CHAPTER 1

PLANNING MAPS

Communication skills are crucial to every professional's work. Verbal skills are not enough to effectively present 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 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 or screen layout, you size each map element relative to its importance for the map's purpose. The positions and sizes of empty spaces between elements are as important to layout as the elements themselves. This chapter presents map-design essentials that will help you produce clear, meaningful maps that invite reading.

Choosing a map projection is also a design decision that depends 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 effect on the message and purpose of your map. The choice of projection partly determines the shape of the map as well as its layout.

Here are the essentials of planning better maps:

- Linking layout to the map's purpose and using visual hierarchy
- Planning a layout, balancing empty spaces, refining alignments in layout, and valuing experimentation and critique
- Selecting map projections to suit the map's purpose

DESIGNING FOR MAP PURPOSE

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 sizes and media 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 for 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.

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 be prominent as foreground. You should design map elements that supply supporting information by decreasing visual importance, echoing their role in understanding the mapped information.

AUDIENCE

If you are laboring over map design, you are probably making a map for people beyond your immediate workgroup. 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 a navigation display you check while driving, demand a simple design. Maps for non-experts 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 on 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 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, approximately four percent of the population.

A map can be tailored to the knowledge level and interests of its audience by reducing the categories of data shown. Figure 1.1 shows many possible layers for mapping a national forest and the surrounding area in Michigan. The map in figure 1.2 selects data, from the wide range available, for a simpler map highlighting example sites attractive for recreational tourism within the forest.

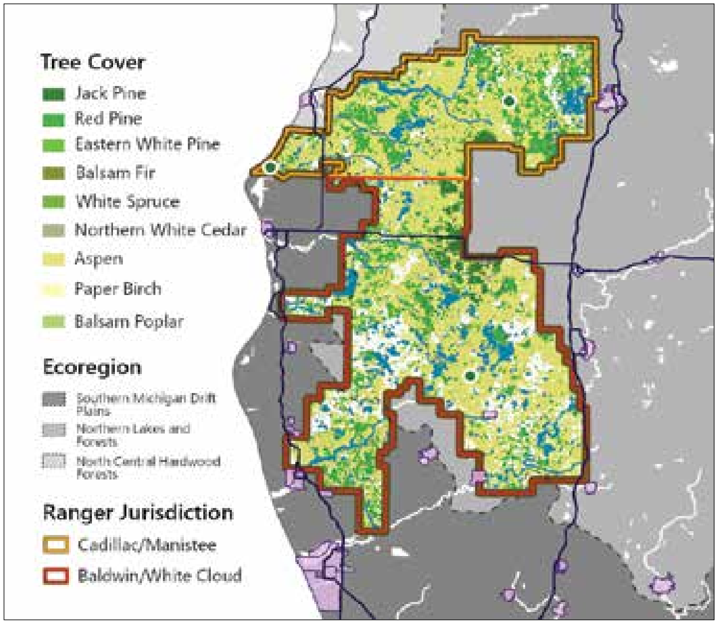

FIGURE 1.1. Numerous data layers for Manistee National Forest, including the public land boundary, cities, roads, hydrography, land cover, and ecological regions. Data source for figures 1.1 to 1.3: US Environmental Protection Agency (EPA), US Forest Service (USFS), US Geological Survey (USGS), National Hydrography Dataset Plus (NHDPlus). Maps by N. Cherok, Department of Geography, The Pennsylvania State University (Penn State Geography).

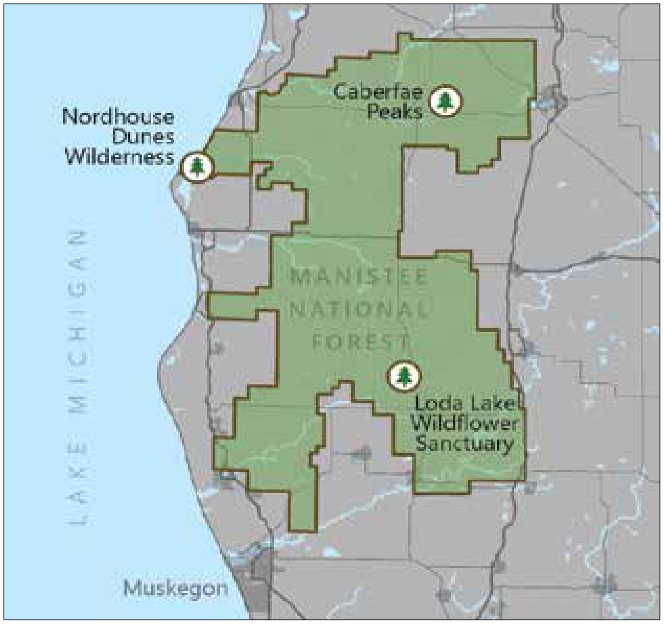

FIGURE 1.2. A simpler map of Manistee National Forest showing three sites highlighted for recreational tourism.

Maps with different purposes may also have similar levels of detail. Figure 1.3 is designed from the same data as figure 1.2. The two maps have different visual emphases. In figure 1.2, the focus is recreational tourism: points of interest (peaks, dunes, and wildflowers), the forest extent, and one city near the forest. The map in figure 1.3 emphasizes travel in the area with more visual prominence for roads, cities, and towns. The recreation features that are bold in figure 1.2 are still present in 1.3, but they are pushed to the background. The two maps show the same set of lines and points for the Manistee National Forest area, but they are symbolized two different ways.

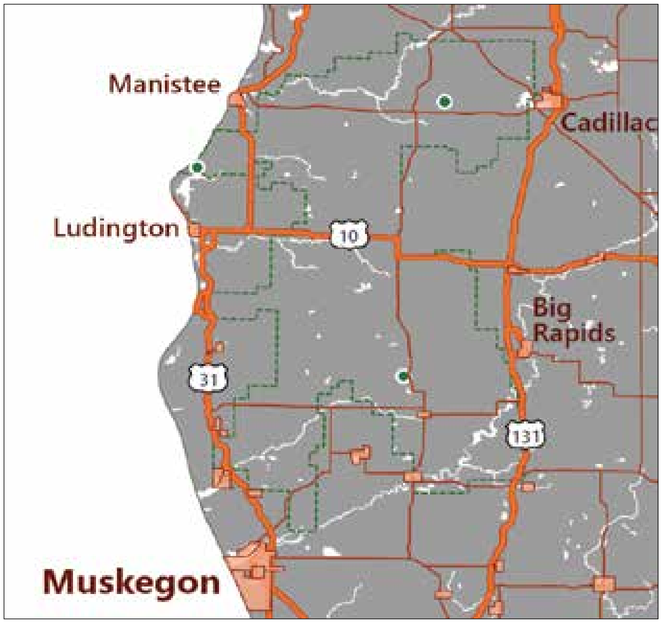

FIGURE 1.3. Map version focused on travel, with visual emphasis on roads and towns in and near the national forest.

The variety of data for a place can be used to make maps with similar purposes by emphasizing different levels of detail. The map in figure 1.2 has less detail. It emphasizes recreation sites and the forest's overall area. This map would be useful for attracting tourist groups to the forest. The map in figure 1.4 includes more data about the forest. It summarizes land cover within two ranger districts in the national forest and includes hydrography and ecological regions. It would be suitable for a more expert group interested in environmental management issues.

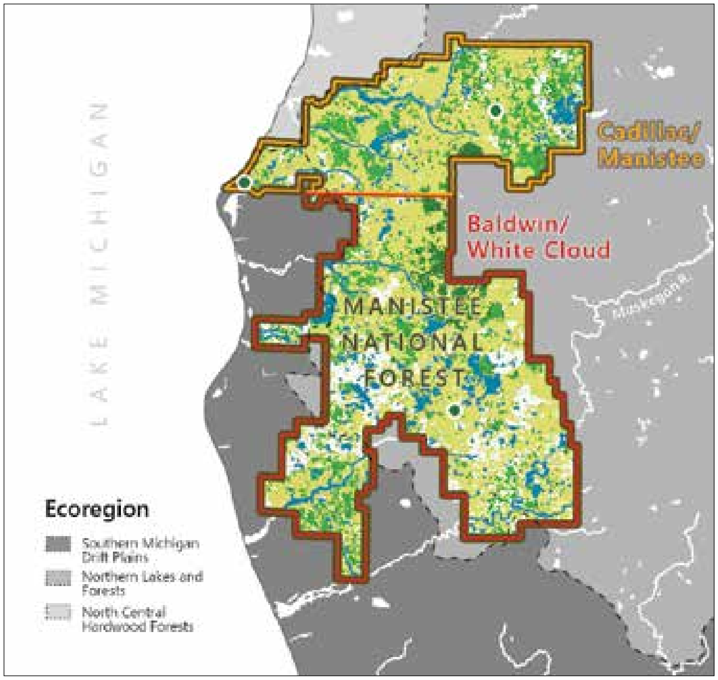

FIGURE 1.4. Map version showing general ecoregions, land cover, hydrography, and ranger districts to summarize the forest's environment for managers. Data source: EPA, USFS, NHDPlus. Map by N. Cherok, Penn State Geography.

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. Base or background geography is lower in the visual hierarchy. Chapter 2 introduces basemap themes common for supporting the main map content. Other supporting information, such as source notes, should be lowest in the hierarchy. These are often along the margins of the display and called *marginal elements*. Chapter 4 elaborates on the design of marginal elements, such as text wording, legends, scale bars, and direction indicators. But first, you need to understand map layout overall.

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 location map
- 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)
- Extent indicators
- Explanatory notes
- Source notes
- Publisher credit and copyright notice
- Author credit
- Neatline
- Additional graphics (such as photos and 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 fire danger map for British Columbia (BC), Canada, in figure 1.5 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 map
- Source note
- Legend and detailed inset map
- Scale for main map
- Orientation indicator (north arrow)
- Explanatory note
- Main map with graticule

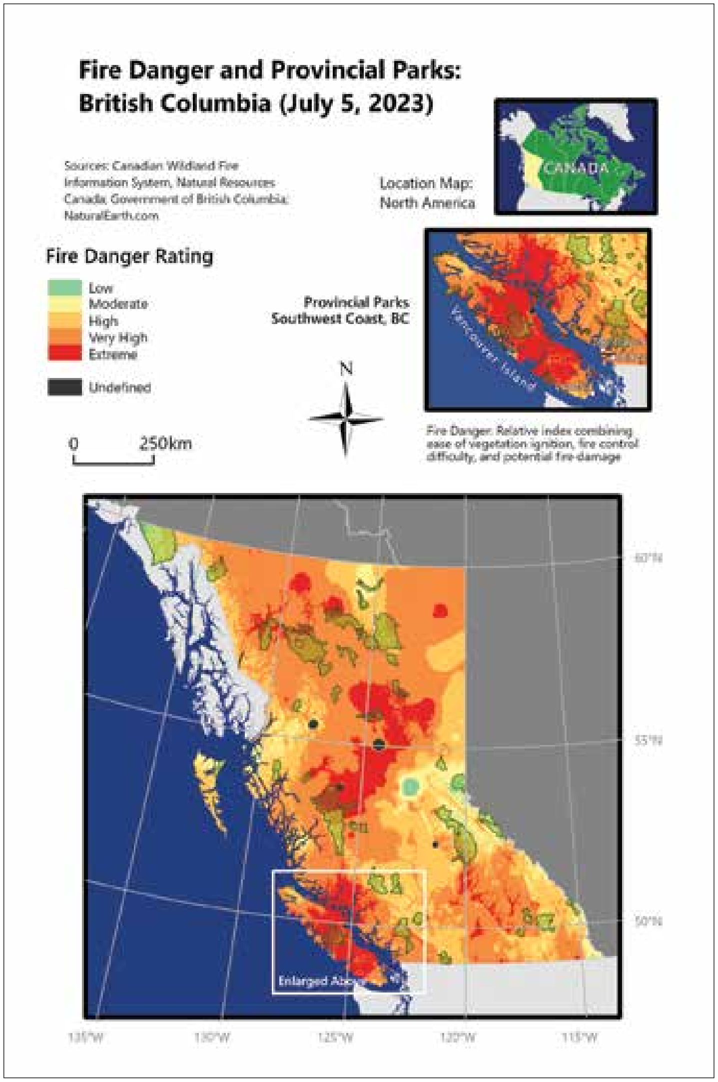

FIGURE 1.5. A jumble of map elements. Data source: Canadian Wildland Fire Information System (CWFIS), Natural Resources Canada (NRCan); Government of British Columbia. Map by N. Cherok, Penn State Geography.

Figures 1.6 and 1.7 show two organized layouts of the same fire danger map. In addition to the different arrangement of the elements, the visual hierarchy of these layouts is also different. The first map (figure 1.6) emphasizes fire danger ratings for the entire province, while the second (figure 1.7) emphasizes park detail in extreme risk areas of southwest BC. 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 figure 1.7, the province map becomes a location map rather than the main map. It is smaller and positioned in a less prominent location than in the previous layout. Because this difference changes the apparent purpose of the map, it has been suitably retitled.

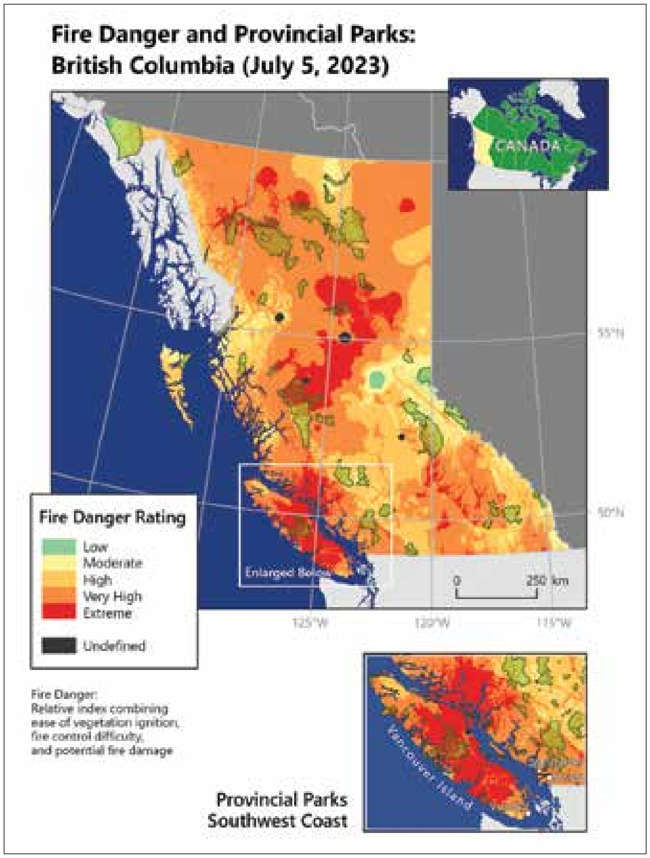

FIGURE 1.6. Layout emphasizing fire danger in BC province.

PLANNING A LAYOUT

Once you have decided the hierarchy of importance for your map elements, position them within the display. 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 layout. Experimenting with your design can reveal new and more effective arrangements of elements in a map 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

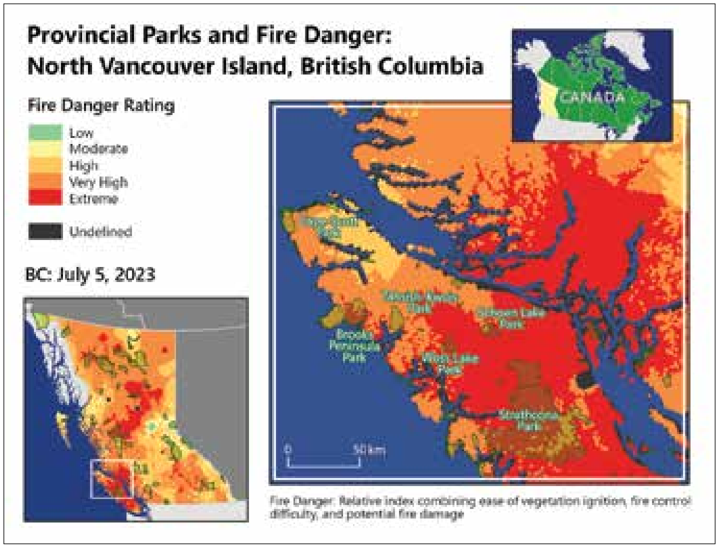

FIGURE 1.7. Layout emphasizing parks in southwest BC, with province serving as second location map. Data source for figures 1.6 and 1.7: CWFIS, NRCan, Government of British Columbia. Maps by N. Cherok, Penn State Geography.

thinking, your future maps will benefit from design practice. The problem with the "fill-in" strategy is overly large or bold map elements that are at the wrong level in the visual hierarchy of the map.

BALANCING EMPTY SPACES

If the goal of layout is not consistent filling in, what is it? Layout on a page or across a screen is an act of balancing empty spaces. If you have an empty space in one corner, you can position other map elements to produce empty spaces that are similar in size in other parts of the display 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 display by separating groups of elements so that their relationships can be better understood.

Two maps of multimodal transportation options in Burlington, Vermont, 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 1.8 and 1.9).

FIGURE 1.8. Compact layout of map elements showing multimodal transportation in Burlington, Vermont.

FIGURE 1.9. Looser layout of map elements for the same map of Burlington, VT. Data source for figures 1.8 and 1.9: State of Vermont, USGS. Maps by N. Cherok, Penn State Geography.

The same maps are marked up to encourage you to focus on the empty spaces in the layouts (figures 1.10 and 1.11). In figure 1.10, the pink highlights are small and similar in size throughout the map. In figure 1.11, the pink 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 distracting shapes that are 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 Burlington map uses boxes around the title, legend, and the locator map (figure 1.12). Compare this design to the two previous designs.

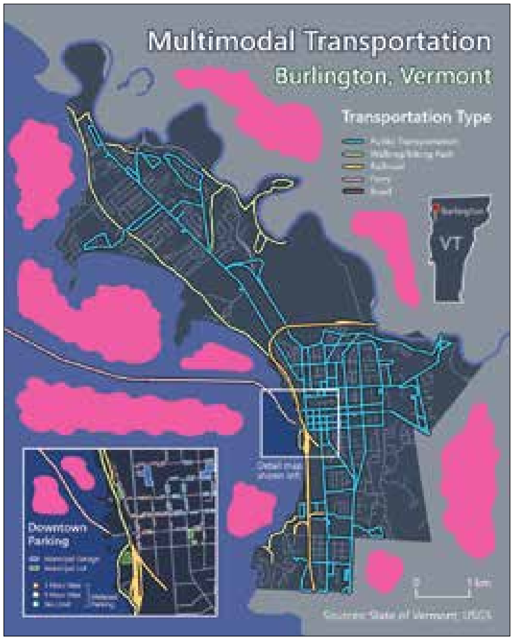

FIGURE 1.10. Pink is used to highlight empty spaces in the compact layout.

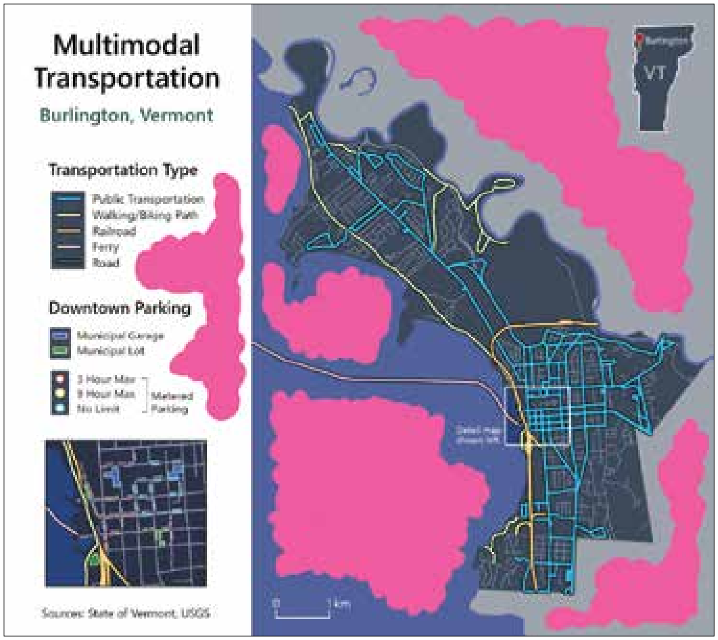

FIGURE 1.11. Pink highlights larger empty spaces in the looser layout. Data source for figures 1.10 and 1.11: State of Vermont, USGS. Maps by N. Cherok, Penn State Geography.

Orange highlights have been placed in the many crowded and tight spaces created by these boxes in a marked-up version of this same design (figure 1.13). These tight spaces can be arranged, but it will be harder to produce a balanced layout.

The orange highlights on the map in figure 1.14 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.

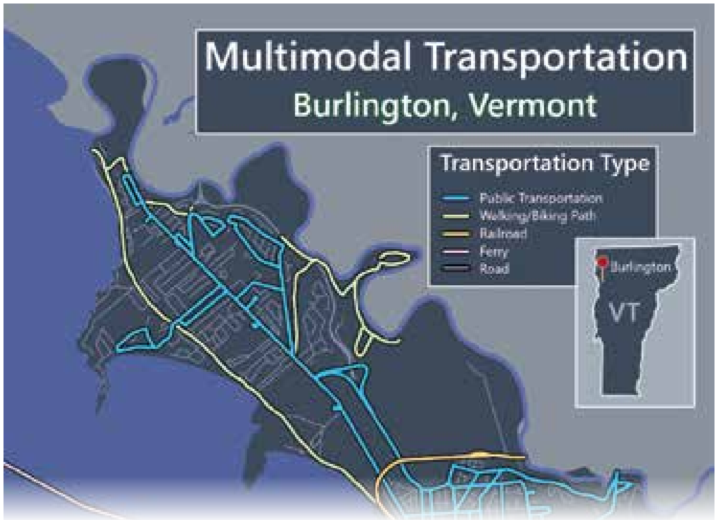

FIGURE 1.12. Boxed elements in the layout of Burlington. Boxes move the legend and locator map higher in the visual hierarchy of the overall display.

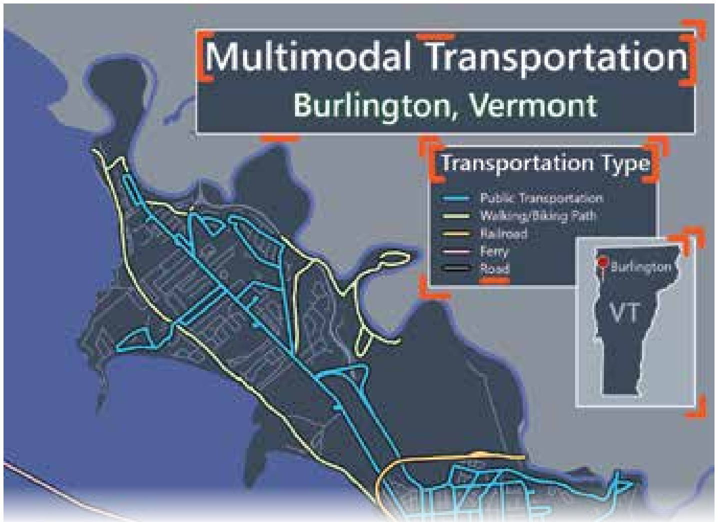

FIGURE 1.13. Orange highlights the pinched and tight spaces in this boxy layout.

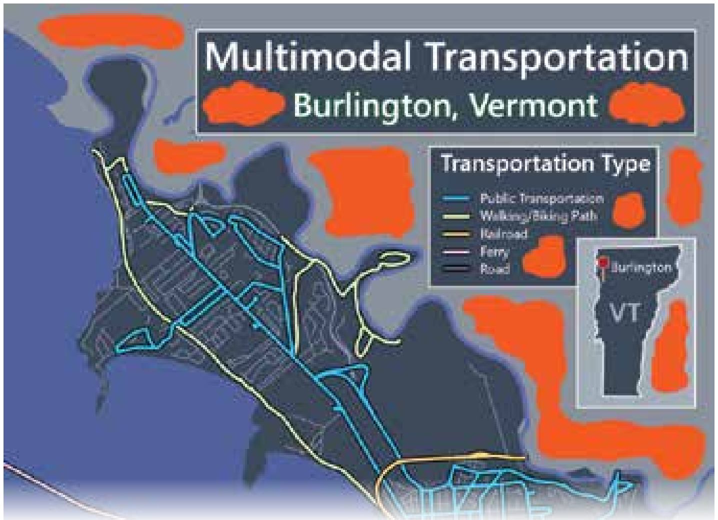

FIGURE 1.14. Orange highlights the numerous empty spaces in the boxy layout. Data source for figures 1.12 to 1.14: State of Vermont, USGS. Maps by N. Cherok, Penn State Geography.

In the 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 1.15).

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 (figure 1.16). Strong geometric shapes like rectangles can unintentionally elevate an element in the visual hierarchy of the layout.

FIGURE 1.15. Boxy layout within inset map of downtown parking details.

FIGURE 1.16. The layout of the inset map is improved when the boxes are removed. This inset is the lower left of figure 1.8 map. Data source for figures 1.15 and 1.16: State of Vermont, USGS. Maps by N. Cherok, Penn State Geography.

Learn to see and use the empty spaces between elements when you are designing a 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 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 it can be difficult to accomplish in a layout with many map elements. For example, a confusing association can result if a scale bar is placed closer to an inset or location map than the main map to which it refers. Proximity is an important visual cue.

An enlargement of a portion of the BC map, redesigned, shows a scale bar positioned within the main map (figure 1.17). The scale bar is also quite close to the inset map and, therefore, might be misconstrued as pertaining to it.

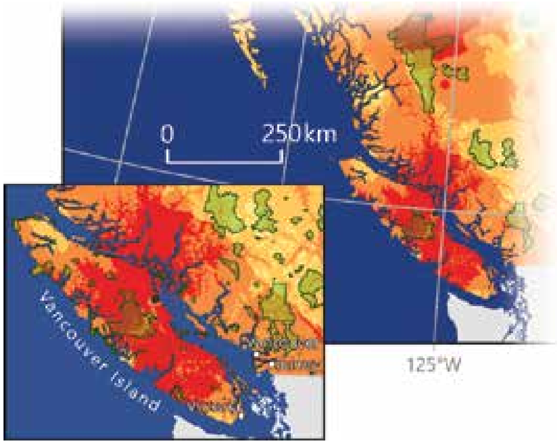

FIGURE 1.17. The scale bar is ambiguous because of its close proximity to the inset. Data source: CWFIS, NRCan, Government of British Columbia. Map by N. Cherok, Penn State Geography.

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 so that they are either perfectly aligned or obviously not aligned confirms that your positioning is intentional, not accidental. Ambiguous alignments look like errors.

The portion of the BC map in figure 1.18 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 1.19).

Figure 1.20 pulls the elements into an organized arrangement with intentional alignments and purposeful spacing. For example, subtitles are closest to their respective maps and the legend title is closer to its content than to the smaller maps. The result is a clear, professional presentation.

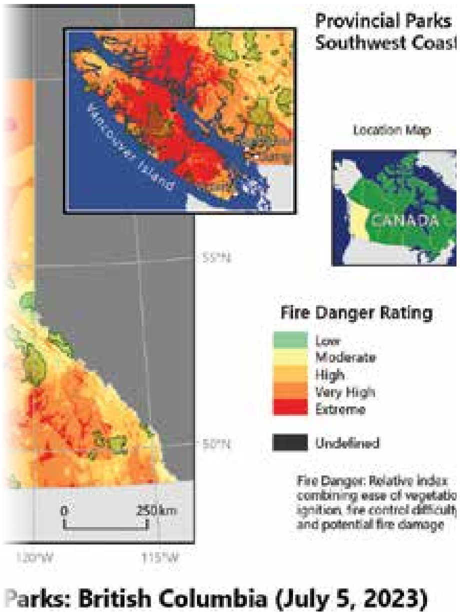

FIGURE 1.18. The slight misalignments of elements produce an unpolished layout of this BC map.

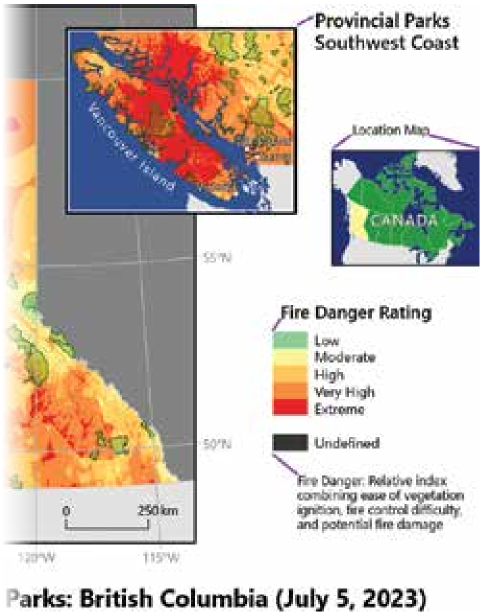

FIGURE 1.19. The misalignments are highlighted in purple.

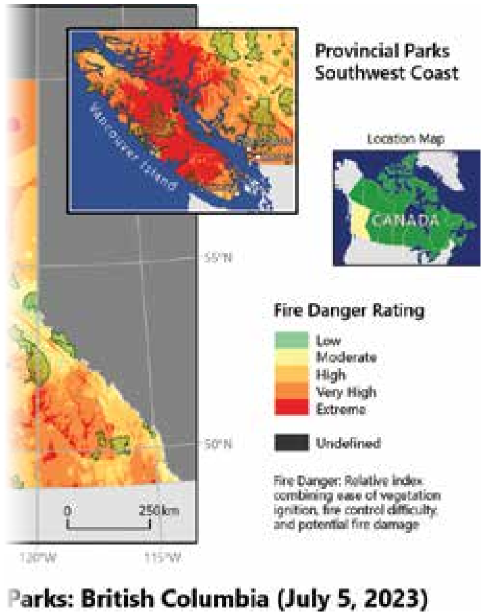

FIGURE 1.20. The elements have been aligned to improve the layout of the map.
Data source for figures 1.18 to 1.20: CWFIS, NRCan, Government of British Columbia Maps by N. Cherok, Penn State Geography.

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 body 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 more 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 1.21 shows a few problem intersections between the vivid main map's frame and the state boundary lines. The problems (highlighted in orange in figure 1.22) 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 southern edge of Newfoundland also creates clutter above the title area within the overall map frame.

The geography is not wrong, but frame positioning is sloppy. Figure 1.23 shows that slight shifts in frame positions relative to the geography solves these problems without compromising the intent of the map, to show mobile wireless coverages in New Hampshire.

Alignment adjustments are the finishing touches that allow you to create a professional-looking display. You can adjust them endlessly, so seeing potential problem areas at the start of

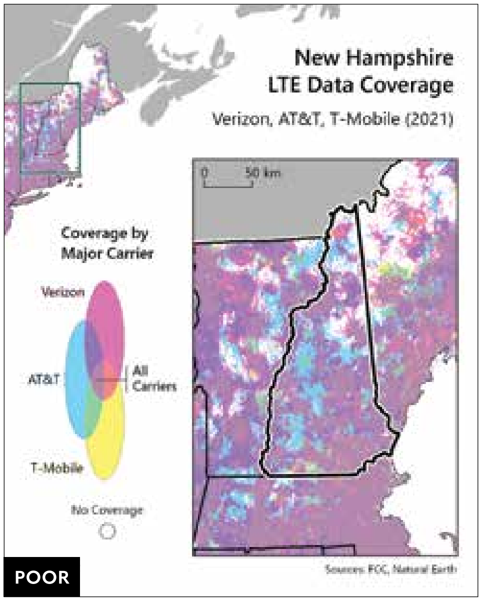

FIGURE 1.21. This map of LTE (Long Term Evolution) data coverage contains distracting intersections of frames with state boundaries and coastlines.

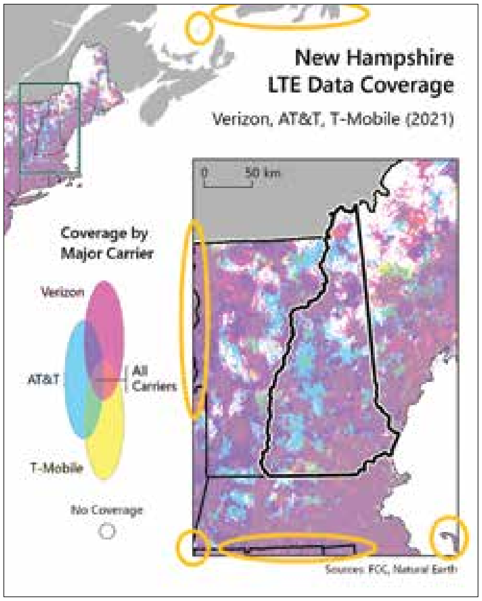

FIGURE 1.22. Intersections that can be improved by alignment adjustments are highlighted with orange.

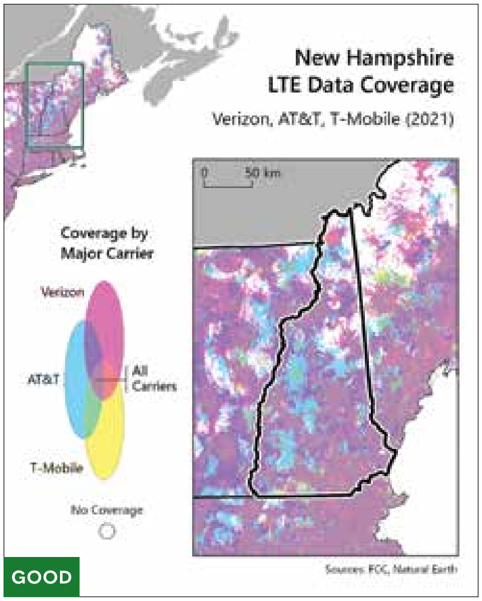

FIGURE 1.23. Slight adjustments in the relationship between the frame and the geography refine the layout. Data sources for figures 1.21 to 1.23: Federal Communications Commission (FCC), Natural Earth. Maps updated by N. Cherok, Penn State Geography.

a project and using guides on-screen 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 in the display.

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 display's 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 BC fire danger map seen in previous examples is shown in portrait and landscape orientations (figures 1.24 and 1.25). 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

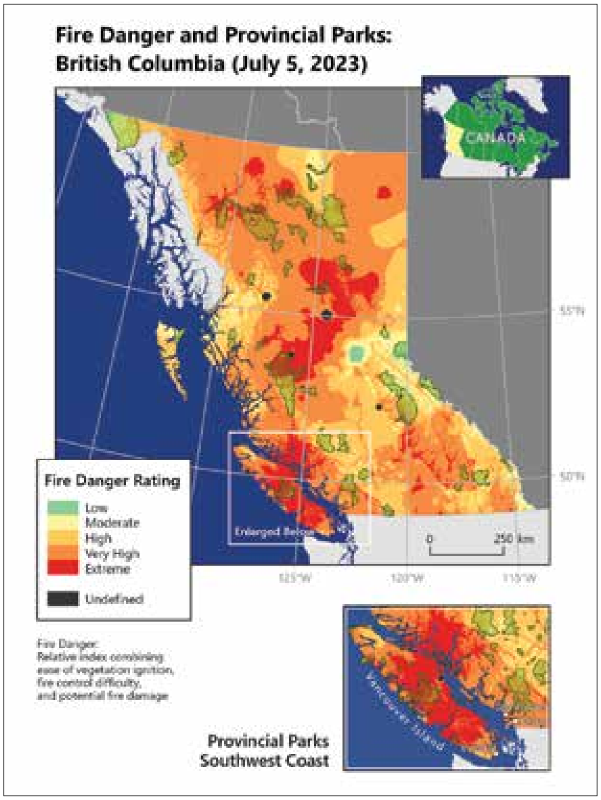

FIGURE 1.24. BC fire danger map in portrait orientation.

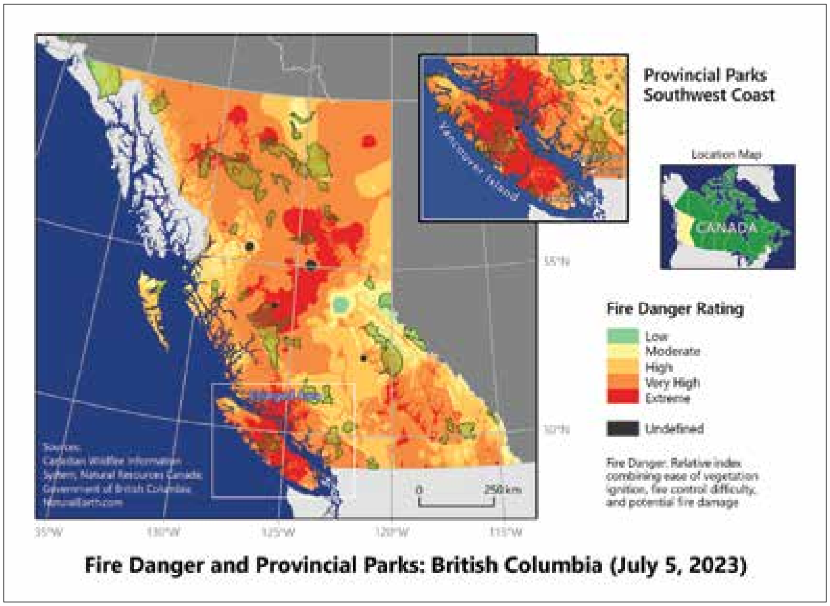

FIGURE 1.25. BC fire danger map in landscape orientation. Data source for figures 1.24 and 1.25: CWFIS, NRCan, Government of British Columbia. Maps by N. Cherok, Penn State Geography.

you have 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 try not to 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 to change the position of the legend so the boxes are not as close to the colorful main map to make 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 seemed perfect at first) has become unwieldy and is ill-suited to the project's current goals. Designers get good at moving on from initial ideas.

MAP PROJECTIONS IN DESIGN

Many mathematicians have been entranced by the interesting puzzle of projecting the spherical globe onto the flat page (or screen). 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.

SHAPE WITHIN LAYOUT

If you are making a detailed map of a small land area (a large-scale map), the particulars of a suitable 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 US 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 US-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. You won't know whether an elongated east–west pattern is influenced by physiography or is a poor projection choice. Likewise, maps of point patterns or area densities need equal-area projections for accurate interpretation.

Figure 1.26 shows a map of western Canada produced with a plate carrée projection (also called an equirectangular projection). 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 gets smaller as you near the poles. (The length of one degree of longitude is half the length of a degree of latitude at 60° 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 sizes of national parks is difficult with a projection that creates these distortions.

A more suitable projection of the same area of Canada is shown in figure 1.27. 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° and 60° north latitude.

The provinces are proportioned quite differently on this map compared to the map in figure 1.26. Wood Buffalo National Park is correctly shown larger and taller than Jasper or Banff, as is the sparseness of the northerly road network. Areas are correct all over this map (figure 1.27), 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 1.27 that was present in the first example (figure 1.26). If northern Canada was relevant for this map, a larger frame or a smaller scale would be needed to suit the map's purpose.

Mapmakers who are not familiar with modifying their map projections may shy away from conic projections, such as an Albers equal area choice. Conic projections have curved latitude lines that produce undesirable rotation away from north-up with increasing distance from the central meridian

FIGURE 1.26. The plate carrée map projection distorts this portion of Canada.

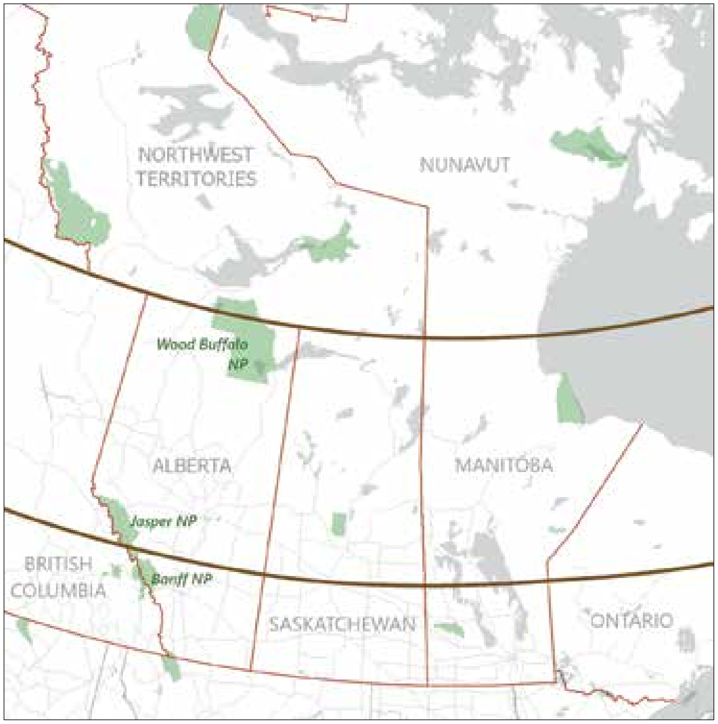

FIGURE 1.27. Albers equal-area map projection of a portion of Canada with standard lines at 52° and 60° north latitude shown as curved brown lines. Data source for figures 1.26 and 1.27: Natural Earth. Maps updated by N. Cherok, Penn State Geography.

(the intended middle of the projection). Figure 1.28*A* shows the state of Pennsylvania framed within the Albers projection for the whole US (its central meridian is 96° west). The central meridian of figure 1.28*B* is modified to 79° west, the middle of the state. The resulting north-up orientation suits the state map much better. Maps of Pennsylvania at an unnecessary tilt (north angles left) abound for the lack of a modified central meridian.

CHOOSING PROJECTION PROPERTIES

Shape differences with projection choices can also affect the map theme in addition to display layout. Figure 1.29 illustrates distorted directions, or azimuths, with a flight path between Nairobi, Kenya, and Sydney, Australia. In both cases, the true shortest path is the solid orange line. If you were hoping to snap a photo out the window of charismatic desert landscapes as you fly over Western Australia, as the dashed straight line in the Mercator map suggests in figure 1.29*A*, you will be disappointed—the direct flight path on the earth instead passes over waters of the Great Australian Bight. The second map (figure 1.29*B*) has an azimuthal projection chosen specifically to position this straight line across the surface of the earth (a great circle route) as a straight line on the map.

If you are making thematic maps—special purpose or statistical maps of geographic phenomena, such as population density—choose an *equal-area map projection* for most topics. Despite all the fun we could have exploring 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, an Albers equal-area projection customized to the United States is a common projection choice. You should also make use of additional customized Albers projections for Alaska and Hawaii. Each projection has repositioned standard lines so that no part of the area of interest gets far from these lines, where there is no distortion. Don't let these states dangle at the distorted edge of a projection optimized for the contiguous United States.

Large-scale reference maps often use another category of projection called *conformal projections*. These projections are better for showing routes and local areas because they preserve angles and shapes at points. These advantages come at the

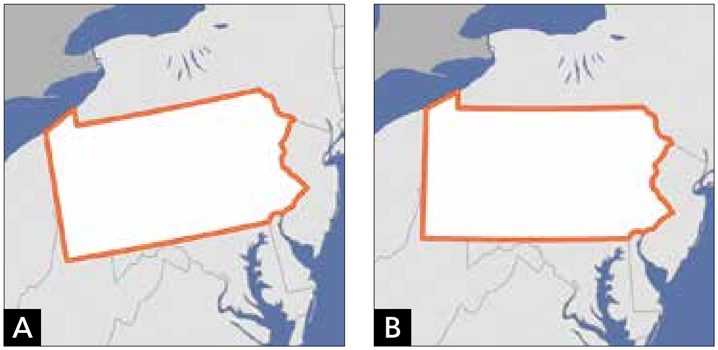

FIGURE 1.28. Pennsylvania state outline in a US Albers projection uses the default central meridian for the contiguous US (*A*) instead of improving the map by changing the central meridian to the center of the state (*B*).

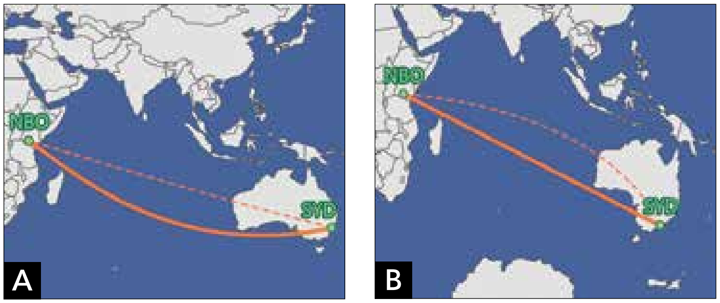

FIGURE 1.29. A Mercator projection (*A*) and an azimuthal projection (*B*) each plot real-world straight paths differently. On both maps, the solid line is the great circle route between Nairobi and Sydney, and the dashed line is the rhumb, a line of constant compass bearing. Data source for figures 1.28 and 1.29: Natural Earth. Maps by N. Cherok, Penn State Geography.

expense of preserving areas, and they will misrepresent densities of features in parts of the map distorted by the projection.

UTM PROJECTIONS

The Universal Transverse Mercator (UTM) system provides coordinates and a set of projections designed to make maps with minimal distortion for any given small portion of the earth. The system uses the Mercator projection flipped sideways, and retains its conformal property. The system divides the earth into sixty zones, each using a specially positioned transverse Mercator projection with two standard lines. Figure 1.30 shows one pair of UTM zones, 18S and 18N, which abut at the equator and exclude the poles. Each zone renders the area within its narrow strip with negligible distortion. The configuration of the projection in each zone suits large-scale mapping in only that zone. The graticule and continent shapes in figure 1.30 show that distortions in area and shape increase away from the example central zones outlined in orange.

Figures 1.31 and 1.32 show the coast of Peru and the extent of the city of Lima, Peru. Each map is projected with UTM zone 18S, providing minimal distortion in areas, shapes, and angles at points (UTM is a conformal projection).

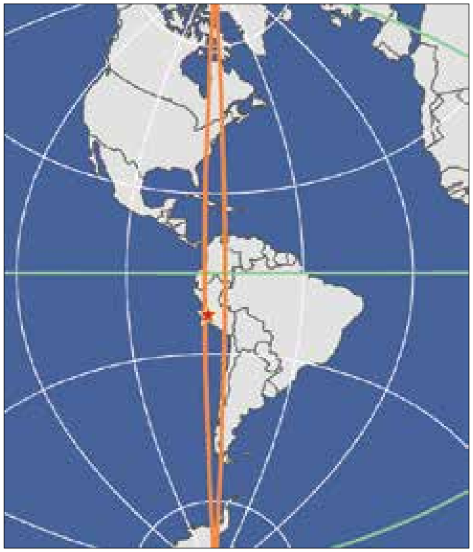

FIGURE 1.30. A pair of UTM zones outlined in orange: 18N and 18S. They span 72° to 78° west longitude and from 80° south to 84° north latitude. The entire map is projected using the zone 18 pair.

FIGURE 1.31. The UTM zone 18S represents the coast of Peru well. White lines show a one-degree grid.

FIGURE 1.32. The UTM zone 18S represents the extent of the city of Lima, Peru. Data source for figures 1.30 to 1.32: Natural Earth. Maps by N. Cherok, Penn State Geography.

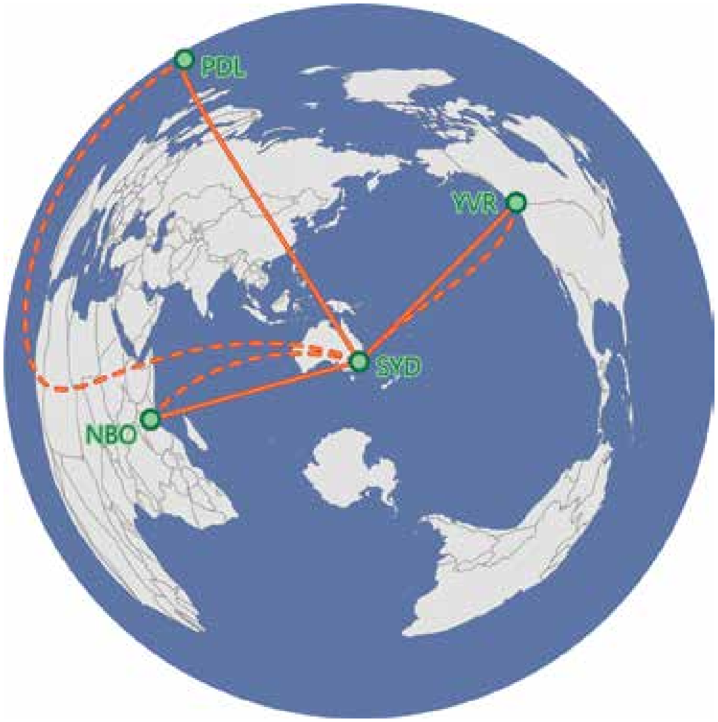

FIGURE 1.33. Azimuthal equidistant projection centered on Sydney (SYD) with lines to a few interesting locations: Nairobi (NBO), Vancouver (YVR), and the Azores (PDL) airports. Solid lines are great circles and dashed lines are rhumb lines. Data source: Natural Earth. Map by N. Cherok, Penn State Geography.

CUSTOM AZIMUTHALS

Small-scale maps that highlight a place often benefit from a customized projection. There are many special properties to choose from. Azimuthal projections of the whole world are circular and have the least distortion near their center. They also preserve angular relationships outward from the center in all directions. The standard point at the center can be readily repositioned to the place you are mapping, and you can zoom in to that area to frame a customized and well projected region. When used whole, these circular projections provide a contrasting shape within your map design that attracts the map reader's eye, and they are useful for making small locator maps.

A good example of a useful projection property is the azimuthal equidistant. This projection shows correct distances (and directions) from the center (the standard point) to all places in the world. This projection choice is useful to show events radiating from a point source, such as a plume of contaminants or radio communications, and to show distances for global travel or trade.

The distortion of shapes and areas at locations far from the center of azimuthal equidistant projections can be entertaining, but that key property of correct distances along great circle routes out from the center is preserved. Notice that the direct route between Sydney and Nairobi is the same in figures 1.29*B* and 1.33 (SYD to NBO). Both projections show the direct route between these two cities as a straight line. If you lived in Sydney and wanted to go on a vacation to a far-away place, the Azores would be a good choice. That direct route on the azimuthal equidistant map (figure 1.33) is very long (SYD to PDL), and you would get to look out the window at China, Russia, Scandinavia, and the United Kingdom.

An azimuthal projection that is useful for location maps is the orthographic projection (figure 1.34). It projects the earth to the flat page so it appears to be a sphere. It is neither equal area nor conformal, but it is nicely attractive as a bit of 3D that stands out from a flattened main map to provide context for the topic. You can add a highlight on the sphere and shadow below it to enhance the three-dimensional effect (figure 1.35).

Chapter 3 includes more discussion of map projections with an emphasis on map scale.

FIGURE 1.34. Orthographic projection centered on Sydney airport (SYD) with a grid which sketches spherical shape.

FIGURE 1.35. Orthographic projection centered on Vancouver airport (YVR) with highlight and shadow to simulate a spherical globe. Compare this location map to the rectangular location map design shown in the BC fire danger examples (such as figure 1.25).
Data source for figures 1.34 and 1.35: Natural Earth. Maps by N. Cherok, Penn State Geography.