Lesson 3: Map Elements and Design Principles

## INTRODUCTION

In this lesson the content will focus on map elements and design principles. The cartographic process will be covered which explains why one would want to create a map and for what purpose. In this process the lesson will identify and explain elements that should be considered and added when creating a quality map. Planar and Hierarchical organization are outlined and to aid in understanding how to organize a map. The lesson concludes with an example map critique which highlights issues and identifies solutions to make the map sound.

## LESSON OBJECTIVES

By the end of this lesson, you will be able to:

1. Identify map elements and design principles.
2. Employ appropriate map elements and design principles for different types of maps and audiences.

## LEARNING SEQUENCE

|  |  |
| --- | --- |
|  | |
| Required Reading | Read the following:  Map Elements and Design Principles   * The Cartographic Process * Map Design and Map Elements * Planar and Hierarchical Organization on a Map * Planar Organization * Hierarchical Organization * Example Map Critique * Ethics in Cartography |
| Assignments | Complete the following assignments:   * Quiz: Map Elements and Design Principles * Lab: Layouts and Figure-to-Ground Relationships |

## INSTRUCTION

**Map Elements and Design Principles**

## **The Cartographic Process**

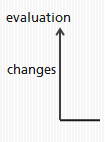
### Creating a Map

The Cartographic process is the process you should follow when you want to go from unmapped data to a map form. The cartographic process is not a rigid processing you need to follow step-by-step, however, it is a recommended set of steps that you should follow in order to properly create a map.

The Cartographic process is composed of five steps. Step one is to define purpose and meaning of the map. Step two is to choose the scale of the map. The third step is to determine the map format, printing limitations you may have, and the economics of production and reproduction of the map. Step four is to abstract and generalize the data. And finally step five is the design and the layout of the map.

Once you reach step five you will often need to make changes, evaluate those changes, and possibly start one of the previous steps in the cartographic process. Also note that the cartographic process does not need to be followed in this particular order. Designing a map is often a dynamic and iterative process which requires you to bounce back and forth between steps in order to produce a cartographically sound map. We will now go over each one of the five steps in the cartographic process in more detail.

**Cartographic Process\***



1. Define purpose and meaning
2. Choose scale
3. Determine map format, printing limitations, and

economics of re/production

1. Abstract and Generalize
2. Design Layout

**\***Note: Does not need to happen in *exactly* this order this is often a dynamic, iterative process.

### Define Purpose and Meaning

The first step in the cartographic process, define purpose and meaning, means that you should interpret the requirements of the user when you’re thinking about the design of the map. You need to answer two important questions.

The first question is “what needs to be communicated?” In order to answer this question you need to make sure you have a thorough understanding of what you want to convey to the map user, who is a map user is going to be, and what you expect the map user to gain from viewing your map.

The second question to answer is “how to best facilitate the communication of ideas?” Once you determine what needs to be communicated you can then determine the best way to communicate that information. Things to think about here are if you’re going to make a tangible or virtual map, what category of map you will create, and how you will produce and deliver the map.

### Choose Scale

The second step in the cartographic process is to choose the scale of the map. Defined, map scale is the ratio of map distance to earth distance. In other words it is the ratio at which the earth has been reduced to fit on the map. Map scale operates along a continuum from large-scale too small scale.

There are no hard rules for exactly what constitutes a large scale, medium scale, or small scale map. Therefore we will present the rules of thumb for determining which category of scale your map falls within. A large scale map is a map it is produced at 1 to 0 all the way through 1 to 600,000. A medium scale map is a method is produced from one to 600,001 through 1 to 2,000,000. A small scale map is a map that is produced from the scale 1 to 2,000,001 through 1 to infinity. A large scale map shows a very small geographic area while a small scale map shows a very large geographic area. While this may seem counterintuitive, we call a large scale map a large scale map because of the relative size of the fraction. For instance the fraction 1/600,000 is a significantly larger number than 1/2,000,000, therefore, the scale 1:600,000 is considered to be a large scale compared to 1:2,000,000.

Because scale is going to have such a bearing on the look of your map, what data will be required, and how much detail you can show on the map, selection of scale is possibly the most important decision a cartographer makes. If you choose the correct scale at the beginning it will make your life quite a bit easier when you run to the iterative cartographic process. However, it is common to slightly change the scale as you work through the map design process, but it is best if you try to decide if you are making a small, medium, or large scale map early.

### Format, Printing, and Economics

The third step in the cartographic process is considering the format, printing, and economics of map production. There are three questions you must answer in this step: The first question is what kind of map will you create a reference or thematic map? If you decide to make a thematic map, what type of thematic map will it be?

The second question to answer is how will the map be displayed? Will the map be printed on 8.5 inch by 11inch piece of paper? Will the map be viewable on a mobile device? Will the map be viewed by a pilot in the cockpit of a helicopter? Answering this question will help determine the options you have for producing the map.

The third question to answer in this step is how much will it cost to create the map? Depending on your format restrictions, whether you are going to use color or not, and many other decisions, these all factor into the cost of creating a map you should check this cost against your budget.

### Abstract and Generalize

The fourth step in the cartographic process is the abstraction and generalization of data. Once you have determined the purpose, scale, format, and type of map, you then need to determine which data sets are required and how to appropriately abstract and generalize them so that you have a unified look on your map.

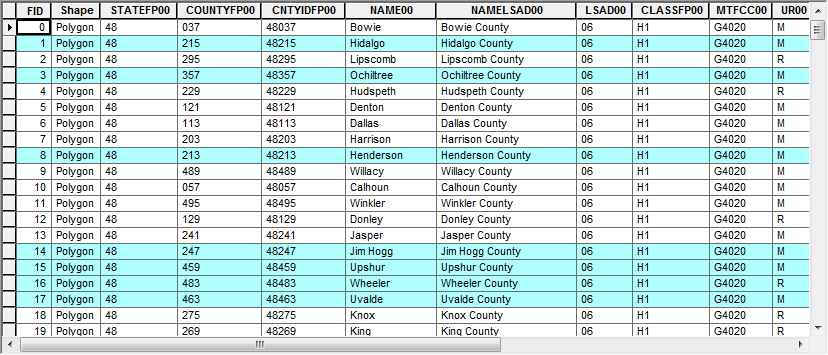
Additionally you should only show information on the map that is potentially meaningful to the context. That means you should ignore placing data on the map just because it looks pretty or because you have the data. You should critically analyze every piece of data you place in the map to determine whether it is useful to the map reader and the purpose of the map.

As you were making an abstraction of reality at a reduced scale of the size of the earth you will need to appropriately reduce the amount of detail in the data so that the map will be a simple visual image. Should you use data that is too detailed for the scale of which you are producing the map, the map will appear very busy, cluttered, and will be difficult to use.

Broadly speaking, there are four methods to abstract and generalize data for display on a map.

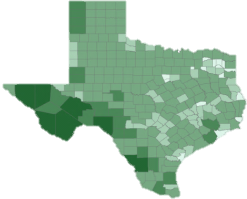
#### Selection

The first method is the selection of data. Selection is when you choose a subset of data that you wish to display on the map. For example if you are showing the roads across the state of Texas you may only want to select the major roads and highways as showing every street in Texas would make the map look like a mass you cannot show that much detail at that scale.



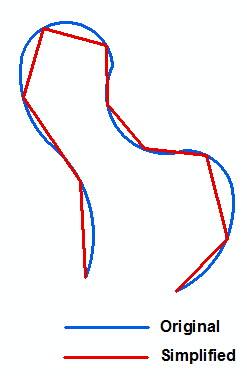
#### Classification

The second method is classification. Classification is when you combine observations into a larger group or class to simplify the data so that it can be displayed easier on the map.



#### Simplification

The third method is simplification. If the data you wish to use for your map contains too much geometric detail you should simplify the geometry so that it looks smoother and appropriate for the scale which you are mapping. This can be done manually or through the use of algorithms.



#### Symbolization

The fourth method when abstracting and generalizing is the use of symbolization on the map. Symbolization is when we use representative shapes or pictures to represent items or spatial phenomena.



### Choosing Symbols

When choosing symbols for your map, there are a few things that you should keep in mind. The first is to use universally accepted symbols when possible. There is no need to reinvent the wheel and it may only lead to confusing your user. For instance if you want to show the location of an airport on a map, a universal symbol is an airplane. If instead of an airplane you chose to represent an airport terminal this may not be instantly recognizable to the user and will require them to visit the legend unnecessarily.

Second you should make sure that you use discrete and continuous symbols appropriately. This is actually fairly hard to do as continuous symbols are typically represented by rasters or surfaces. To be thorough it is important that discrete objects be displayed as discrete. Third, use universally accepted colors when possible. For example, hospital symbols are typically blue, and parks are typically green. As people are used to seeing these categories of items in these particular colors, if you adopt those color conventions, it will make your map easier to use as things will be more readily identifiable by your map reader.

### Design Layout

The fifth step in the cartographic process is designing the maps layout. In this section we will only speak about design layout in general terms, but will soon discuss the map elements and map design principles in more detail.

When designing your map layout the first bit of advice is that you should always experiment with your map design! Rarely should you accept your first design. It is recommended that once you have created one map design you drastically rearrange elements to see if there any other layouts that may work better. Do not be afraid to start over from scratch if a map design is not working for you. Remember that cartography is a creative process that often requires multiple iterations of design.

For each map design you create you should critically evaluate the map for the following. First, you should make sure that in its current design, the map is still suited to the needs of its users and is not overly complicated, or too simplistic in nature. You should also make sure that you have included all relevant information that the map user will need to reference when viewing your map.

Second, the map should be easy to use. If you have included unnecessary detail, placed elements in awkward locations, used nonstandard symbols or colors, among other issues, the map will be difficult to use in your user will get quickly frustrated.

Last, you should always make sure that your map is an accurate representation of reality. You should double check to make sure that you have not included any false information or displayed the data in such a way that the user could easily arrive at an incorrect conclusion.

As you continue to evaluate your map design you should also consider these qualities. The language of the map should relate to elements or qualities represented. This means that the language of the map should not be stating one thing, when the map clearly points toward a contrary position. Both the visual portion and language portion of the map should have a cohesive and consistent message.

You should also consider whether the map is clear, legible, and attractive. This is often harder to determine therefore it is recommended that you show your map design to colleagues, friends, or family to get their opinion and see what they think about the map. Last, you should see if your map will permit interaction with the user and engage the user in a meaningful manner.

You should try to make sure that your map is as interesting as possible and has an important message to convey. If the map is boring, not visually attractive, or does not show any useful information, your map will not be useful to the map user.

### Element Considerations

As you create your map design you should aim to design a map that is a functional visual communication device that is visually pleasing and is truthful and accurate. This is quite a tall order, however as you work iteratively through the cartographic process, you will achieve this goal.

#### Harmony, Composition, and Clarity

Broadly speaking a cartographically well-designed map will have harmony, composition, and clarity. A map is harmonious with the map elements looking like they belong together which means all map elements have the same feel to them and the same style. No one element looks to be out of place or “pasted on”. A well-designed map also has good composition. This speaks to the structural balance of the map. Does the map “feel” off balanced or do the map elements look to be placed very poorly.

Ideally the positioning of the map elements will be in accordance with their importance on the map and will be easy to reference in support of the main map body. Lastly, a well-designed map has clarity. This means that the map reader can instantly recognize elements on the map and can easily recognize and use all the elements you placed around the map for reference.

#### Map Aesthetics

Wright, in 1942 stated this about map aesthetics. “The quality of a map is also in part an aesthetic matter. Maps should have harmony within themselves. An ugly map, with crude colors, careless line work, and disagreeable, poorly arranged lettering may be intrinsically as accurate as a beautiful map, but it is less likely to inspire confidence.” What Wright is alluding to is that in order for map to be effective in the eyes of a map user, the map must not only be accurate, but it must also have harmony, good composition, and clarity.

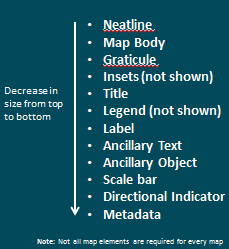
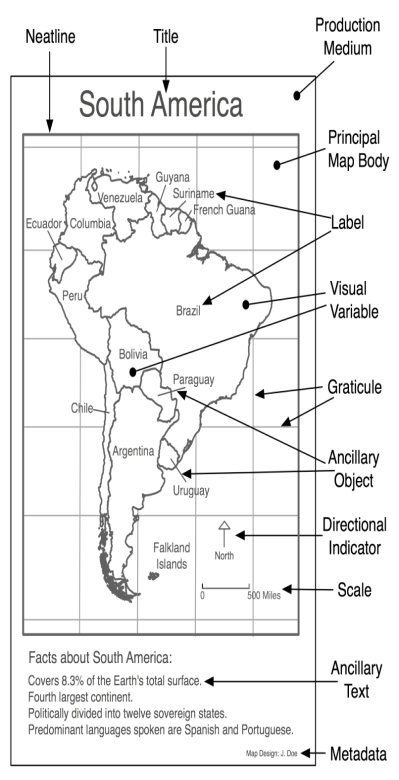
## Map Design and Map Elements

### Map Elements

A map is composed of multiple parts known as map elements. Map elements that may be included on the map are a neat line, map body, graticule, insets, title, legend, label, ancillary text, ancillary object, scale bar, directional indicator, and metadata. It is important to note that not all map elements are required for every map. In fact the only map element required to create a map is the map body which is what shows the data.

In the image the map elements are listed from top to bottom. The elements towards the top of the list are larger in size and the elements at the bottom of the list are smaller in size. On a map elements are sized relative to their importance to the map reader. For the rest of the section, we will discuss each map element in detail including its purpose, and design considerations.

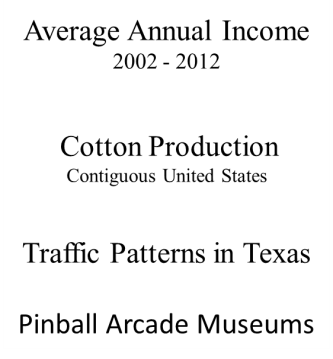
**Map Elements**

### Title

The first map element to discuss is the title. The purpose of the title is to focus attention on the purpose the map; therefore, it is dominant in size and is typically placed at the top of the map and centered. A good map title is brief and will typically include where, what, and when as related to the map’s topic. Every map should have a map title, however a common reason not to put a title on the map is if the map is a figure in a larger body of text and in it the map will have a caption. In that case place a map title as the caption text. You should avoid ornate or complex fonts for the map title so that it is easy for the map user to read quickly and with these. You should also use a bounding box around the title if the legibility of the title is decreased due to elements of the map. The following are examples of map titles.

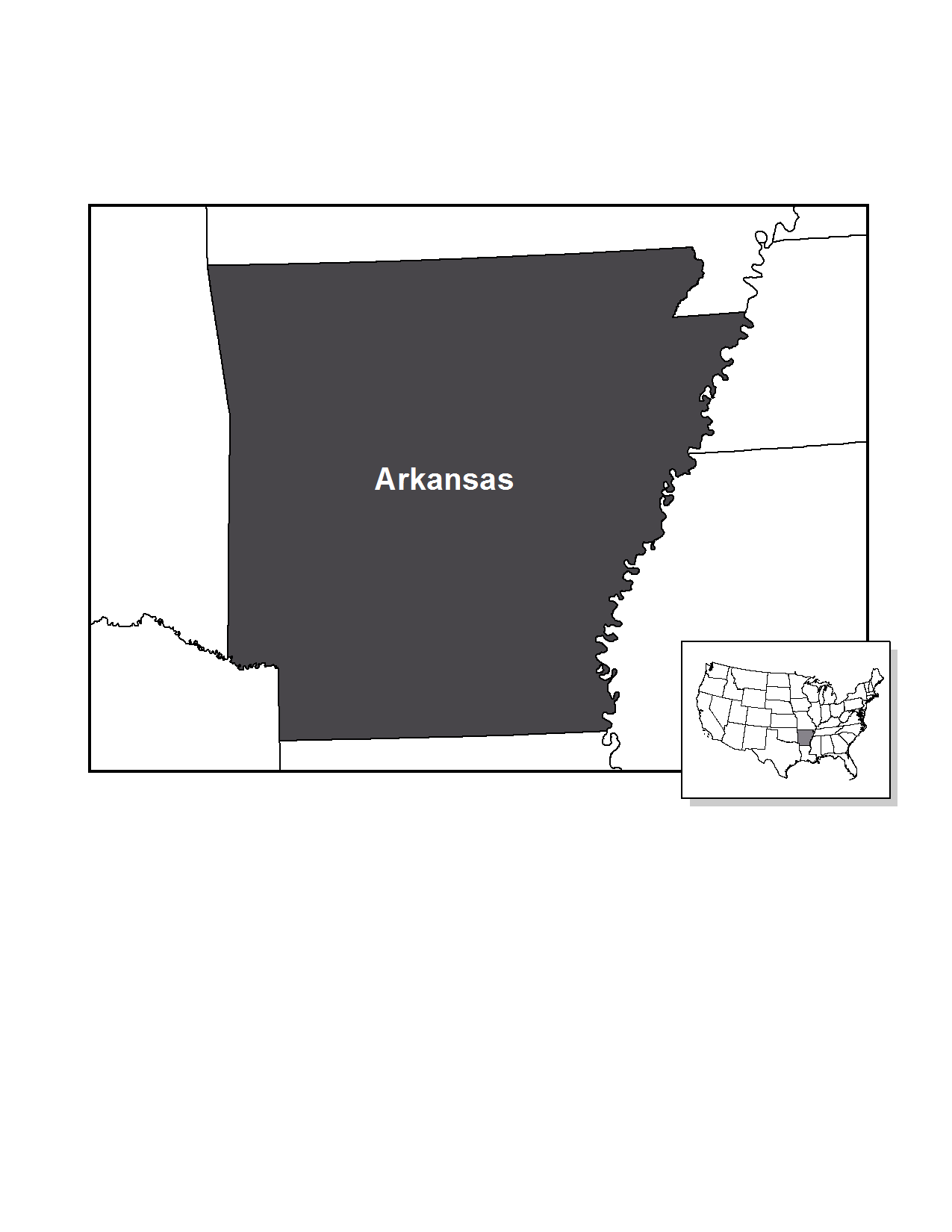
### Title Example

This image is an example of a map with the title “average annual income 2002-2012”. This is a good map title as it uses a simple font that discusses the why and the when of the subject matter. The second example is “corn production contiguous United States”. This too, is a good map title as it states in a clear font the: what and the where. Perhaps a statement about what time period the map covers would be useful.

The third title example is “traffic patterns in Texas”.

This map title leaves a little to be desired as it does not tell us important information about the time coverage of a map. As traffic patterns often change throughout time and based off of seasons, holidays, or workdays, the map title has a little too much ambiguity. The last title example is “pinball arcade museums”. This is a reasonable map title, but perhaps the specification of where the map covers and what time period the map covers would be useful.

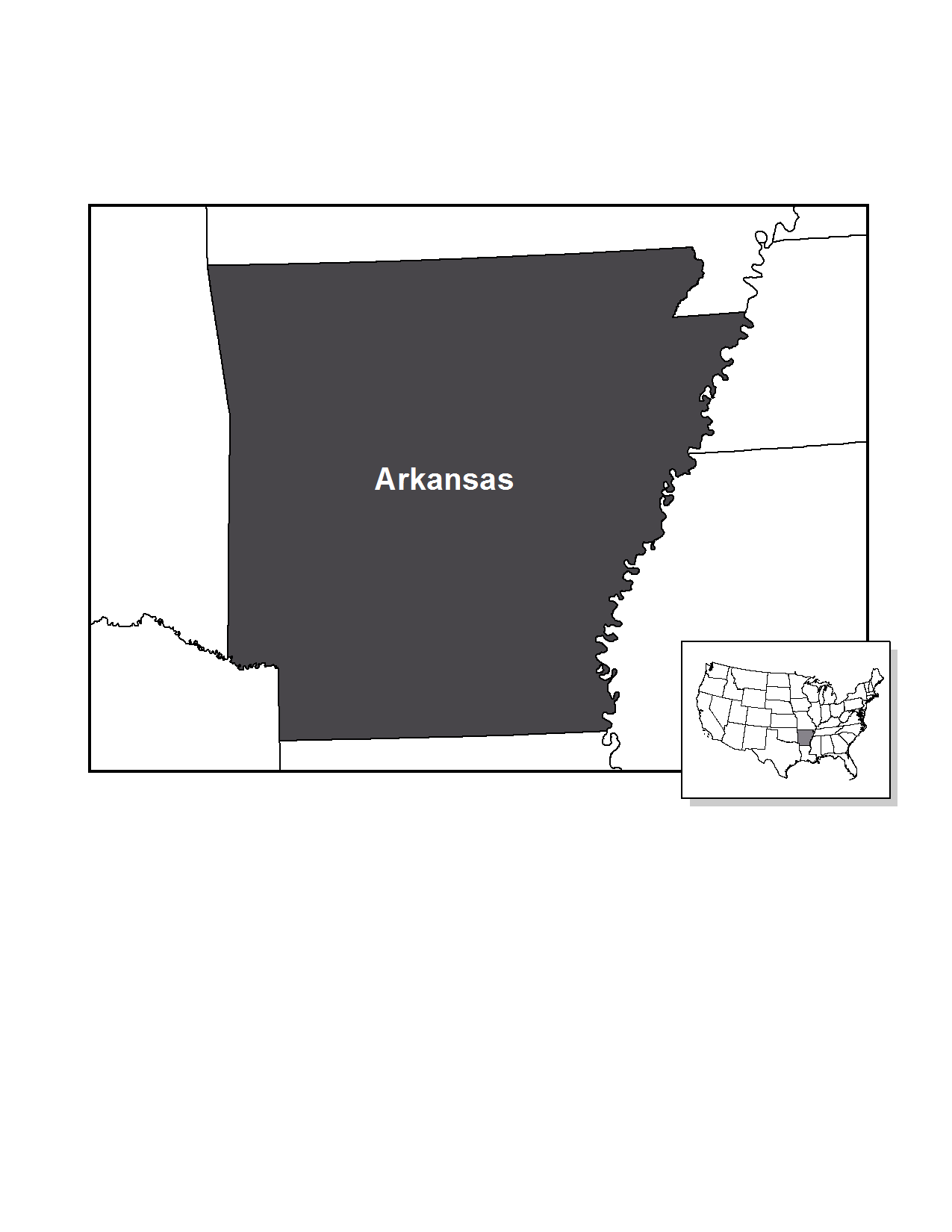
### Map Body

The map body map element is the main focus of the map and should be visually dominant in every case. The map body contains the features important to the message of the map. The map body should be made as large as possible on the medium but should also leave room for other map elements and should not crowd the edges so that the map has a little “breathing room”. The map body is the only map element that is absolutely required when composing a map. However, the map is often much more useful when other map elements are included.

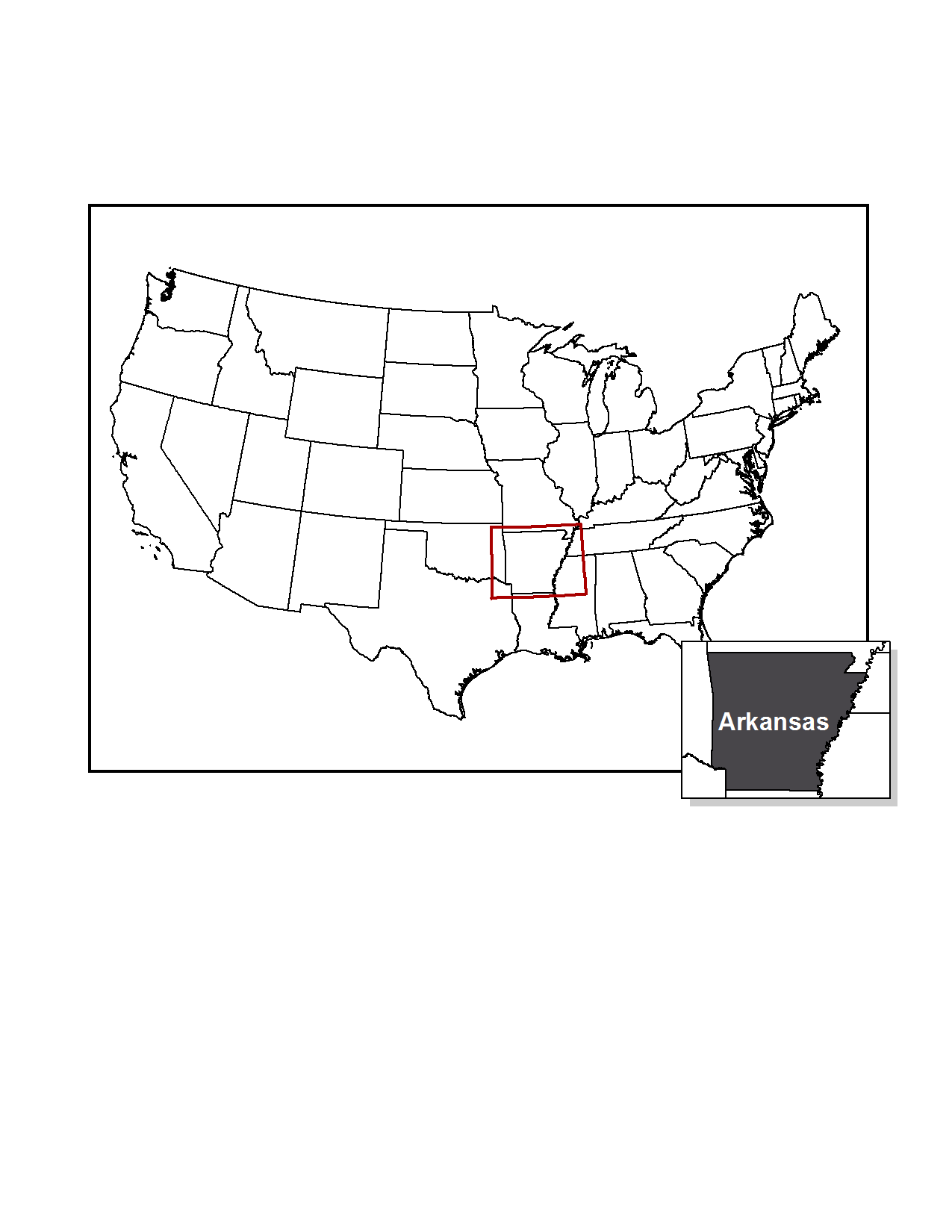
### Map Body Varieties

There are two map body varieties: cropped and floating. Both map body varieties are widely used so it really comes down to preference when designing your map.

#### Cropped

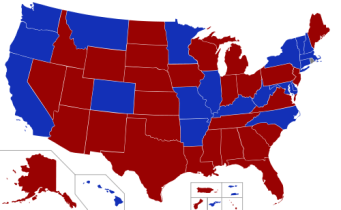
A cropped map body represents a region of interest within a geographic context and the surrounding area is cut off often by a neat line. The cropped map shows Arkansas and portions of surrounding states for context.

#### Floating Map

A floating map body is a region that is disconnected from neighboring regions. This might confuse map readers. However, it is good for opening space up for placement of other map elements.

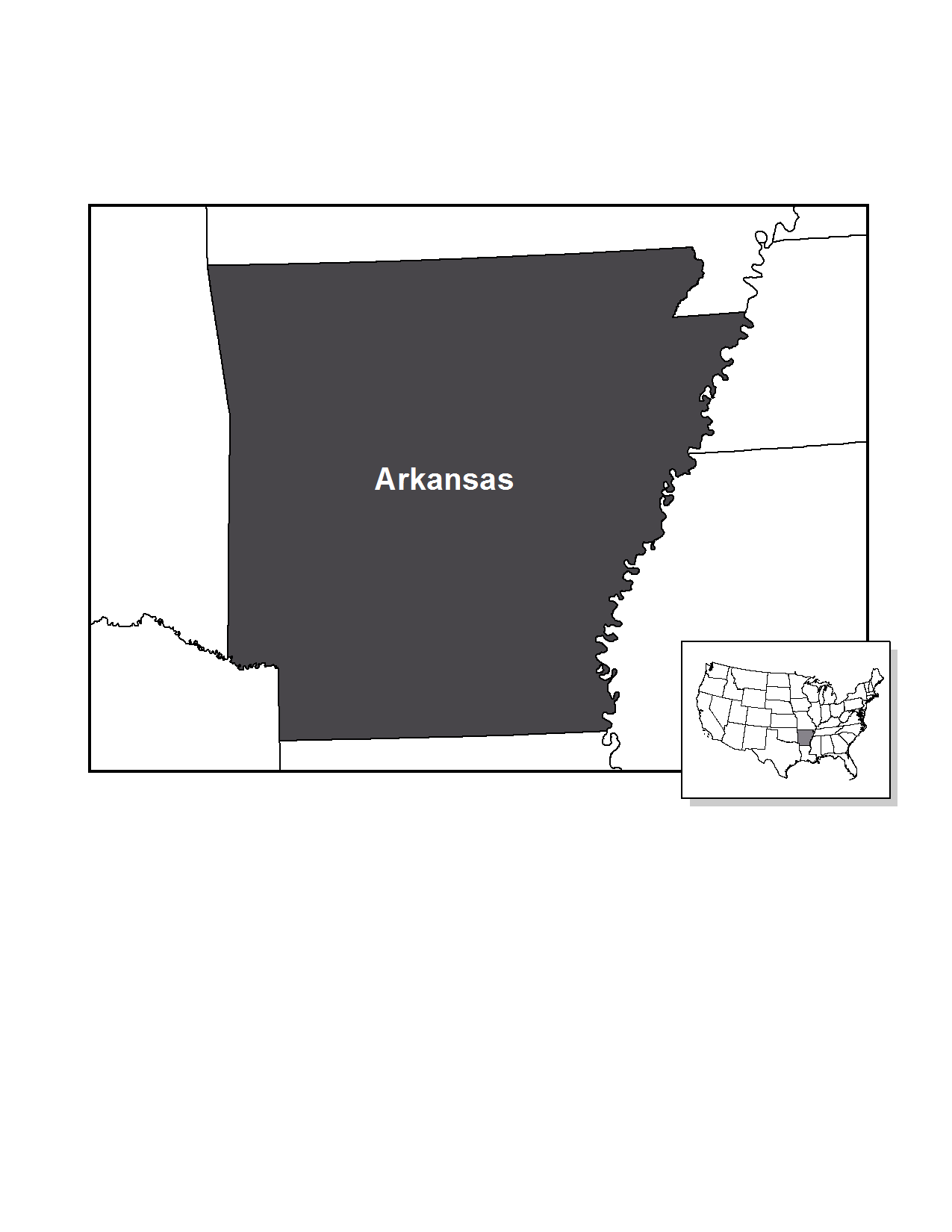
This floating map shows the contiguous United States, but does not show oceans, the Gulf of Mexico, or Canada and Mexico which might provide important context.

#### Inset Map

****An inset map element is a small ancillary map that is typically larger in scale than the map body. The purpose of the inset map is to show more detail in the map body. For instance, it is common to see inset maps of the New England area when looking at a map of the states because there is so much detail that cannot be shown at a map scale that shows the entire United States.

To learn where the inset map is covering, an outline of the extents of the inset map may be shown on the main map body. Another use for an inset map to show other areas related to the primary map body, but at a different scale or location. A common example of this is when showing all 50 states, where Alaska and Hawaii are placed as inset maps. In this case, typically, Alaska is shown at a reduced scale and Hawaii is shown at an enlarged scale.

#### Location Map

A location map is a small ancillary map that is at a smaller scale than the map body. The purpose of the location map is to identify the location of the main map body in relation to its larger geographic context. You should include location map on your map layout with the area is unfamiliar or non-intuitive to a map reader.

### Map Scale

The next map element is map scale. The purpose of the map scale is to measure linear relationships and distances on the map. Map scale should use a unit of measure that is appropriate for the audience and its purpose. Additionally, the map scale should be subtle and small. The scale should be noticeable but not stand out too much as map readers are expected to search for the map scale when required.

A map scale is typically included on a reference map as again if you remember, a general reference map does not have any one particular purpose. That means you should prepare for the possibility that the user wishes to measure distances on the map. Some thematic maps do not expect that the map reader will be able to measure meaningful distances on the map; therefore, it is appropriate for the map scale to not be included on some thematic maps.

When choosing and designing a map scale there are a few things you must keep in mind. The first is to use round, meaningful numbers on your map scale. Decimal numbers should be avoided on a map scale unless the decimal number is a meaningful and significant interval that you expect map readers to measure. The map scale should be long enough to be useful, but not too long. There are three types of scales that you can use for a map: graphic, verbal, and representative fraction.

#### Graphic

The graphic scale uses a graphic element, typically a bar or line, to represent a certain distance on the map. The graphic scale bar is often divided at meaningful intervals to assist the map reader in measuring. The graphic scale should show meaningful round numbers and the unit of measure. A major advantage in using a graphic scale is that if the map is ever enlarged or decreased in size the graphic scale will scale accordingly and will always be correct.

**Graphic Scale**



#### Verbal

The second type of scale is the verbal scale. The verbal scale is a sentence that describes the relationship of the distance on the ground to the distance on the map. Again it is important that you relate the ratio which the earth has been reduced in meaningful and appropriate numbers and units. For instance, in the verbal scale shown here, it reads “1 inch on the map equals 20 feet on the ground”. Both units of measure are nice round numbers and are included in an appropriate measurement unit. One inch on the map translates to 20 feet of the earth. It would not be useful if you asked the map reader to measure on the map in feet when the map itself is less than 1 foot wide, and it might also be inappropriate to state the distance on the ground as millimeters, for instance, when a small distance of the map represents miles.

**Verbal Scale**

*One inch on the map*

*equals twenty feet on the ground*

#### Representative Fraction

The third type of scale is the representative fraction scale. In a representative fraction scale two numbers are written separated by a colon. The number of the left of the colon represents the distance measurement map and a number to the right of the colon represents distance measured on the ground. You can have a representative fraction scale without units as they are shown here.

That means that whatever units were used to measure on the map should be the units used to measure on the ground. In our example a representative fraction of 1 to 20 means that if I measure on the map 1 inch, it represents 20 inches on the ground. You can also have representative fractions that use units. An example of this would be 1 inch to 20 feet. One important issue to note with both the verbal and representative fraction scale is that they do not scale accordingly if the map is enlarged or reduced.

**Representative Fraction Scale**

*1:20*

### Scale Bar

When placing the scale bar on the map layout you should make sure that the scale bar is large enough to be found but small enough to be subtle. Finding the best balance requires experimentation on your map and there is no hard rule. Looking at our example you can see that the top and bottom scale bars are not appropriately sized.

The top scale bar is quite small and is not really useful to the map user when measuring longer distances. The scale on the bottom is too large and it becomes visually dominant on the map. Therefore, the map scale in the middle is considered to be at a reasonable size for this particular map.

**Scale Bar**

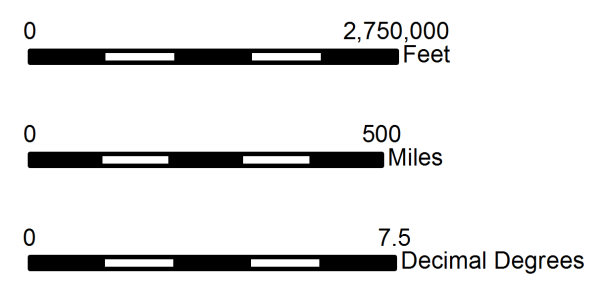


### Quality Criteria

When creating your map scale you should always make sure that they meet these three criteria. First, the scale units should be meaningful. If you are making a roadmap of Arkansas it would be appropriate to place a scale with units in miles or kilometers. A scale bar in feet would not be appropriate for that scale as people tend not to measure car trips in terms of feet. Additionally, decimal degrees would be inappropriate as it is not a useful linear distance measurement.

Second a scale unit should be appropriate to scale. That means that if you were showing a map of a small neighborhood maybe your map unit should be in feet or meters and not miles. Third, the scale interval should be rounded easy-to-use meaningful numbers. A map scale from the numbers 0 to 23.78 is not easy-to-use or meaningful to many map users. Therefore, if at all possible, you should use nice round numbers.

The third criterion related to quality is that the number divisions should divide equally into the scale range. As an example the middle scale bar is from the numbers 0 to 500 miles. There are five divisions in the scale bar and each division represents a distance of 100 miles which is a nice round, meaningful number. If you look at the top scale bar which goes from the number 0 to 2,750,000 feet, there are five divisions and each division represents 550,000 feet which may not be a very useful or meaningful number.



### Legend

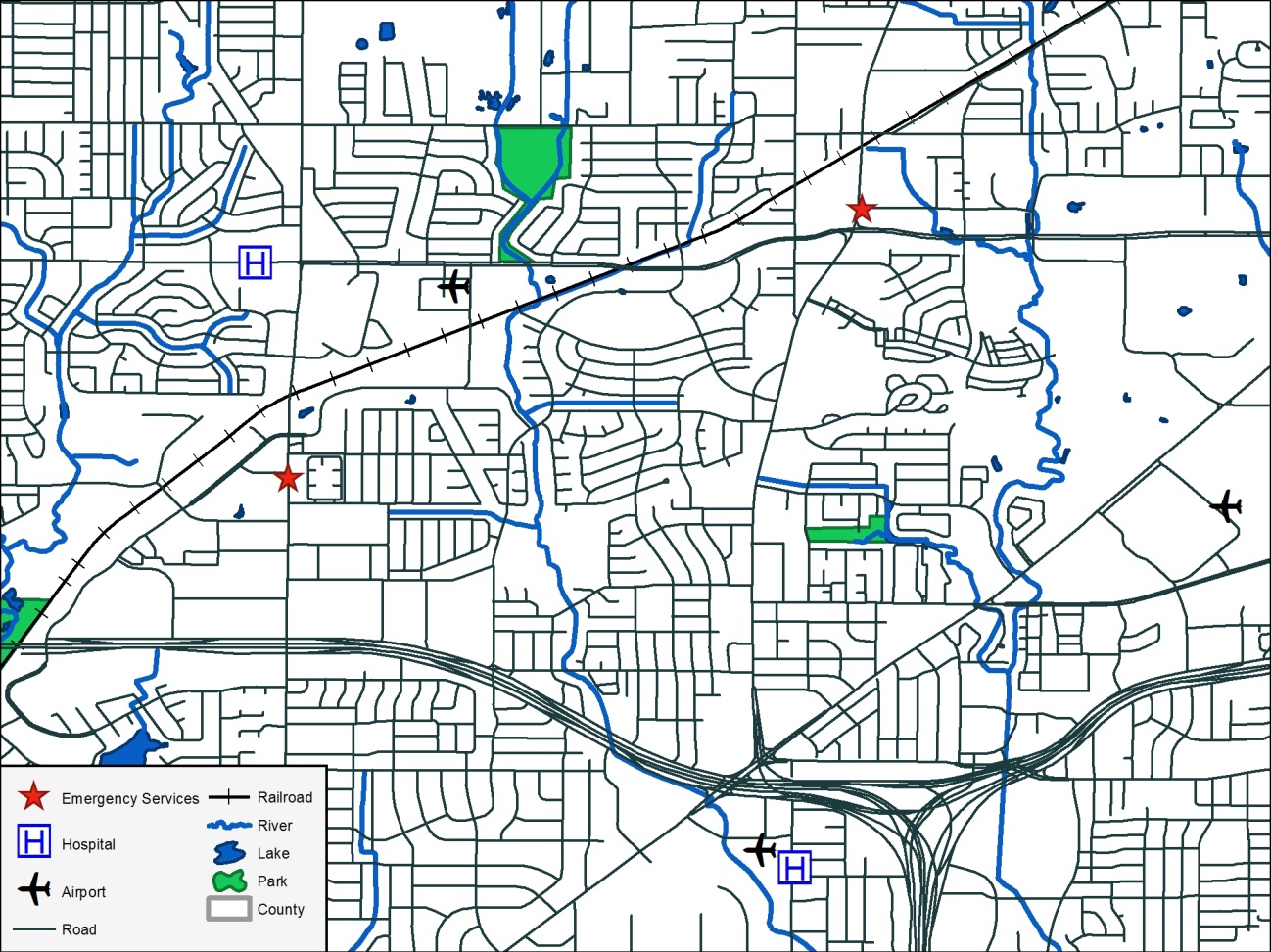
The purpose of the legend is to identify unknown or unique map features succinctly. This means that a map legend does not need to include a representation of all map features that are self-evident such as water features, or roads. However, general reference maps traditionally define all symbols.

When designing a legend you should not include the word “legend” as a map reader knows that it is a legend. Instead you could put some other meaningful text at the top the legend or no text at all if it is not needed. An exception to this is if the audience is not skilled at map reading such as young children. Symbols that represent map features on the legend should be identical to the symbols on the map. If the symbol size is on the map, the legend entry should be the size of the average symbol on the map. If you choose, polygon and line symbols can be represented by irregular shapes instead of just using squares or straight lines.

#### General Reference Map Legend

Take a look at the general reference map legend example. This map legend has two columns of information that are roughly equal in size. Each map feature is identified with a symbol that is identical to the symbol found on the map followed by the name of the map feature to the right of the symbol. On this general reference map legend common features such as lakes, parks, rivers, railroads, and roads are included, where they may not be included on thematic maps. This thematic map legend is for a graduated symbol map.

**General Reference Map**



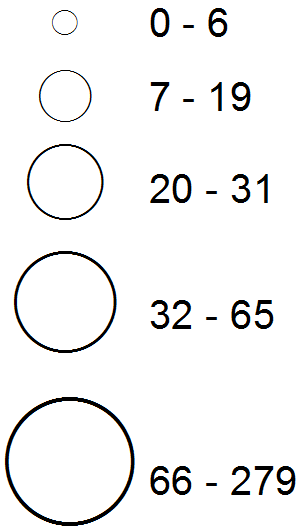
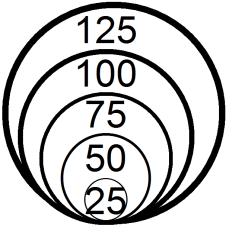
#### Graduated Symbol Map

In a graduated symbol map the symbols vary in size as related to the values they represent. Therefore it is important to show a representative size for each value, or range of values, as we wish the map reader to be able to determine the value at those locations based on the size of the circles. In the vertical legend we see the different size circles which are the same size of the circles shown on the map, followed by the value that each circle represents to the right. In the nested legend, to save room, the circles are nested inside of each other, and the labels are placed inside the appropriate circle.

**Thematic Map**

**Graduated Symbol Legends**

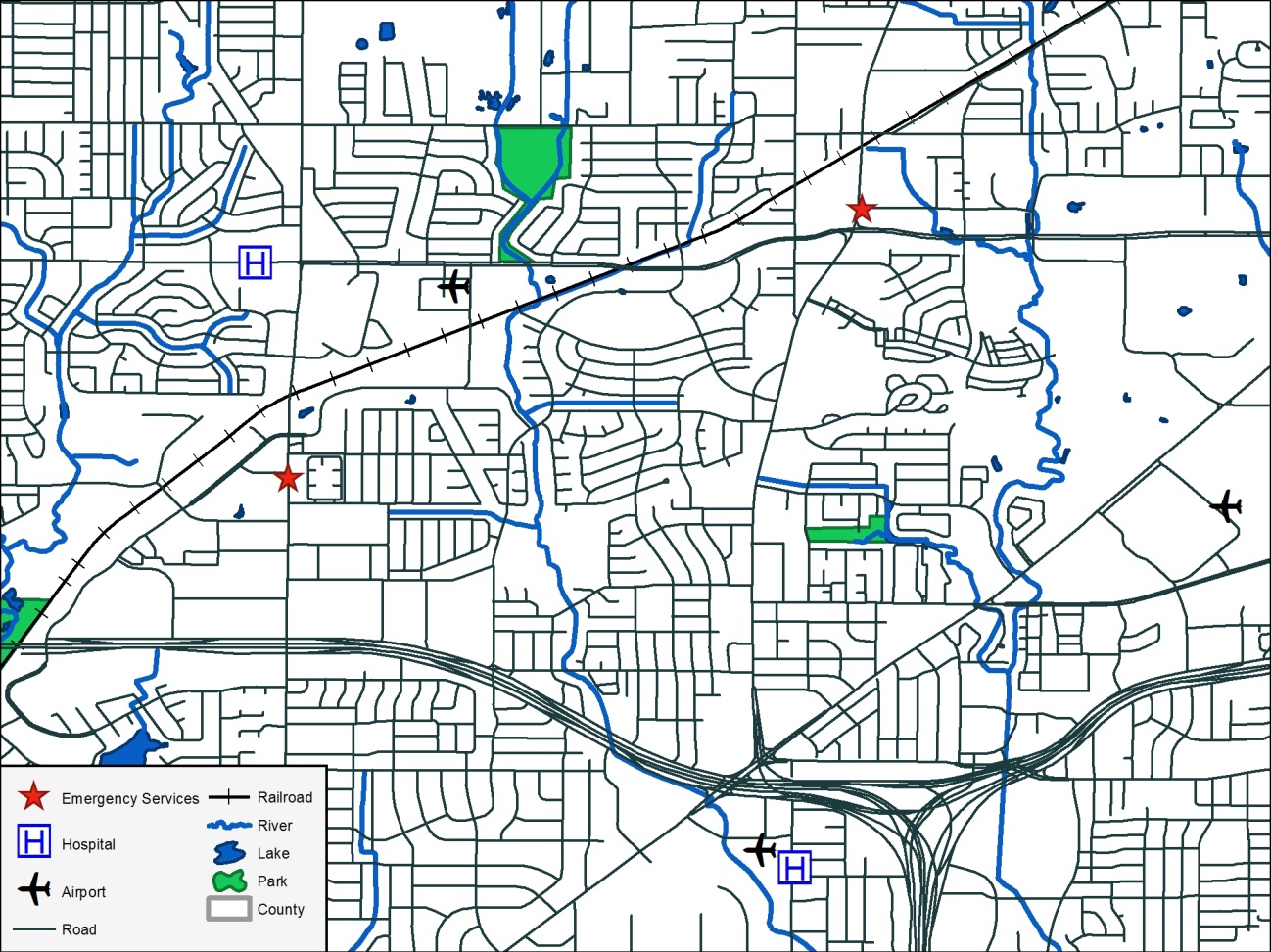
**Vertical Layout Nested Layout**

#### Legend Design

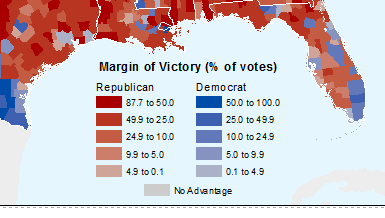
When designing a legend you should take great care to make a legend look well-structured and consistent. There are a few issues you should pay attention to while designing your legend. First, the symbol should be at the left with the description to the right. The symbol should be evenly distributed and spaced from each other and the description. The symbol should be aligned with the descriptions to the right. The symbol should also be horizontally centered.

Last, the descriptions should be left justified in line with each other. Humans are very good at seeing slight irregularities and if a map reader notices any regularity and placement or alignment in your map legend it may diminish the map reader’s trust in your map.



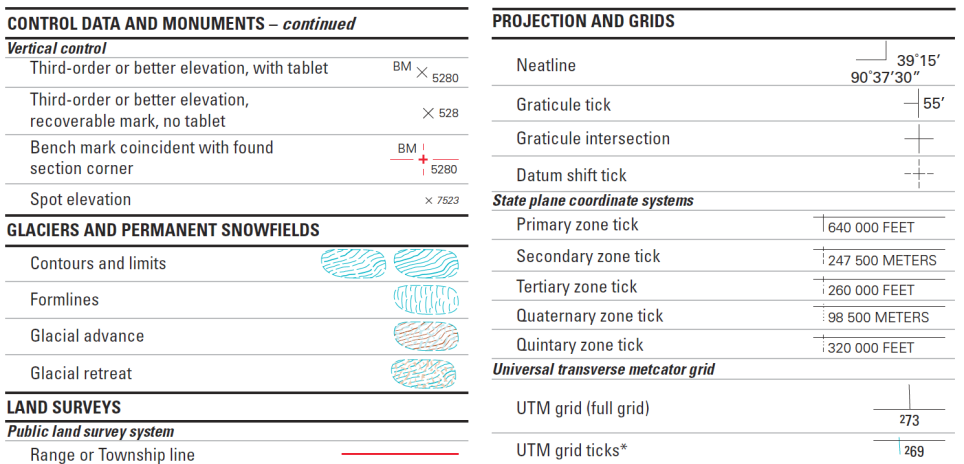
#### Columns

When designing your legend you can choose to split the legend of multiple columns so that the map legend is to be placed properly on the map or the legend entries can be split into meaningful separate columns. Any decimal numbers on your legend that are smaller than one should have a leading 0. Ranges of numbers are normally separated by a hyphen or the word “to”, however, the word “to” can help reduce confusion when there are negative numbers in the legend.



#### Headings

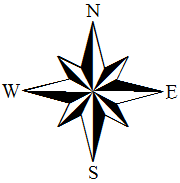
A legend may contain headings to meaningfully separate groups of legend entries. Symbols representing a single feature on the map should have a singular description and multiple features with the plural description.



### Directional Indicator

The directional indicator is typically a North arrow. The purpose of a directional indicator is to indicate a direction on a map. Map readers are used to most maps showing North as up. Unless you have a good reason to have north pointing anywhere but up you should not buck this trend. North arrows are necessary on a map when North is not at the top of the map and where map readers not familiar with the area on the map.

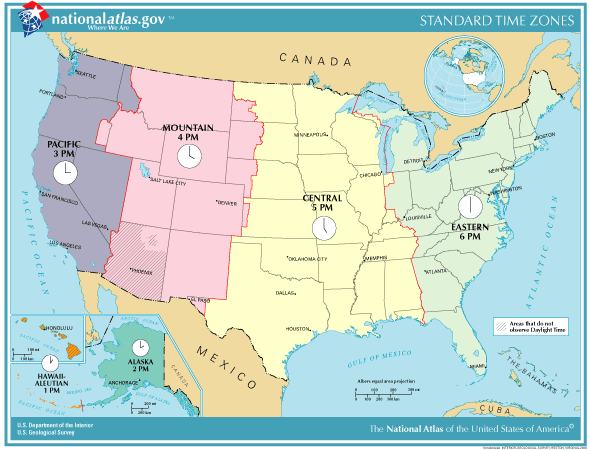
The directional arrow is often not necessary on a small scale map as many map readers are familiar with the orientation of larger landmasses or areas. The North arrow should not be made overly large and should not be placed in prominent locations. If a map reader needs to know the orientation of the map, they are expected the search to find the North arrow. A North arrow may come in many different designs and may show other directions other than North. When you choose a North arrow make sure it is not overly ornate and easy to use and understand.



### Indicator Examples

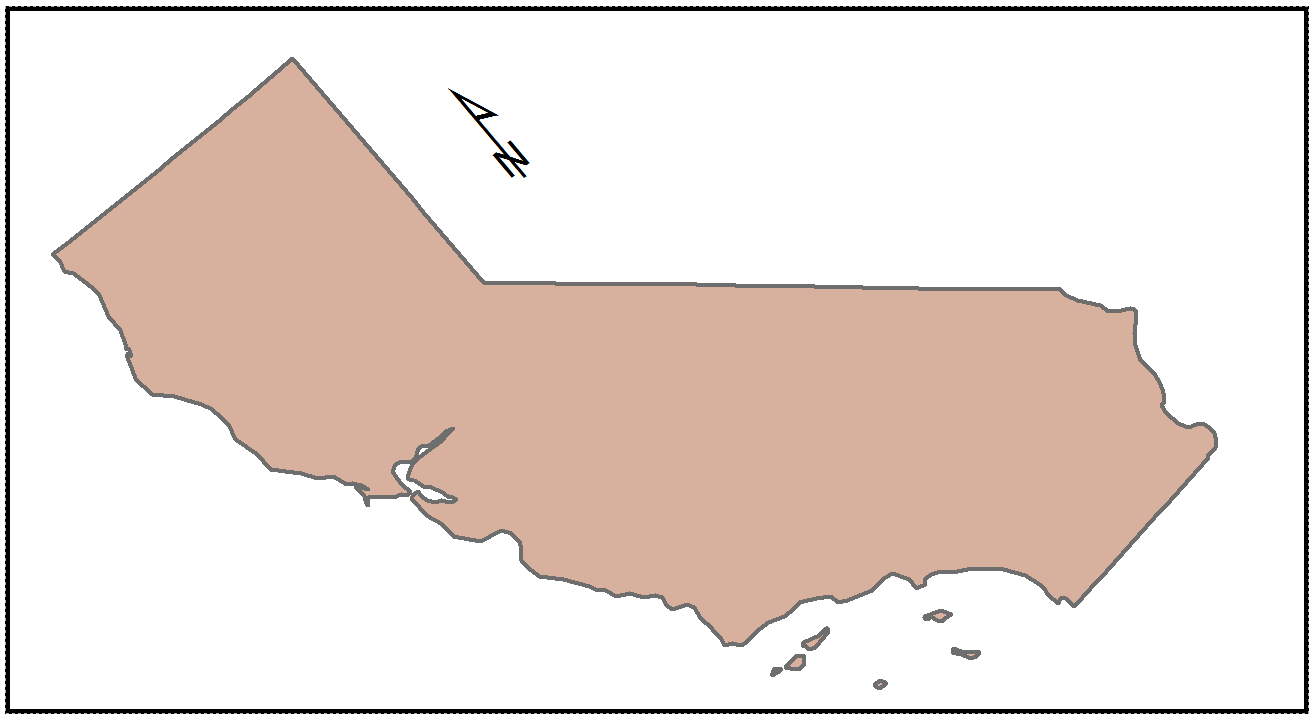
On this qualitative thematic map showing the standard Time zones of the United States of America, notice that there is no North arrow. This is an appropriate choice as most map readers should be aware that North is at the top of this map. A North arrow could have been included on this map which would be fine; however, consideration should be taken to make sure that the North arrow is not visually dominant on this map.

**Time Zones of the United States**



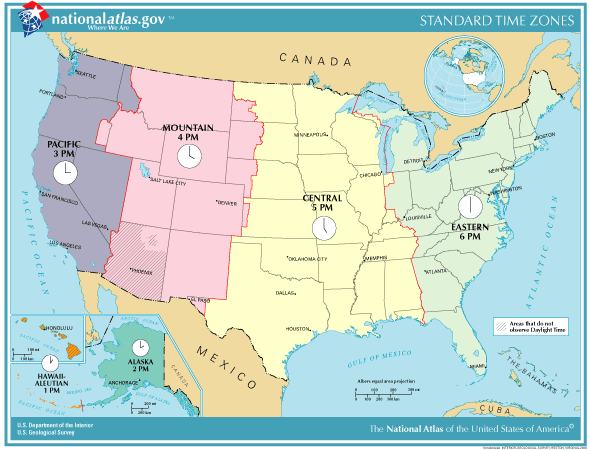
On this map of California, since North is not up, a North arrow is appropriately included on this map.

**California**



### Label

The purpose of the label map element is the communicate attribute or ancillary information to the map user. A label helps orient the user to the map and the features shown on the map. As labeling is such an important and large topic, it will not be discussed in the section, as it will be covered in depth in its own module.



### Metadata/Credits

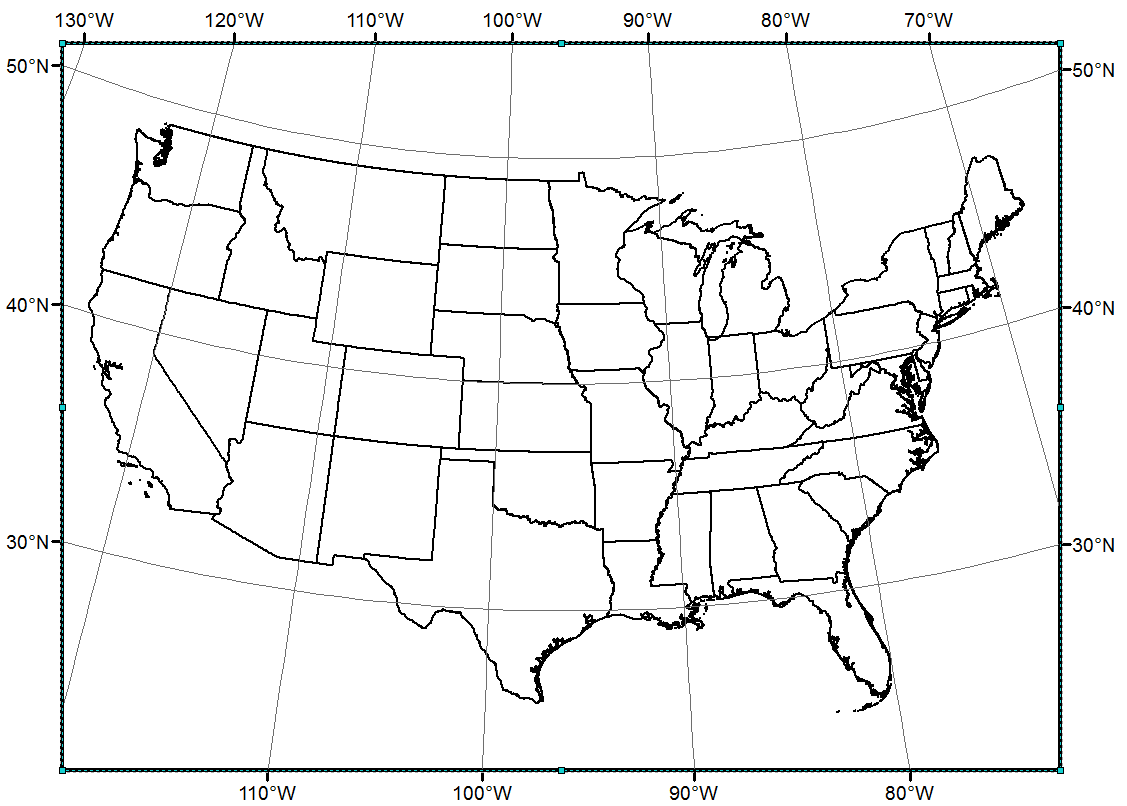
The next map element is the metadata which may be referred to as the credits. The purpose of the metadata is to cite the source of data sets used to create the map. They can also contain the map author’s information, such as their name, and contact information. Metadata should also include the date the map was created and other explanatory information about the creation of the map such as the map projection used.

Metadata is typically placed along the bottom edge of the map and deemphasized as it is typically not that important for the map reader to notice right away. The metadata should be among the smallest text on the map. If a map reader wishes is to learn more about the details of the map and its data they are expected to search the map for the metadata.

### Graticule

A graticule is a visual representation of a coordinate system or location scheme used on the map. You should include graticule on a map if the map reader will be referencing coordinate locations throughout the map.

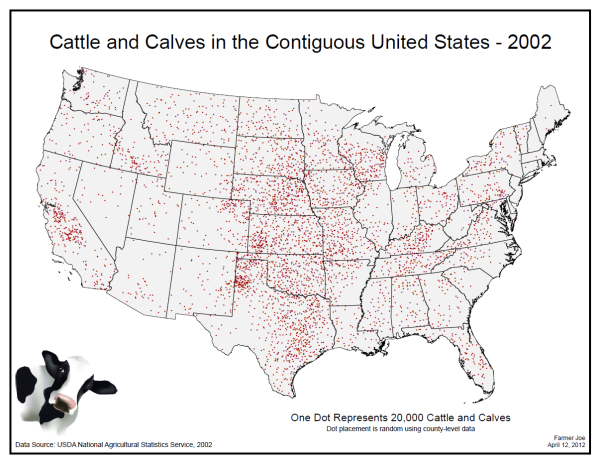
The graticule should use meaningful divisions and meaningful units. Typically the graticule is omitted from a thematic map as thematic maps wish to convey the spatial distribution of a theme and is not to be used for determining precise locations. Graticules should be reasonably dominant on the map so that it is easy for the map reader to use even when the details of the map may become dense.



### Neat Line

The neat line map element serves as a frame around the entire map or individual map elements. The purpose of a neat line is to provide a nice, clean frame for the map. It helps the users find the center of the map which is where the most important map elements should be placed. A map layout may contain multiple neat lines surrounding other map elements should the map elements need a frame helping focus on a map element.

The style of the neat line should be simple and subtle and should not be overly ornate. Looking at the example you see a single fixed neat line surrounding the entire map which allows the eye to focus on the center of the map to separate the map from the rest of the page. This is an example of a very effective neat line serving as a frame.



### Ancillary Text and Objects

The final map elements to be covered are ancillary text and ancillary objects. The term ancillary refers to an item that supports another item. In our case the ancillary information is additional information if it provides a greater understanding of the topic of the map.

Examples of ancillary items are text, pictures, sounds, movies, and graphs to name a few. A common use of ancillary information is to indicate the data manipulation that is pertinent to the interpretation of the map. Examples also include additional explanatory information or discussion of special cases or missing data.

### Placement

When considering map elements and your map layout you should carefully consider map element placement. In general you should place map elements so that they are positioned and sized in accordance with their importance.

You should also strive to reduce white space on the map. This means you should try to fill the available space with useful information and not have any large unused space on the map. If you find that you have a large amount of unused space of a map, perhaps you should bring the neat line in closer, reposition map elements, or consider a new layout altogether.

You should also balance the map layout so that map elements are evenly distributed around the map if the map does not feel to be too “heavy” on one side of the map.

## Planar and Hierarchical Organization on a Map

### Purpose of Map Composition

The purpose of the map composition is to develop an intellectual and visual structure that the map reader can use to understand the message the map author is trying to get across. A well composed map stresses the purpose of the map through the use of well selected and design map elements. A well-designed map and title directs readers’ attention to the purpose and the primary focus of the map that the author wants the map reader to notice.

A properly composed map will also coordinate base and thematic elements so that the map reader has enough geographic contexts to interpret the focus features on the map. A well-designed map will maintain cartographic conventions that make the map easily accessible and familiar to as many map readers as possible so that they can have an easy time utilizing the map. A properly composed map attains all of this, for the map reader will have the highest possible chance to get the most out of the map and properly understand what the map is trying to convey. When properly designing a map there are two important concepts to consider: the planar organization on the map, and the hierarchical organization on the map.

## Planar Organization

### Aspects of Planar Organization

There are three three aspects of planar organization as they relate to composing a map. These three aspects are balance, focus of attention, and internal organization. After discussing the two centers of an image, this part of the lesson will cover each of these three aspects in more detail.

On any image, and specifically a map, there are two centers of the image. The first center is the geometric center. The geometric center is the location that it is exactly half the height and half the width of the image. The optical center is a location that the human eye initially rests on when viewing an image. The optical center is slightly above the geometric center of the image. This is important to know for map composition as it is the first thing you want your map reader to view which is the most important feature on the map. Therefore, it is going to be important that you only place the most important features of your map in the optical center.

Geometric Center

Optical Center \*\*

### Balance

The first aspect of planar organization is balance. Defined, balance provides the visual impact of the arrangement of the map elements. There are two factors to consider related to the balance: weight and direction. Weight refers to the location, size, and shape of the map element of the map composition. Direction refers to the relative location, shape, and subject of the map elements on the map composition.

### Weight

When considering weight as related to balance on a map, the visual weight of an object depends on its location on the map composition. Elements at the center of the map composition pull less weight than those off center and off-track. An object in the upper part has more weight than in the lower part of the map. Objects on the right are considered to be heavier than the objects on the left and weight increases in proportion to the distance from the center. Because of all this, it is important that we evenly distribute the weight around the map.

Imagine if the ink on a map weighed a significant amount and you try to place the piece of paper on the tip of a pen. Ideally if you place the geometric center of the map at the tip of the pen the map would balance. If the center of the map does not have as much weight as elements placed around the edges, or one edge of the map has significantly more elements on the other edges, the map would feel off balance to the map reader. Visual weight also depends on the size of the object. Large objects are heavier than small objects. If a large object is placed off center and off-track it will have significant weight and may run the risk of throwing the entire map off balance.

Visual weight also depends on color, interest, and isolation. Related to color red is heavier than blue, white is heavier than black, and bright is heavier than dark. Related to interest, objects of intrinsic interest to the map reader will be considered heavier as they will tend to linger at that portion of the map. With isolation if an item is significantly isolated from other objects, perhaps with a large amount of white space between them, then that object will be quite heavy.

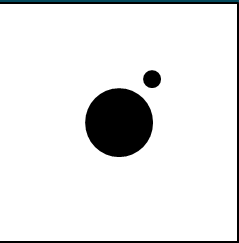
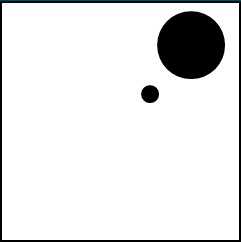
And finally, visual weight depends on shape. Regular shaped objects are heavier than irregular shaped objects. Compact shapes are heavier than those not so shaped. Therefore solid geometric objects such as circles, squares, and triangles are heavier than other geometric shapes such as stars, and +.

### Direction

The second aspect of planar organization is direction. Visual direction depends on location. The weight of an element attracts neighboring objects imparting a direction to them. Visual direction also depends on shape. Shapes of objects create axes that impart directional forces into opposing directions. Visual direction depends on subject matter. Objects possessing intrinsic directional forces impart visual direction on other elements. Consider some examples of direction based on location, shape, and subject matter.

In these direction examples we see two circles, a large black circle and a small black circle. If we consider location and its effect on direction we can see that in the example on the right where the large circle is in the upper right-hand corner the smaller circle is the lower left of the large circle, that figure seems to have a direction pointing in the top right-hand corner. This is because our eyes naturally started the visual center of the image and then it gets pulled to the small circle and finally to the large circle which imparts a direction to us.

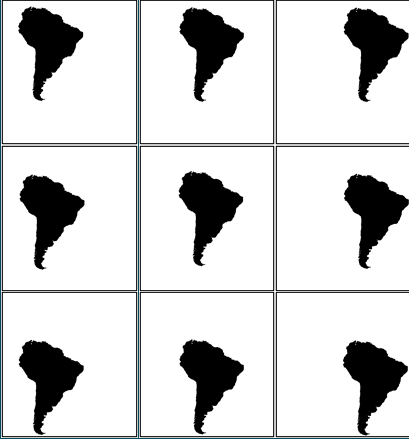
For the example on the left, since a large circle is in the center of the image and the small circle is close but does not have as much weight, this image does not seem to have an overarching direction as our eyes do not wander too far from the center. It would consider shape of objects, in these cases, the circle does not have any intrinsic directional force; therefore, we are relying on location to determine direction. Had the circles been replaced with triangles, or lines, those shapes have axes that can impart a directional force.

### White Balance

Also related to balance is the use of white space on the map. White space refers to a blank space on the map that does not have an element placed at the location. In general, white space should be minimized in a map; however, white space can be useful to visually separate or group elements. Excessive amounts of white space can also make the map visually unbalanced.

Consider the white space around South America on these nine images. The center image has South America centered on the geometric and visual center. Because of this, even though there is as much white space on the images there and the images around it, South America interrupts the whitespace and allows for the image to have doubts.

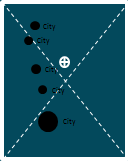


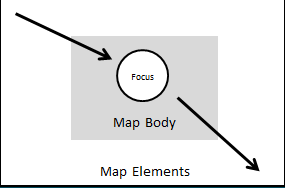
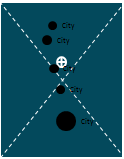
If you look at the other eight images where South America is placed along the edges, significant amounts of white space are exposed and each individual image seems to be visually off-balanced which is not desirable. In order to counteract all the whitespace there are two options: reduce the size of the neat line to bring it in tighter around South America, or add map elements to fill in the whitespace.

### Focus of Attention

The second aspect of planar organization is the focus of attention of the map reader. When a map reader first looks at a map they follow a path from the upper left corner to lower right corner passing through the optical center. Because of this, it is important to put the focus of the map at around the optical center and not skewed to one side of the optical center. If you look at the two examples on the right, the example on the top has a location of the cities well to the left of the optical center.

As a user focuses on the optical center, the important map features are to the map reader’s periphery and may be overlooked. In the example on the bottom the locations of the cities are placed very close to the optical center and commanded the attention of the reader.



### Internal Organization

The third and final aspect of planar organization is the internal organization of the map. You should strive to have order on all of your maps. An ordered map has an overall structure that defines place and function of every detail on the map. Without strong internal organization a map element may look out of place and awkward. We should strive for creating a structure of all elements, or a place for everything and everything in its place. We will now discuss how to create a strong, structured internal organization.

Contrast is the first method that we can use to assist in defining an internal organization on our map. Contrast leads to differentiation of objects in our map. Contrast can help distinguish between important and unimportant parts of a map as well. Contrast can be achieved through line, texture, value, detail, and color.

There are two types of line contrast: line character and line weight.

#### Line Character

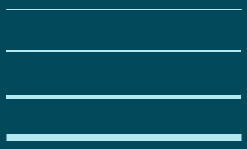
Line character is the nature and pattern of the line. By varying the nature of the line, we can differentiate the lines from each other which will allow us to create contrast. Examples of ways which we can change the nature of the line is to dot the line, or dash-dot the line, or dash the line, or some other variation thereof.

**The Nature of the Line**



#### Line Weight

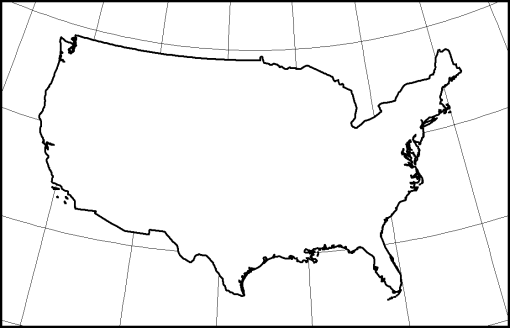
We can also modify the line weight. Users can see half a point difference in line thickness pretty easily. Maps with multiple line thicknesses focus attention, are lively, and provide structure to the map. Users can see 0.5 point difference. The focal features of the map can have a thick line weight which will allow the user to differentiate from the background features.



### Map Examples

These images are two examples of maps: one with good structure, and one with poor structure.

**Poor Structure Good Structure**

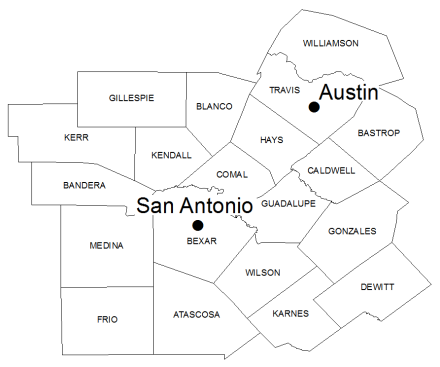
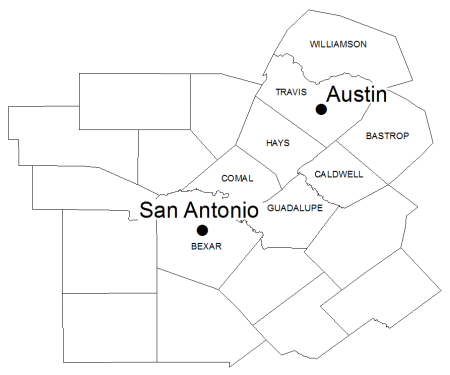
Things that change between these two maps are the line thickness of the outline of the United States of America. Basically by increasing the line weight of the national outline, the map now has a strong visual contrast between the focus features in the background features and thus a good structure.

We can also modify texture to achieve contrast. Texture contrast is typically used more with grayscale mapping to show differences whereas on a color map texture is used less because color is typically a more attractive option. One thing to be careful about when considering use of texture to show contrast is that texture can be visually irritating to the eye and may confuse the readers.

We can also use value to create contrast. Brighter areas on map tend to attract the eye more than dark areas; therefore, brighter areas are considered to be more interesting and are placed towards the top of the visual hierarchy.

Another method to show contrast is to vary the amount of detail on the map. Reader’s eyes are naturally attracted areas of a map of the most amount of detail. Therefore, we want the reader to focus on an area of the map which can be done when you increase the amount of detail and remove detail in unimportant areas.

Here is an example of how the variation of detail on a map provides a visual hierarchy. On the left all counties surrounding San Antonio and Austin are labeled which does not allow the eye to focus in any one particular area. In the map of the right only the counties that are between San Antonio and Austin and around Austin are labeled which allows our eyes to focus on the northeast corner of the map and the other counties that are not labeled to fall into the background and be considered less important for the purposes of this map.

Finally, we can vary the color of features to create contrast. By changing the color, or hue, of the feature, it allows us to differentiate between the features and kinds of features. If we have multiple features that are of the same kind, but have a different value, you can use a single hue, but change the value for that hue to represent different quantities.

## Hierarchical Organization

### Visual Hierarchy

Visual hierarchy is the intellectual plan for the map and the eventual graphic solution that satisfies the plan. In this section you will learn about strategies for planning and executing a visual hierarchy format.

### Customary Positions in Hierarchy

When planning the hierarchy for your map design, there are some customary positions we may want to consider adopting. Assume that a map has five visual levels, visual level one being at the top of the visual hierarchy and immediately viewable and visual level five being deemphasized, something map user may have to search for briefly.

On visual level one, first and foremost, the map reader should immediately see the thematic symbols that create the map. Next, the map reader should easily see the title, legend, other symbols on a map, and labels on the map. On level two of a visual hierarchy, the user should become aware of the base map which may include land areas, and water features. In level three of the visual hierarchy, the map user should see the scale, graticule, inset map, and North arrow.

These items are important to the overall map layout; however, they are considered aids for the map that the map reader will rely on only when they need them so they do not need to be readily apparent. On visual level four we see the metadata which is typically deemphasized, the smallest text on a map, and which are is placed along the bottom edge. Finally, on level five is the neat line. With the neat line it is extremely important to help focus the reader to the center of the map. The neat line itself should not draw any attention.

|  |  |
| --- | --- |
| **Visual Level** | **Object** |
| **1** | **Thematic Symbols** |
| **1** | **Title, legend, symbols, and labels** |
| 2 | Base map – land areas: political and physical |
| 2 | Base map – water features |
| 3 | Scale, graticule, inset map, north arrow |
| 4 | Metadata |
| 5 | Neatline |

### Symbols

It is important to note that symbols on the thematic map are almost always at the top rank in the visual hierarchy. Even the enumeration units in which the symbols’ data are aggregated to should take a lower rank than the thematic symbols themselves.

### Figures and Grounds

An important concept in visual hierarchy is the concept of figures and grounds. When we design a map we design elements on the map into two categories: category one is for the figures of the map and category two is for the grounds. Figures are items that have “thing” qualities and are important to the map.

Figures should have solid lines and bright colors to attract attention. Grounds should be formless and lost in perception when the map reader is viewing the figures. Grounds are typically considered the background or supporting figures on the map. Ground should have gray or pastel colors and weaker lines. Grounds are considered to be unbroken behind the figure so there is no need to make the figure semitransparent so the map reader can see the grounds unless the ground is significantly obscured by the figures.

### Figure and Ground example

In this example there is a strong figure, ground relationship. The United States has a strong outline that allows the eye to focus on the country. The graticule is considered to be the ground, has weaker lines, and is interrupted by the United States polygon, but the map reader can assume that the graticule continues uninterrupted by the figure.



### How to Achieve Visual Hierarchy

To achieve a visual hierarchy you can employ perceptual grouping. In a perceptual group the viewer spontaneously combines elements that share similar properties. Elements can be grouped by shape or by size.

In this example you will most likely consider the group of the three triangles together and the three circles together as two separate things.

**Grouping by Shape**



The large circles will naturally be grouped together as will the medium and small circles since they all share the same size properties.

**Grouping by Size**



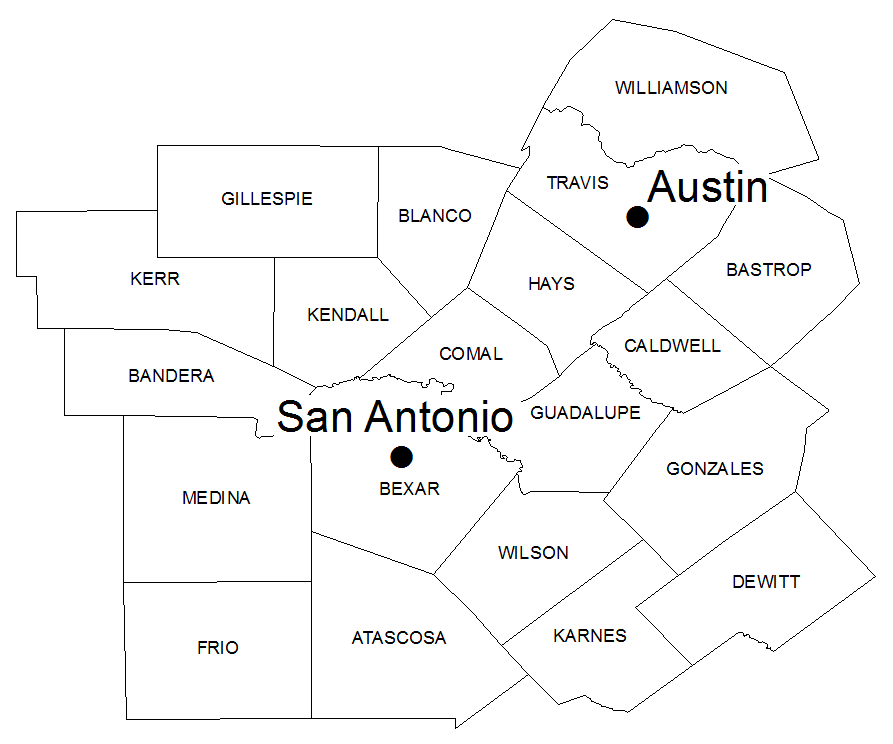
In addition to perceptual grouping by shape or size, users tend to group elements together based on proximity. For example, without explicitly stating so, they saw the proximity of the circles to each other, three groups of circles are perceived here.

**Grouping by Proximity**



### Figure Closure

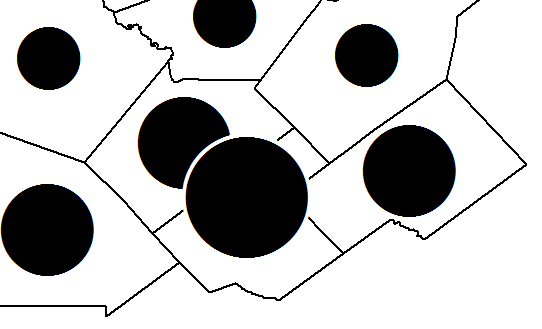
Another concept related to visual hierarchy is figure closure. Figure closure is the tendency for the viewer to complete unfinished objects or objects that may be obscured by other elements. For example, on the left we have a portion of the letter F, but we naturally will complete the outline of the letter F even though it is not drawn. On the right, the San Antonio label obscures multiple segments of outlines for multiple counties. We will assume that the county outlines exist beneath the label and will consider those items to be closed.

****

### Strong Edges

Now consider the edge of objects and how they relate to visual hierarchy. Crisp edges help to define an object as a figure and visually set it apart from other objects. Reducing the edge definition of an object weakens it. Edges result from a contrast of brightness, texture, or line type.

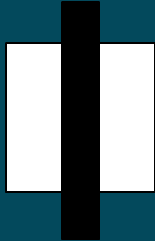
In this example, the counties are well-defined as they have strong solid edges. The circles are also well-defined as they have crisp edges. Where the two circles overlap in the center, the larger circle has been given a white edge so that it is visually distinct from the circle and county outlines that lie underneath.

****

### Interposition

The next topic in visual hierarchy is interposition. Interposition is the interrupting of the edge of one object with another object that causes the object to appear on top and closer to the viewer. If you do overlap two objects, be careful to not overlap the two objects too much especially with quantitative data. The rule of thumb is that there should be no more than 1/3 overlap between the objects.

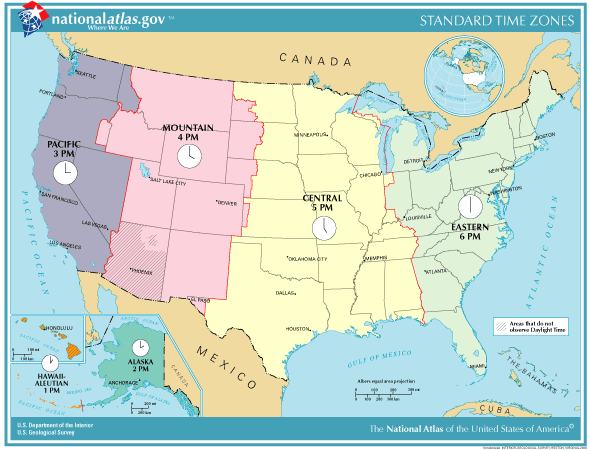
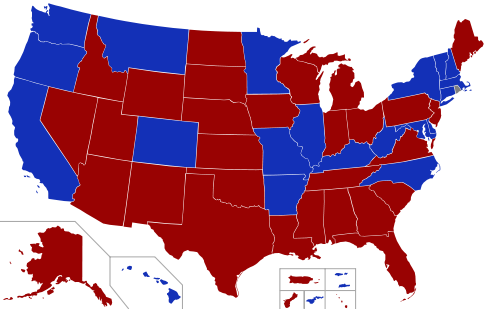
To illustrate this point consider these two interposition examples. On the left, the northernmost square is overlapping the southernmost square. As the northernmost square is complete and the southernmost square is being interrupted, we visually perceive the northernmost square as closer to us in the southernmost square as further away. On the example on the right, the black bar is obscuring the white box. Because of this, the black bars perceived to be closer to us.

### Water

Water plays an important part in establishing a visual hierarchy. Water provides significant geographic clues as to where landmasses begin and end and also often serve to be the base for all other objects in the map. On thematic maps it is commonplace to leave the water off of the map. We shall include water on a map if it is important to the thematic variable. This also goes for other general reference features such as roads, locations of towns, or locations of parks for example.

Here we see a thematic map. The map on the left is the Standard Time Zones map which includes water. The waters considered a ground on this map and serves to punctuate the location of landmasses. The map on the right shows election results by state but without water. Water is not included on this map because it is not an important indicator for election results.

### Example Map Critique

This is a map that may be considered typical for someone who is new at making maps. Some of the undesirable characteristics of the map result from the map author choosing not to alter the default behavior of the mapping software. Other issues with the map are probably due to the map author not knowing any better. In either case look at the map and determine how the map design could be improved. As the title is often the first thing a map user reads, and provides a concise description of the map, you can examine that first.

### Map Title

The map is simply current entitled population density. While at its core the map is about population density, the title is still fairly vague. It does not answer the question of when the population was that dense, and why we are only seeing the lower 48 states of United States. Why were Alaska and Hawaii left off the map? Additionally the title is slightly off center. It would be much better if the title was centered on the top of the page.

### North Arrow

Now take a look at the North arrow. The North Arrow is way too large for this map. Remember that items should be sized relative to their importance. The North arrow is not so important for this map that it needs to stand out that much. Additionally, assuming that the audience for this map would be Americans, the North arrow might not even be necessary since Americans are used to seeing United States, and having north be up on a map, making the north arrow redundant. If the North arrow is to be left on this map, it should be made considerably smaller, and placed out-of-the-way.

### Metadata

If you look right below the North arrow you have the metadata showing the map author and the data source. There are two problems here. One, the text is too large. Map readers will look for the metadata if they want to see it, but it should not jump out this much. The font size should be reduced for the metadata. For the data source, ‘ESRI’ is not very descriptive. It doesn’t tell us what year the data set was created, and a majority of map users would not be able to track down the original data source simply by ‘ESRI’.

### Scale Bars

The next elements to consider are the scale bars. The scale bars have multiple problems. First, one of the scale bars represents the distance in decimal degrees. Decimal degrees are not a useful unit to measure distances on a map. Second the divisions and end points of the scale bars are not in meaningful, easy-to-use numbers. Instead of 0 to 32, why not 0 to 30? Instead of 0 to 2,840, why not 0 to 3,000? Using round numbers on your scale bars, make it easy for the map reader to scale distances. Third the scale bars are too wide. The scale bars could easily be one third their width and be just as useful, and not so visually dominate the map. Remember the scale bars in this map are not that important and should be deemphasized so as to not attract the eye from the map body. The last problem is that the scale bars are too tall. Again, having scale bars that large detract from the map too much. The scale bars are emphasized too much.

### Legend

As a matter of style, you should not title the legend with the word legend. Map readers know that this is the legend, and you could use that space better by replacing it with a descriptive title for the legend. One exception would be for, say, elementary school children who are not familiar with the components of a map yet and therefore need this instruction about what a legend is and looks like. Next the description of the population density data is not well formed and provides the column name from the attribute table which is not useful to the map reader. Instead of the word counties, and POP07\_SQMI, a more appropriate legend title would be ‘Persons per square mile’. Looking at the numbers to the right of each patch in the legend, it is not consistent with the number of decimal places.

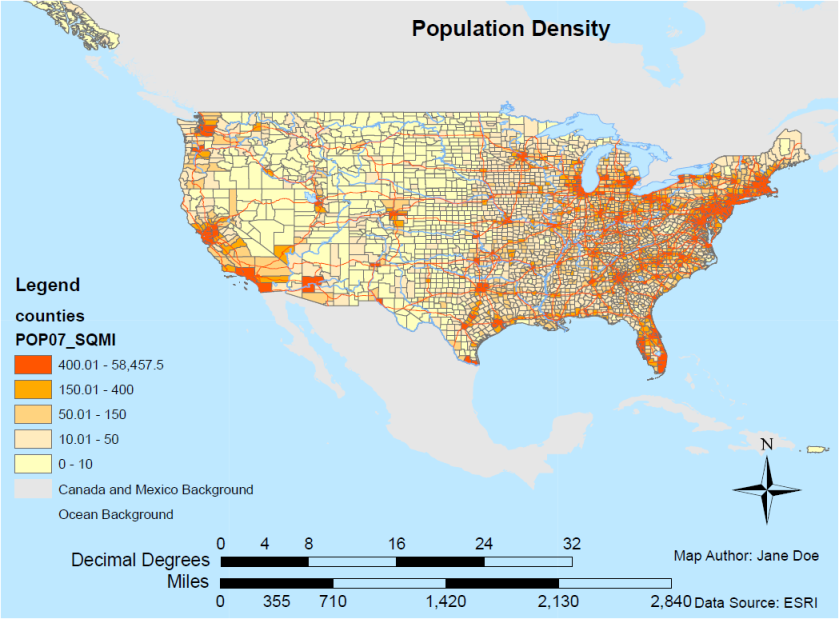
For instance, the bottom entry has no decimal places and is simply the entry 0 – 10. The next three entries above it have two decimal places for the lower number and no decimal places for the higher number, while the top entry has two decimal places for the lower number, and one decimal place for the higher number. Since we are talking about persons, we should round to the nearest whole person. The bottom two entries referring to Canada and Mexico background, and the ocean background, are not required for this legend, as the water and surrounding countries features aren’t unfamiliar for the map reader, and therefore, do not need to be placed on the legend. Additionally, the symbol for the ocean background on the legend blends in with the actual ocean background behind it, therefore, making it look like there is no legend entry for the ocean background.

### Overall Map

Now you can look at the map itself. The United States is slightly off center and could be made quite a bit larger to fill the page. There is quite a bit of white space above and below the main feature of the map, which is considered wasteful. Additionally only the Southern tail of Alaska is shown on the map which looks sloppy and makes the map reader wonder why only a portion of Alaska was shown. By enlarging the contiguous United States the tail of Alaska would not be shown.

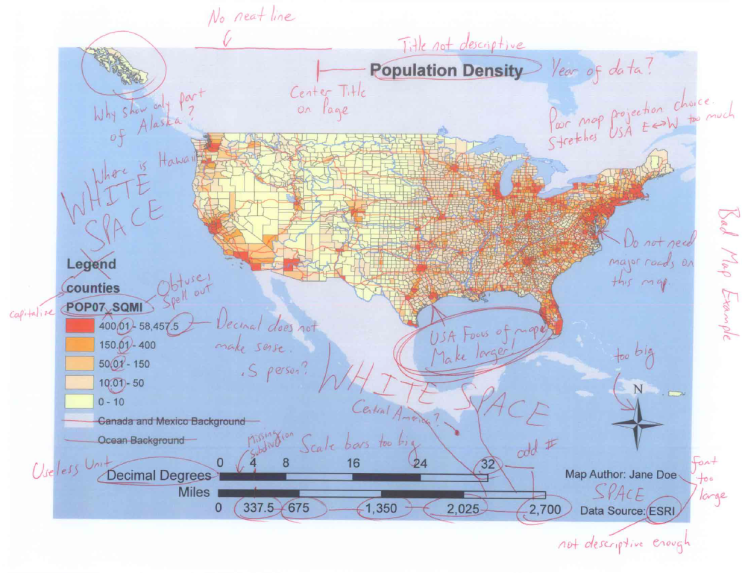
If we consider the features included on the map, we have county outlines, roads, and rivers. The question becomes: “Are roads and rivers really necessary to show a map of population density?” Perhaps the roads, and/or rivers should be left off the map so that it is less cluttered and simpler to read. Additionally, the color of the roads is very close to the color of the most densely populated area, which makes it hard to see exactly what is going on in the counties underneath the roads, and smaller counties may be completely covered by road lines, therefore making it look like a county is densely populated when it is not. Moving to the map projection, it’s clear that this map is not any particular projection based on the flatness of the northern boundary line of the United States.

As the data that we are showing is based off of population per square mile, an equal area projection should be applied to this map as relative size is important when determining how dense counties are. Another thing to note about the map is that although Canada and Mexico are included, South America is not. If you’re going to include surrounding countries, you need to include all of the surrounding countries that my show up on the map. Lastly, there is no neat line surrounding the map. In order to provide a nice frame for the map, and to have it stand out against its surroundings, a neat line should be included.



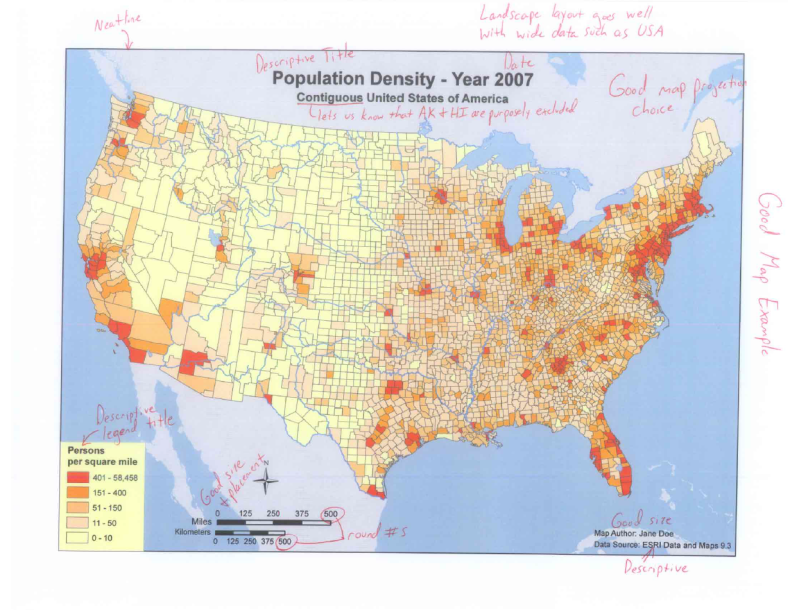
### Issues Highlighted

Here is the same map with all the issues highlighted. As you can see what may initially look like an ‘OK’ map really has many problems.



### Redesigned Map

This is a redesign of the map.



This redesign took about five minutes of time, made the map significantly more attractive, and useful. Consider the following updates that were made.

* Note that the title is much more descriptive. It states that it is the population density for the year 2007, and specifically notes that it is for the contiguous United States of America which lets the map reader know that Alaska and Hawaii are purposely excluded from the map.
* The projection is changed to an equal area projection that allows for the map reader to make proper areal comparisons between counties.
* The roads have also been taken off the map which allows for the counties to be the main focus of the map and not be obscured.
* The scale bars have been greatly reduced in size and are using round numbers in meaningful units.
* The North arrow has been greatly reduced in size and placed in a better location.
* The metadata is more descriptive and is a good size.
* The legend has been reduced in size has been given a descriptive title, and the numbers are now consistent with respect to the number of decimal places and included around the map is a nice frame.

Even with this redesign one could argue there are still a few issues. For instance, the metadata is placed on top of some background data which makes it a little difficult to read. Additionally, the scale bars are half on and half off of Mexico and rivers are still included on the map, which might be a feature that is not required. However with just a little extra work and careful consideration the map has gone from a very poorly designed map that was hard to read, not pleasing to the eye, to a well-designed map that is much easier to read and is pleasing to the eye. Remember, map design is an iterative process, so do not be afraid to radically redesign your map a few times to see how you might improve it. Also show your map to a friend, family member, or colleague and get feedback. Even though they may not be trained in cartography people can often easily identify an ugly map, and might provide an important perspective on your map design.

## **Ethics in Cartography**

This section focuses briefly on ethics and cartography. There are 10 items in the cartographer’s code of ethics.

The recommended text to cover the topic of “Ethics in Cartography” is as follows:

 Dent, Torguson, and Hodler.  “Cartography: Thematic Map Design” 6th Ed.    
          McGraw-Hill, New York.  2009.  Pages 19-20.

## SUMMARY

## This lesson focused on map elements, design principles and the cartographic process. In this lesson you learned about why one would want to create a map and for what purpose. Planar and hierarchical organization were outlined which are important concepts that help to guide how one would determine the organization of a map. The lesson concluded with an example map critique which highlights issues and identifies solutions to make the map more attractive and useful.

## ASSIGNMENTS

1. Quiz: Map Elements and Design Principles
2. Lab: Layouts and Figure-to-Ground Relationships