**Lab 1. Map Design & Layout**

## Introduction

This lab introduces some basic map composition concepts and provides practice using ArcMap tools that can make the map design process easier. The material was adapted from Cynthia Brewer’s Cartographic Design for ArcGIS course.

Copy the Lab1 data folder to your flash drive. Note when you open the maps that they are all set to store relative pathnames. This is a practice you should follow to make your life easier – you will not disconnect your map from the data simply by changing drives (e.g., plugging your flash drive into drive E on a lab computer and drive F on your home computer). When setting up a new map, choose Map Document Properties from the File menu, and make sure that the store relative pathnames box is checked.

**Deliverables**

Your lab document should be typed, well organized, and submitted according to the “How To” guidelines provided in the course syllabus (one document with all the maps).

**Part I. Work with Visual Hierarchy**

**a.** Open **Pennsylvania.mxd**

* This map contains five data frames. Each frame displays a different thematic topic: relief and physiographic regions, coal fields, urban areas, major watersheds, and Pennsylvania's location within the United States.

***Data frames*** are used to organize multiple maps on a single page. Each data frame can have unique properties. A data frame can be repositioned and resized, the geographic extent of a data frame can be changed, and each can have a different coordinate system.

**b. Change the layout's visual hierarchy**

***Visual hierarchy:*** *[map design] the presentation of features on a map in a way that implies relative importance, usually achieved with visual contrast (GIS Dictionary)*

* Currently, the data frame showing relief and physiographic regions is the highest element in the map's visual hierarchy.
* Your task is to create a map focusing on Pennsylvania coal fields.
* Right-click the Coal Fields data frame and choose Activate.
* On the map, the Coal Fields data frame now has dashed lines around it, indicating that it is the active data frame. Notice that the data frame name is bold in the table of contents (TOC).
* On the map, click the Coal Fields data frame so that you see selection handles around the frame. Drag one of the corner selection handles to enlarge the Coal Fields data frame so that it is the largest data frame on the layout.
* Move the Coal Fields data frame to a prominent position on the layout. You will need to reposition and resize the other data frames as well to suit the new visual hierarchy, but you will do this in the next step.
* Zoom in to the Coal Fields data frame using the Layout Zoom tool.
* Use the Tools toolbar Pan and Zoom buttons to adjust the data frame's map scale and extent so that all the Pennsylvania coals fields are visible in the frame.
* Since you changed the extent of the data, you need to update the legend associated with the Coal Fields data frame. Click the legend label for the Coal layer so that it becomes editable (the legend label is next to the symbol in the TOC). Change the label text to “Coal fields” and note that the legend updates on the map. Move the Coal Fields legend so that it can be clearly seen inside the Coal Fields data frame.

**c. Work with graphic elements**

There are several types of ***graphic elements*** on this map, including the north arrow, legends, and text. You control the appearance of graphic elements through their properties.

* Zoom to the extent of the whole layout page (on Layout toolbar, Zoom Whole Page) and select the map title. Right-click on the title and go to Properties.
* Change the title to reflect the new map theme (emphasis on Coal Fields).
* Use the buttons on the Draw toolbar to change the font, size, style, and color of the title. You can also change the location of the title.

On any map layout with more than a few elements, it can be helpful to use ***guides*** to help place and align those map elements.

* Be sure that the rulers are showing in Layout View (if not, right-click in the white space outside your data frames and choose rulers).
* Click on the location on the ruler where you want to create a guide. Clicking on the vertical ruler creates horizontal guides and vice versa. Guides can be easily moved after they are created. As a default setting, map elements will snap to guides. If you wish to turn off snapping, right-click in the white space outside your data frames and choose guides. To delete a guide, right-click on the arrow on the ruler and choose clear guides.
* Use guides to create margins for your map that are ½” from the each side of the page (top, bottom, left & right).
* Now take the time to rearrange and resize the other data frames so they all fit neatly on the page. You can adjust the map extent or scale of these data frames so that your map makes sense. You will also need to reposition the legends, text, and north arrow to fit the new layout. Remember, double-clicking any element opens a Properties dialog for that element. In the Properties dialog, you will have various options for controlling the element's appearance.
* If you feel that any of the elements don't belong on the new layout, you may drag them off the page (but don't delete any elements). All data frames should be kept on the map layout.
* Make sure that as you re-arrange the elements on your map that Coal Fields remains at the top of the hierarchy, and that the page layout is well balanced.

1. ***Select Export Map under the File menu in ArcMap. For file type, select jpeg, and for resolution select 200 dpi. Give the map a recognizable name. After you have exported the map, create a lab document in Word and insert the map jpeg into your document.***

* To make sure map elements align nicely, you can use guides. To create a guide, click on a ruler (if there are no rulers on your map, right click in the white space of your map outside any data frames and choose rulers). Clicking on the horizontal ruler will create a vertical guide and vice versa.

The default setting is to snap to guides and you usually want this if you are using guides. Rght click in the white space of your map outside any data frames and choose guides to disable snapping. Guides can be easily moved (place cursor over the arrow on the ruler that indicates the guide location) and deleted (right click the arrow).

**d. Create a layout emphasizing the Susquehanna watershed**

* In this step, you will rearrange the map so that the Major Watersheds data frame is highest in the visual hierarchy.
* Resize and arrange the Major Watersheds data frame so that it is the most prominent element on the page.
* For the Major Watersheds data frame, modify the appearance of the data frame neatline. Right-click the Major Watersheds data frame and choose Properties then Frame. Check out the options for the border, background and drop shadow. You can adjust the size of the border, background & shadow using the offsets and rounding. Experiment with these options until you settle on a neatline that works well in the map design & layout (don’t go overboard with decorations – it should be unified with the rest of the map).
* Zoom in to the Major Watersheds data frame using the Layout Zoom tool.
* In the TOC, expand Major Watersheds to see its layers. Right-click the Watershed layer and choose Properties then the Labels tab. Check the box next to "Label features in this layer" (make sure the Label Field, chosen is DRAINAGE).
* Click the Symbol button (under Text Symbol), and in the Symbol Selector, choose Physical Region in the list of symbols. Change the color to a medium gray and make the text bold.
* Adjust the map scale and extent so that the Susquehanna watershed is centered in the data frame.
* Add a neatline for the whole map to enclose the different elements of the map. From the Insert menu, choose Neatline, then the option to "Place inside margins." Customize the neatline to be unobtrusive and unified.
* Reposition and resize the other data frames so that they all fit neatly on the page (think about sight lines!).
* Change the map title to reflect the main theme, and reposition the title if desired. Reposition the legends, text, and north arrow to suit the new layout. Change the properties of the elements as desired. Ensure a well-balanced page layout.

1. ***Export the map and paste it in your lab document.***

**Part II. Work with Decorative Design**

**a.** Open **Ireland.mxd**

This map of Irish archaeological sites needs some work. The designer has used lots of “map crap” that obscures the purpose of the map. These decorations are properties of the data frame, the layers, and the graphic elements.

**b. Change background colors**

* Start by creating guides .2” from top, bottom, left & right of page. This is the print margin and will help you keep all elements within the print frame.
* In this map, the ocean is represented by a graphic rectangle positioned behind the other elements and frames. A gradient has been applied to the rectangle's fill color, which calls too much attention to this background element.
* Double-click in an empty area in the upper left corner of the map to select the rectangle representing the ocean. In the Properties dialog, click the Change Symbol button. In the Symbol Selector's list of symbols, click the Blue symbol in the top row.
* Background colors can also be a property of the data frame. In the TOC, right-click the Hill of Tara data frame and choose Properties then the Frame tab. Data frames can have a border, background color, and drop shadow. In this case, you will change the background color to light blue.
* Continuing to change the Hill of Tara data frame properties - Under Background, click the dropdown arrow and choose Lt Blue in the list. Under Border, click the dropdown arrow and choose 1.5 Point. Change the border color to white. If you see a warning message about the coordinate system, click Yes.
* Change the background color and border of the Aran Islands data frame to match Hill of Tara.

**c. Work with scale bars**

* This map displays the three regions shown at different scales. The designer created three scale bars that are stylistically different. ArcMap provides many different templates for scale bars. These are found in the Properties dialog for that map element (right-click on the scale bar and go to Properties).

* For this map, the decorative scale bars are too elaborate and different from one another. Double-click the scale bar under the large map of Ireland, and explore your options for creating a better and more simplistic, scale bar.
* Choose a style for the new Scale bar (under format), then set the units to kilometers, the label to km, the location of the label to below bar (and adjust the gap as needed), the length to 200 km, the number of both divisions and subdivisions to 2, the numbers and marks to both be divisions and all subdivisions, and do not use a background color. Change the color of the bar and font to something other than black.
* Assign the same scale bar style to the two other scale bars.
* You can set the scale so that it maintains useful round-number divisions. Reopen the scale bar properties dialog. In the Scale and Units tab, in the Scale area, under When resizing choose "Adjust width." If it's not already, specify 100 km as the Division value. Notice that there are no longer any selection handles and you can no longer resize the scale bar; it stays at the 200-kilometer length.
* A map's scale is not always shown with scale bars. Depending on the purpose of the map, a verbal or fractional scale may suit the data. Explore the different scale text options from the Insert menu.

**d. Work with north arrows**

* That GIS-layers north arrow under the large map of Ireland is just obnoxious. Double-click it and make a better choice. Note that north arrows are stored as font characters within ArcMap so they have fewer editable properties, but you can change size and color.
* Since north arrows are stored as font characters, if the map is viewed/printed on a computer that does not have the same font installed (does not have ArcGIS installed), the north arrow will be replaced by some other font character. You can avoid this problem by converting the North arrow to a graphic (right click and select Convert to Graphics). You should do this only if you have decided on the map's final orientation. A ‘graphic’ north arrow is no longer linked to the data and will not update with a new extent.
* The north arrows in the other two data frames are unnecessary, so delete them.

**e. Simplify the design**

* You will often have inset maps that show either location or an area of detail. Although you want to link the main map with the inset maps, in this case, the designer used zoom lines and the result is distracting. You will simplify the design.
* Double-click the Ireland data frame and choose Properties then the Extent Indicators tab.
* In the list of data frames on the left, select both Hill of Tara and Aran Islands and click the right arrow button to move it to the box on the right.
* Click the Frame button. Choose an appropriate border width and color. After you close out of the dialog, you will see boxes on your Ireland map that indicate the exact extent of your inset maps.
* Now you can remove the zoom lines. One at a time, click each zoom line to select it, then press Delete. Also delete the boxes drawn around these areas.
* To clearly link your main map with the inset maps, you can add explanatory text. On the Draw toolbar, click the New Text button. On the Ireland map, click next to the locations of the extent rectangles (inside the main map) for the Hill of Tara and Aran Islands inset maps and type “Area of detail”.

**f. Change the map projection**

* ***The display coordinate system (a data frame property) can be different from the coordinate system of the datasets.*** For example, it is possible to create a map with a Lambert conformal conic projection using data stored in Universal Transverse Mercator (UTM) coordinates. This is not good practice for GIS data analysis, but it is perfectly acceptable for making maps & cartography. As you know, all projected coordinate systems distort the spherical globe in some way. You should choose a projection that minimizes distortions that will interfere with the map purpose. For many thematic maps, it is a good design strategy to use an equal area projection.

* Consider the map of Ireland you have been editing. The *purpose* of the map is to show the distribution of archaeological sites. The main data frame, Ireland, uses a geographic coordinate system (GCS\_Clarke\_1866). Without a specified projection, this system will display the world as a rectangle with the north and south poles stretched to a line the same length as the equator. This means that as you move away from the equator (north or south), area becomes increasingly distorted. ***This geographic coordinate system is not a good choice for your map***. In fact, a geographic coordinate system is **NEVER** a good choice for displaying map data.

* Open the properties for the Ireland data frame and choose Coordinate System. Navigate to Projected Coordinate Systems, National Grids, Europe. Scroll down and click TM75 Irish Grid. Click OK to change the data frame's coordinate system, and click Yes if you see a warning message that this coordinate system has a different geographic coordinate system than other data sources on the map.

* Zoom to the full extent of the layout page and notice how the spatial extent of the Ireland data frame has changed. Resize the Ireland data frame so that it takes up the entire height of the map and then enlarge Ireland on the page. If necessary, move the "Area of detail" text that you added so that it is in the appropriate location.
* Reposition the other map elements to make the map work as a unified composition. Change the position and size of the title & legend. Make this a map that follows good design & layout principles!

1. **Export the map and paste it in your lab document.**

**Part III. Create Balanced Layouts**

**a.** Open **Mexico.mxd.**

To the right of the layout page are several other map elements: a title, legend, scale bar, and a locator map.

**b. Rearrange supporting elements to create a balanced layout**

* Place these map elements to create a well-balanced and logical layout.
* Remember that you can change the number of columns of your legend, move text, change the look and symbology of your locator map, change the styles of map elements, and resize any map element. Use guides as needed.
* If the Locator data frame cannot be seen when you drag it onto the map, right-click over it, choose Order, and then Bring to Front.

1. **Export the new balanced & logical map and paste it in your lab document.**

**c. Create an alternate layout**

There are so many possibilities for a well-designed & balanced map.

* Experiment with a different layout for your map. Change the map page size in Page and Print Setup to be 7 inches by 7 inches. Rearrange elements or change element properties to support that layout.
* To change the page orientation, choose Page and Print Setup from the file menu. In the Map Page Size area of the dialog, click Portrait.As you are rearranging the map elements, ask yourself some questions:
  + Are the map elements balanced on the page?
  + Are the open spaces balanced on the page?
  + Do boxes disrupt the fluidity of the space?
  + Are gaps evenly spaced?
  + How cleanly do the shapes on the map intersect the edge of the frame (sight lines)?
* On your map, the graticule is a combination of a map layer (showing the lines) and a data frame grid (showing the labels). Notice that if you turn off the map layer (Latlong), there are no graticule lines on your map.
* Change both the graticule line color and the ocean color to give your map a somewhat different look. The ocean color is the data frame background.
* Now change the labeling for your graticule. Open properties for the Major Habitat Types data frame and choose the grids tab, where you can change the look of the graticule under properties.
* Click the Labels tab and then Additional Properties. In both the Minutes and Seconds areas, uncheck the box next to "Show zero." Close out of the properties box.

1. **Export the map and paste it in your lab document.**

**Part IV. Customize Map Legends**

**a.** Open **legends.mxd**.

There is a layout with one data frame named "Horn of Africa."

**b. Create a default legend**

*A map legend is the key to understanding the symbols used on the map.*

* You use the Legend Wizard to create a legend in ArcMap. When you open the Legend Wizard, you are prompted for a number of specifications. The default legend includes all layers as they appear in the table of contents. Before you learn how to customize a legend, you will examine ArcMap's default version.
* From the Insert menu, choose Legend. Advance through the wizard by clicking the Next button in each wizard panel. Read the information, but for now do not make any changes. Click Finish to create the default legend.
* The legend is added to the middle of the layout. Move the legend to the empty white space to the right of the layout page.

**c.** **Create a custom legend**

* Now you will use the Legend Wizard to create another legend but you will change some of the default settings. Reopen the Legend Wizard.
* The first wizard panel shows the layers that will be included in the legend. By default, all layers are included in the order in which they appear in the table of contents. You can remove layers from the legend and change the order in which they are listed in the legend.
* Remove the Borders layer from the legend by selecting Borders, then clicking the left arrow button to remove the Borders layer from the Legend Items list.
* Now reorder the layers. Click Rivers, then click the Up arrow button to position it below Roads. Click Next.
* In the box under Legend Title, delete the word "Legend." Change the font size to 10.
* ArcMap will establish a hierarchy of font sizes for other legend text based on this initial setting. Click Next.
* For the background color, choose white from the list of colors. Select an unobtrusive border with a subdued color. Specify a Gap of 15 and round the edges of your border a little bit. Click Next.
* You will not make changes to the symbol patch properties at this time, so click Next again.
* You can control the spacing between all the different elements in the legend. Click in each value box and notice how the spacing diagram changes in the sample legend on the right. For Legend Items, change the spacing to 16. Click Finish.
* Position the new legend in the lower right portion of the layout page. If necessary, move the first (default) legend so you can see the two legends side by side. Zoom in on the page and compare the new legend to the first.

1. **Export the map and paste it in your lab document.** Be sure that it is sized so that the legends are readable. Do not worry about what the map looks like; in this exercise you are only concerned with the look of the legend.

**d. Customize layer symbology, wording, and symbol order**

* Everything that displays in a legend is a reflection of the map's table of contents (TOC). Changes you make to wording, symbology, or order will also be made in the legend.
* Open the Layer Properties dialog for the Rivers layer and choose the Symbology tab.
* The rivers are symbolized by type. You can change the order in which the river types display here. In the Value column, click Perennial, then click the Up arrow button on the right to move it to the top. Move Intermittent below Perennial. Notice that both legends have updated.
* Use the same procedure to invert the order of the Road types.
* Position *Lake; Reservoir* at the top of the Lake types.
* Next, you will change the symbology for the Cities layer. Open the Layer Properties dialog for Cities and specify a Graduated symbols legend, using POPULATION as the Value field.
* Change the number of classes to 2. Set the first class break to 500,000. Set symbol sizes of 5 and 10. Right-click in the empty white space in the symbol area and choose Flip Symbols. Right-click again and choose Reverse Sorting. The larger population category is now at the top of the list.
* To make the population numbers easier to read, right-click in the empty white space and go to Format Label. Under Numeric, check on ‘Show thousands separators’ and uncheck ‘Pad with zeros’. Click OK twice.
* In the TOC, expand the Cities layer if necessary. Click the POPULATION heading and change it to “Cities by population.”
* Now you will change the symbolization of the Elevations layer. Open the Layer Properties dialog for Elevations and click on the Symbology tab.
* In the Show area, click Classified. If prompted, choose to create a histogram. You'll use the default five-class scheme, but you'll change the class values.
* Click the Classify button. In the box under Break Values, click each break value and change them to 0, 500, 1000, 2000, and 5200. Click OK.
* Next, flip and reverse sort the symbols so that black represents the highest elevations and is at the top of the five classes. Double-click the top symbol and choose More Colors in the Color Selector. Click the right-facing arrow and choose CMYK Sliders. Change the K value to 50 and click OK. Change the other symbol colors (from dark to light) to: 36 K, 25 K, 13 K, and 0 K (white).
* Change the class labels so they are all whole numbers (format label). Click OK.
* In the TOC, change the Elevations heading to “Elevation in feet.”
* Finally, you'll customize the remaining layer headings (not layer names):
  + Expand the Rivers layer and change River Type to Rivers.
  + Expand Roads and change Road Type to Roads.
  + Expand Lakes and change Lake Type to Water bodies.

1. **Export the map and paste it in your Word document. Be sure that it is sized so that the legends are readable.**

**e. Edit legend properties**

* Once a legend is added to your map, you can edit it just like other layout elements.
* Double-click the custom legend to open the Legend Properties dialog. Click the Items tab. Most of the major customization controls are located under this tab. In the Legend Items column, click Lakes. Check the box next to "Place in new column."
* Click Cities, then click the Style button. In the Legend Item Selector, click the Properties button. Click the General tab if it's not already active. The General tab provides appearance controls for all the elements in a layer: the layer name, heading, patch, labels, and descriptions. Each layer shown in the legend can be customized individually using the options found here.
* Click the Heading Symbol button and change the font to a serif font (try Bookman Old Style). Change the size to 10 and make the style bold.
* Next, click the Label Symbol button and specify Arial for the font and 8 for the size. Click OK until you're back in the Legend Properties dialog. Notice that the symbols you just customized are updated.
* One problem with the current legend is that the layer names and headings are both included for all layers except Cities. Including both names is unnecessary. You will remove the layer names from the legend.
* In the Legend Items list, click Roads, then Style. In the Legend Item Selector, scroll down and click Horizontal with Heading and Labels, then Properties. Set the Label Symbol and Heading Symbol the same as you did above.
* Make the same changes to the legend style, label symbol, and heading symbol for the Rivers, Lakes, and Elevations layers.
* Because in the real world lakes are not usually rectangles, you'll change the patch to a different shape. Click Lakes, then Style, then Properties. Check the box next to "Override default patch." Click the Area dropdown arrow and choose Water Body. Next, check the box next to "Override default patch size." Specify a width of 18 pts and a Height of 12 pts.
* Click OK to close all the open windows. Examine the custom legend. Zoom in to see it better if necessary.

1. **Export the map and paste it in your lab document. Be sure that it is sized so that the legends are readable.**

**f. Make manual changes to the legend**

* Up until now you have explored a variety of automated customization techniques. It is often desirable to go beyond these controls and craft a manual legend. In some cases, this may even be a less tedious way to customize your legend. ***Making manual changes to a legend should be left to the very end of the design process***, because changes made to the map will not be reflected in a manually edited legend.
* Right-click the custom legend and choose Convert To Graphics. Right-click the legend again and choose Ungroup. You can now see individual legend elements. Click in the white space away from the legend to unselect all the elements.
* Under Roads, click the "Gravel; Track or trail; Unsurfaced" symbol. Notice that the symbol and description are grouped. Right-click and choose Ungroup.
* ArcMap does not allow descriptions to wrap onto two lines, but you can make this change now. Double-click the description (label text). In the Text tab of the Properties dialog, click in front of "Unsurfaced" and press Enter to move it to a second line. Click OK.
* Hold down your Shift key and click the symbol so that both the symbol and label are selected. Right-click and choose Align, then click Align Vertical Center. Click in empty white space to unselect the elements. If you do not like right-clicking, open the Graphics toolbar which contains buttons for aligning, distributing, ordering, and rotating map elements.
* Your map includes elevation data. These data are displayed as a continuous sequence on the map, without outlines or gaps to separate classes. In the legend, the patches have outlines and gaps. To make the legend symbols match the map symbols, you need to customize the legend. The Elevations layer is originally derived from a raster. Raster-based symbols act differently in the TOC and in legends than do vector-based symbols. The following instructions describe how to create a legend element by hand.
* Ungroup each of the five elevation classes and delete the gray patches.
* Use the New Rectangle tool on the Draw toolbar to redraw a single patch. Copy and paste this rectangle to create five patches. Arrange the five into a vertical stack. Don't worry about aligning the patches with the legend labels right now. Select all the new patches and align left.
* Now specify fill colors for the new patches. Double-click the top patch. In the Symbol tab of the Properties dialog, click the Fill Color box and choose More Colors. Use the CMYK sliders to specify 0 C, 0 M, 0 Y, and 50 K. Click the Outline Color dropdown arrow and choose No Color.
* Repeat this process to change the fill colors for the other patches (working down the stack) to 36 K, 25 K, 13 K, and 0 K. The C, M, and Y values should be 0 for all the colors. Remove the outlines from all the rectangles.
* Now that you've changed all the fill colors, you'll arrange the patches so that they all touch, then group them. To arrange the patches, start with the white patch selected. Drag it up so that it touches the bottom of the lightest-gray patch, then hold down your Shift key and select the lightest-gray patch. Use the same process to work up the stack until all patches are touching and selected. Right-click over the selected patches and choose Group. Click in an empty space to unselect the grouped patches.
* Draw a new rectangle around the stack of patches. Right-click over the selected rectangle and choose Properties. Change the fill color to none, the outline color to black, and the outline width to 0.5. Click OK and unselect the rectangle.
* Finally, realign the labels, and then move them closer to the patches. If necessary, zoom out so you can see the entire custom legend.

1. **Export the map and paste it in your lab document. Be sure that it is sized so that the legends are readable.**

When choosing the file format, consider the needs of map readers.

Expand AnswerAnswer

PDF is probably your best bet here. The difference in file size is minimal between the highest quality JPEG file and the highest quality PDF file that you created. With the PDF version, however, readers can explore the map much more easily.

Adobe Reader's zoom and pan tools allow map readers to readily interpret the text symbols on the map as well as the text in the legend. In the JPEG version, the map appears small and the text is blurry.