or print publication, it must first be exported to a suitable graphic file format. There are a number of graphic formats available, but each falls into one of two categories: raster or vector. Some vector formats may include raster elements as objects within a file.

A raster file uses a regular grid of small cells—called pixels—to store color information across the map surface. It can be thought of as a picture of the original file. The size of cells in this grid determines the resolution: finer grids retain more detail but produce larger file sizes. Individual map elements, including text, are no longer grouped together as digital objects, but rather reduced to collections of pixels. The file can only be altered by editing individual pixels.

A vector file maintains separable objects, and renders their shape, size, and position in the file by connecting locations on the map. Even text characters are built from tiny curves connecting series of x,y locations with mathematical formulae.

The degree to which map objects and text can be edited in a vector file depends on the file type chosen and its associated export options. There are trade-offs between quality, editability, and file size among all export file formats. As with many graphic decisions, testing the suitability of a choice before committing to it is an important step in producing a high-quality final product.
A simple map of Joshua Tree National Park (figure 1.43) was exported from ArcMap to seven other file formats. Two files each of the bitmap and JPEG formats were created so that resolution settings could be compared. The resulting list of files is shown here with their sizes (figure 1.44). Notice that the sizes vary dramatically, from 31 KB to 24 MB.

Figure 1.43 To compare export formats, a very simple map of Joshua Tree National Park (JT1.mxd) with just two line styles, three labels, and a background fill was prepared. Source: National Park Service, www.nps.gov/carta, Joshua Tree National Park Desert Eco-Systems.

Figure 1.44 Names, types, and sizes for an example set of files exported from the Joshua Tree project (JT1.mxd). Files are in the same order they are discussed in the text of the sections that follow. Source: National Park Service, www.nps.gov/carta.
Raster export formats

The three most common raster formats for exporting maps are bitmap (.bmp file extension), Tagged Image File Format (TIFF, .tif extension), and Joint Photographic Experts Group format (JPEG, .jpg extension). The bitmap and TIFF formats produce pixel-by-pixel renditions of the map. JPEG is a raster format that is commonly used for Web publishing. It uses a compression algorithm to store a slightly generalized version of the map in a smaller file.

The resolution options vary among formats. To export a bitmap file from ArcMap, height and width of the output file in pixels are specified. When the map of Joshua Tree National Park was exported as a bitmap, the default resolution choice (1,056 × 816 pixels) produced a file with coarse resolution but a relatively small file size (2,525 KB). An enlarged section of the bitmap file is shown in figure 1.45.

Exporting the map again as a bitmap, but this time with three times more resolution (3,168 × 2,448 pixels) produces a higher-quality image (figure 1.46). The type edges are no longer jagged, and the lines are much smoother. The pixels making up this bitmap file are one-ninth the area of pixels in the coarse-resolution version when they are examined at the same map scale. Smaller features can be recorded at higher resolutions. A higher-resolution file will typically come into graphics software with larger dimensions than the coarser version. The image dimensions can be alarming (the file may initially be many feet across when you were hoping to show it on letter-size paper). Raster files can be resized by changing a pixels-per-inch setting without affecting their content.
But the improved quality comes at a price. The high-resolution setting produces a much larger file—over 22 MB—than the coarse version. To put this size difference in context, you could store more than two hundred coarse-resolution files on a 600 MB CD-ROM, but only twenty-six of the higher-resolution files.

Other choices for file export, beyond numbers of pixels, will also affect file sizes. The color depth setting you choose has an effect on file size, with 24-bit files producing the largest exported files. (Higher depth numbers provide greater numbers of distinct colors in an image because more digits are allotted for storing color information for each pixel in the file.)

To export a map as a TIFF, you specify resolution by choosing the number of dots-per-inch (dpi) in the output file. The default export resolution may be a dpi suited to screen resolutions (such as 72 dpi), which results in a coarse image. The TIFF example shown in figure 1.47 was exported at 296 dpi. It is a high-quality image suitable for publication. Again, this quality came at the price of a large file size (over 24 MB).

All raster file formats share the common characteristic that they are made of only pixels. In raster files, text, lines, and colors are difficult to edit. For example, editing a label would require using graphics software to erase the existing pixels that form the characters and then overlaying new text. Lines and areas do not continue beneath the text and would need to be repaired as well. Changes in the font or style of many map labels would really require going back to the GIS software and re-exporting the map since there are no text objects on the raster map to select and change. To change a map color, every pixel in an area first needs to be selected, working around text and lines that overlay the area. This can be done, but it is much harder than selecting polygons in a vector image and making the color change once.

These raster export formats should be used only for maps that you want to show or print “as-is.” This inflexibility can be an advantage when you do not want to pass on a version of your work that can be easily edited or adapted for other purposes.

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**Figure 1.47** The Joshua Tree National Park map exported as a high-resolution TIFF file (JT3.tif). Source: National Park Service, www.nps.gov/jotp, Joshua Tree National Park Desert Eco Systems.
Vector export formats

The three most common vector formats used to export maps from ArcMap are Enhanced Metafile (EMF) format (.emf extension), Encapsulated PostScript (EPS) format (.eps extension), and Adobe Illustrator format (.ai extension). Exported vector files are often much smaller than the raster files discussed in the previous section. Comparing exported vector files of the Joshua Tree National Park map, the EMF file is 42 KB, the EPS is 129 KB, and the AI file is 162 KB. Recall that raster files of comparable quality were larger than 24 MB (figure 1.48). The simplicity of the example map is key. An elaborate file with many small features and numerous labels could readily produce a vector export much larger than a corresponding raster export.

EMF is a multipurpose vector format native to the Microsoft Windows operating system. When exported to an EMF file from ArcMap, the example map did not fare well: the type shifted relative to the line work (figure 1.49).

Opening the EMF file in Adobe Illustrator—a vector-based graphics software program—made the map dimensions bigger, requiring it to be rescaled back to its original size. Entire text strings, however, did remain complete and editable. The type was not broken into individual letters or groups of letters, a consequence of exporting to some vector formats. For example, “Park Boundary” can be selected as a single editable object (indicated by the blue line below the letters).

EPS is a common high-quality vector format used to exchange graphics. Exporting to EPS from ArcMap unfortunately causes type strings to break into segments. For example, the “rk” of “Park Boundary” can be selected on its own; the label has been

![Figure 1.48](#)

*Figure 1.48* Note file sizes for the vector formats .emf, .eps, and .ai from the simple map of Joshua Tree National Park.

![Figure 1.49](#)

*Figure 1.49* Portion of the Joshua Tree map exported as an EMF file (JT4.emf). Letters in the area label MOJAVE are not registered with their halos, and Park Boundary is offset from the line it labels. Source: National Park Service; www.nps.gov/jova, Joshua Tree National Park Desert Eco Systems.
broken into four separate segments. If you needed to edit or restyle this label, the segments would overrun each other or gaps would appear between them. The EPS export may not be a useful option for maps in which type editability is important. As export engines are improved, these types of problems may be repaired, so you may want to periodically do some simple comparison tests like the ones shown in figure 1.48 to investigate format improvements as well as problems.

Exporting to the AI format results in complete text strings and high-quality lines that include Bezier curves between points. For example, “Park Boundary” can be selected as a single object, then edited or restyled. This is important because you want the process of editing text labels to be easy, that is, to not require tedious repairs or manual replacement of individual labels. Map elements are exported as vector objects and can therefore be altered in shape, texture, and color in Adobe Illustrator or other illustration software that can import AI files.

Opening the exported AI file with Adobe Illustrator showed that the character spacing effect used for “MOJAVE DESERT” did not export properly. The letters were no longer registered with their halos. Halos are used to make text more legible over the top of complex line work. They are typically the same color as the background, appearing to “break” the lines before they intersect with the letters. The halos shown in figure 1.51 are somewhat darker than the background, for illustrative purposes. Each halo is exported as an individual vector object, and exporting many halos can create an unmanageably large file. It may be easier to apply halos in the post-GIS editing phase.

Despite the problem with halos and letter spacing, the AI format will be the most trouble-free for publication. You should be aware that some custom type effects and special characters do not export well; therefore, you should always test your choices before relying on them for a design that will need to move beyond GIS software.
Distributing maps on the Web

There are two export formats well suited for displaying maps on the Web: JPEG in a raster format, and PDF with both vector and raster elements.

JPEG uses a sophisticated compression algorithm to make high-quality raster files smaller. You can see the difference this compression makes by comparing the size of the example (JT7_maxqual is 1.195 KB) to the high-resolution BMP and TIFF files described earlier, which are over twenty times larger. JPEG is a lossy compression algorithm, which means that data is lost when a map is exported as a JPEG. In contrast, a TIFF file has a larger size because all data is retained for the chosen resolution.

When exporting to JPEG from ArcMap, you can control resolution (in dpi) and quality (ranging from low to max). The map shown in figure 1.52 was exported to a JPEG at 300 dpi and maximum quality. The result is a high-quality image with a reasonable file size (1,195 KB). This size is a bit large for Web display, but the quality is good enough that it could be used for some printed contexts.

The second JPEG, shown in figure 1.53, was saved at 300 dpi with medium quality. The savings in file size is good (249 KB) but notice the speckled artifacts around lines and type where compression losses are visible. The reduced file size savings comes at the cost of a poorer-quality image. The file would be fine for many Web applications or Microsoft PowerPoint presentations, but the quality is not good enough for print publication.
JPEG files are raster files, so you cannot edit lines and type as objects using illustration software. You should use JPEGs to show your finished work when no further changes will be needed.

Portable Document Format (PDF) is a vector format common for Web display and file transfer. PDF files can be viewed with Acrobat Reader®, which is available free from Adobe. PDF works well for displaying a high-quality vector image that can be panned and zoomed. The file in figure 1.54 is 31 KB.

You should use PDF for maps with a completely finished design and when you are not concerned about details of type positioning. Notice that the font has changed in the PDF file (compare it to the JPEG shown on the previous page). Single letters, such as the “k” in Park, can be selected. Searchable words are not retained by ArcMap 8 in the PDF because they are exported letter by letter, but ArcMap 9 does a better job with this export format. If you would like to put a map on the Web and have search engines (such as Google®) catalog the title, labels, and descriptive text within the file, you want your map to be exported with complete words and text blocks that can be searched online.

Letter-by-letter type is very difficult to edit, and adjusting font characteristics (such as changing a label to bold) will produce a garbled image. Another problem that may arise with a PDF export is differences in map colors resulting from poor RGB conversions. These problems limit the usefulness of this format as it is currently exported, though improvements in export engines may remedy them. A higher-quality PDF can often be produced by exporting AI files and then saving PDF files from Illustrator or another graphics program.