

MAPPING EXERCISE

Thematic Mapping: Graduated Symbol Mapping

The proportional symbol map is a widely-used form of thematic mapping. In this technique, the cartographer selects a symbol and alters its size, the area to be exact, based on the data values. There are three methods for setting symbol size: *absolute scaling*, *apparent magnitude (perceptual) scaling*, and *range grading*. Absolute scaling involves scaling symbol area proportionately to the data value. For example, a symbol for a point with a data value of 100 should be twice the area of the symbol for a point with the value of 50. Apparent magnitude scaling incorporates correction factors to compensate for map-reader underestimation of symbol area. ArcMap uses Flannery Compensation, a mathematical increase to the symbol sizes to account for map readers underestimating the size of symbols. With range grading, a symbol represents a range of data values. As in the choropleth technique, data are classed and then each class is assigned a symbol of a distinctly different size.

While most cartographers use the terms “proportional point symbol map” and “graduated point symbol map” interchangeably, in ArcMap these two terms have specific meaning. In the software, proportional symbol maps use *absolute scaling* or *apparent magnitude scaling* and graduated symbol maps use *range grading*.

With proportional symbols, ArcMap allows you to set only the size of the smallest symbol (from which other symbols are scaled upwards). You can also use Flannery Compensation to adjust the symbol sizes. With graduated symbols, you have the ability to control the size of *each* of the symbols used in the map. In this exercise you will use range grading which, using ArcMap’s terminology, is the graduated symbol map.

This exercise uses data from NOAA’s Coastal Services Center (maps.csc.noaa.gov/hurricanes/) to map the intensity of two hurricanes that took place during 2005. Geographic information is widely available from government agencies and online data clearinghouses. However, not all data is available as ArcMap-compatible layers (e.g., shapefiles). Government agencies often make *data tables* available for viewing and downloading.

Under certain circumstances it is possible to create a map layer using nothing but a data table. There are two major requirements that you must have in order to be able to do this. First, the data table file must be in a format that can be read in ArcMap (dBase, text file, etc.). Second, the file will need to include latitude and longitude coordinates. In this exercise, you create a point layer from a data table.

In this exercise, you will:

- ✓ Create a shapefile from a table containing Latitude and Longitude coordinates
- ✓ Create a spatial bookmark
- ✓ Limit the displayed data using the Definition Query
- ✓ Manually adjust class upper limits
- ✓ Redundant coding
- ✓ Add a graticule
- ✓ Insert a legend
- ✓ Modify legend properties
- ✓ Convert legend to graphics
- ✓ Insert and modify a scale bar

Making the Map

- Start ArcMap (**Start All Programs >ArcGIS >ArcMap**); if there is an icon on the computer desktop, you can start ArcMap by double-clicking it. You will be shown a window asking whether you want to open a new empty map, a template, or an existing map.
- Make sure the **An existing map:** radio button is selected and click OK. If you did not see this window, click **File >Open**.
- Browse to where you saved the **GraduatedSymbol.mxd** project file and open it. You will find two map layers: Countries and Hurricane Track, which shows the track of two hurricanes (Figure 1).

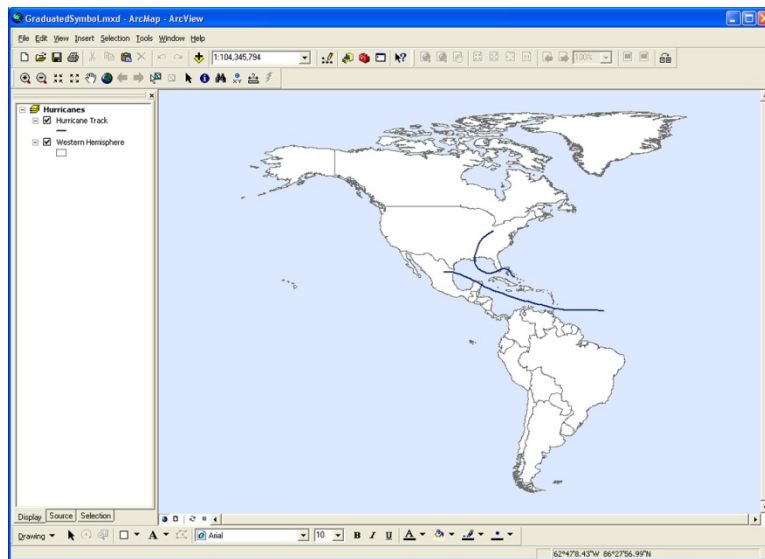


Figure 1. The western hemisphere with two hurricane tracks.

Notice that the western hemisphere fill pattern is white and there is a blue background for the entire map. The blue background was set using the **Frame** properties for the data frame. To see where this is set in the data view, right click the **data frame** (Hurricanes) and select **Properties**. Next, click the **Frame** tab to see that the **Background** has been set. You can do this same procedure in the Layout view by right-clicking the mapped area the layout.

In the GraduatedSymbolData folder is a dBase file of hurricanes that occurred in called **2005_hurricanes.dbf**.

- Using the **Add Data** button, add this file to your project.

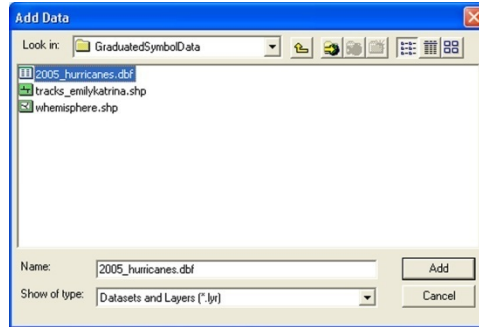


Figure 2. Adding the 2005 hurricane database file.

Note the tabs at the bottom of the Table of Contents – the Table of Contents switched from “Display” to “Source.” Stand-alone data tables do not display using the “Display” tab. Switch between the “Display” and “Source” tabs to observe the difference.

- Right-click “2005_hurricanes” in the Table of Contents and select “Open.” The file displays the same as an attribute table for a shapefile.

OID	YEAR	MONTH	DAY	AD_TIME	BTID	NAME	LAT	LONG	WIND_KTS	PRESSURE_CAT	BASIN	
0	2005	6	8	1800Z	1326	ARLEN	16.9	-84	25	1004	TD	North Atlantic
1	2005	6	9	0000Z	1326	ARLEN	17.4	-83.9	30	1003	TD	North Atlantic
2	2005	6	9	0000Z	1326	ARLEN	18.2	-83.9	35	1002	TS	North Atlantic
3	2005	6	9	1200Z	1326	ARLEN	19	-84	35	1002	TS	North Atlantic
4	2005	6	9	1800Z	1326	ARLEN	19.7	-84.1	35	1002	TS	North Atlantic
5	2005	6	10	0000Z	1326	ARLEN	20.4	-84.2	40	1001	TS	North Atlantic
6	2005	6	10	0600Z	1326	ARLEN	21.2	-84.4	45	1000	TS	North Atlantic
7	2005	6	10	1200Z	1326	ARLEN	23	-84.7	50	1000	TS	North Atlantic
8	2005	6	10	1800Z	1326	ARLEN	24.9	-85.1	55	995	TS	North Atlantic
9	2005	6	11	0000Z	1326	ARLEN	26.5	-85.6	60	990	TS	North Atlantic
10	2005	6	11	0600Z	1326	ARLEN	27.7	-86.8	60	993	TS	North Atlantic
11	2005	6	11	1200Z	1326	ARLEN	28.9	-87.2	55	990	TS	North Atlantic
12	2005	6	11	1800Z	1326	ARLEN	30.1	-87.5	50	991	TS	North Atlantic
13	2005	6	12	0000Z	1326	ARLEN	31.4	-87.6	30	984	TD	North Atlantic
14	2005	6	12	0600Z	1326	ARLEN	32.7	-87.7	25	986	TD	North Atlantic
15	2005	6	12	1200Z	1326	ARLEN	36	-88	20	1003	TD	North Atlantic
16	2005	6	12	1800Z	1326	ARLEN	37	-87.8	20	1005	TD	North Atlantic
17	2005	6	13	0000Z	1326	ARLEN	38.5	-87.5	20	1006	TD	North Atlantic
18	2005	6	13	0600Z	1326	ARLEN	40.5	-86	20	1006	TD	North Atlantic
19	2005	6	13	1200Z	1326	ARLEN	42	-86	20	1005	L	North Atlantic
20	2005	6	13	1800Z	1326	ARLEN	43	-84	20	1005	E	North Atlantic
21	2005	6	14	0000Z	1326	ARLEN	43.7	-81.1	20	1003	E	North Atlantic
22	2005	6	28	1800Z	1327	BRET	19.7	-86.4	30	1006	TD	North Atlantic
23	2005	6	29	0000Z	1327	BRET	20	-86.8	35	1005	TS	North Atlantic
24	2005	6	29	0600Z	1327	BRET	20.4	-86.4	35	1005	TS	North Atlantic
25	2005	6	29	1200Z	1327	BRET	20.8	-87.3	35	1005	TS	North Atlantic
26	2005	6	29	1800Z	1327	BRET	21.4	-88.1	25	1007	TD	North Atlantic
27	2005	7	2	1800Z	1328	CINDY	18.3	-86.7	30	1009	TD	North Atlantic
28	2005	7	4	0000Z	1328	CINDY	18.6	-87.2	30	1007	TD	North Atlantic
29	2005	7	4	0600Z	1328	CINDY	19.3	-87.9	30	1007	TD	North Atlantic
30	2005	7	4	1200Z	1328	CINDY	20.9	-88.5	25	1011	TD	North Atlantic

Figure 3. 2005 hurricane data.

- Scroll through the table to observe the various attributes for the file, including the storm name, location, wind speed, barometric pressure, and category.

You will now create a new shapefile using this data. Specifically, you will use the latitude and longitude attributes in this database. This is a two-step process.

- Close the 2005_hurricanes data table.
- From the **Tools** menu, choose **Add XY Data**. The Add XY Data dialog box appears.

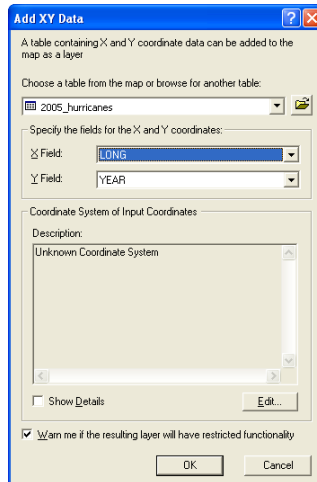


Figure 4. The Add XY Data dialog.

- Confirm that the Table is “2005_hurricanes” and the X Field is **Long**.
- Next, set change the Y Field from Year to **Lat**. This may seem backwards at first, as longitude lines run North-South and latitude lines run East-West, but it is correct. Remember, longitude is a measure east or west (i.e., the X direction) of the Prime Meridian and latitude is a measure north or south (i.e., the Y direction) of the Equator.

The coordinate system is presently set to “Unknown Coordinate System.” You will match the coordinate system of your output file to the rest of the map layers.

- Click the **Edit** button. The **Spatial Reference Properties** window appears.
- Click the **Import** button. A **Browse for Dataset** window appears.
- If you are not in the GraduatedSymbolData folder when the window opens, use the **Look in:** drop-down menu to navigate to this location.
- Select **whemisphere.shp** and click the **Add** button.

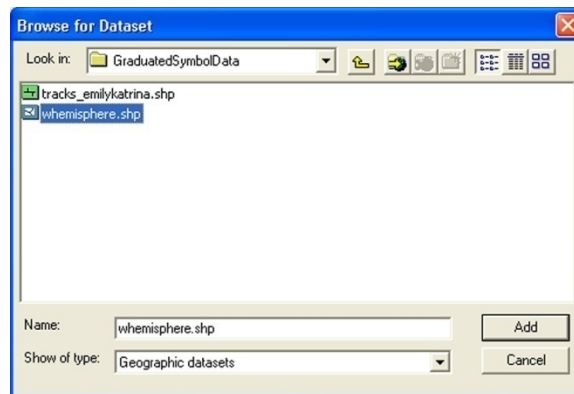


Figure 5. Select the countries shapefile to establish the coordinate system.

You should now notice that the Name of the coordinate system is **GCS_WGS_1984**, and there are several items in the “Details” window.

- Click **OK** to return to the “Add XY Data” window and then **OK** again to create the new layer from the data table. “2005_hurricanes Events” now appears in the Table of Contents.
- Make sure the layer is turned on to see where these hurricanes occurred. Because ArcMap randomly selects a symbol color, the layer may be difficult to see. If this is the case, change the symbol color to see the points better.

You have now completed the first step in creating a shapefile. Although your data points are now being displayed on the map, *you do not have a shapefile yet*.

Now you will convert the “2005_hurricanes Events” points to a shapefile.

- **Right-click** the **2005_hurricanes Events** layer and choose **Data >Export Data**. Save this shapefile in your GraduatedSymbolData folder as “Hurricanes 2005.” ArcMap will ask if you want to add the exported data to the map as a layer. Choose **Yes**.

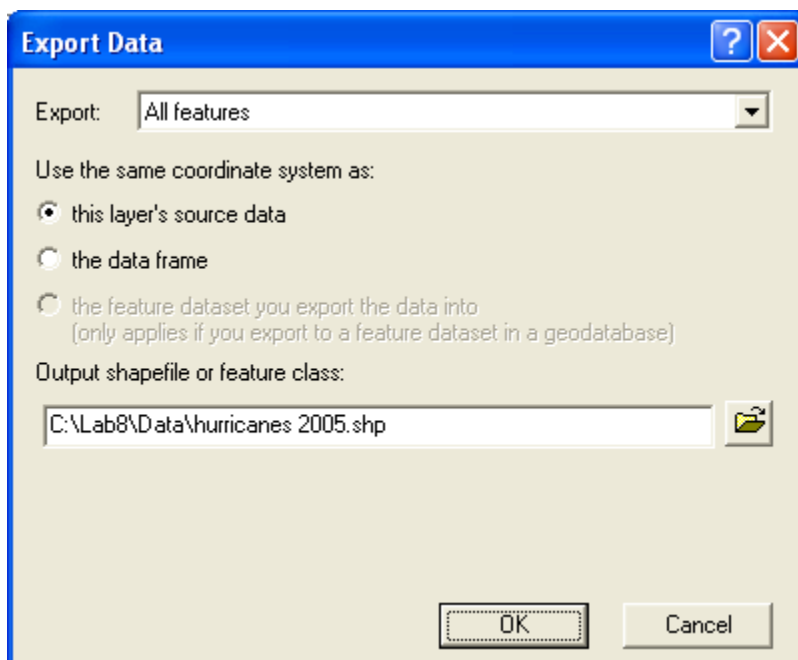


Figure 6. Exporting the data as a map layer.

- Now **delete** the **2005_hurricanes Events layer** (not the table!) from the Table of Contents. To ensure that you are not deleting the table, switch the Table of Contents tab from Source to Display. Right-click the layer and choose Remove.

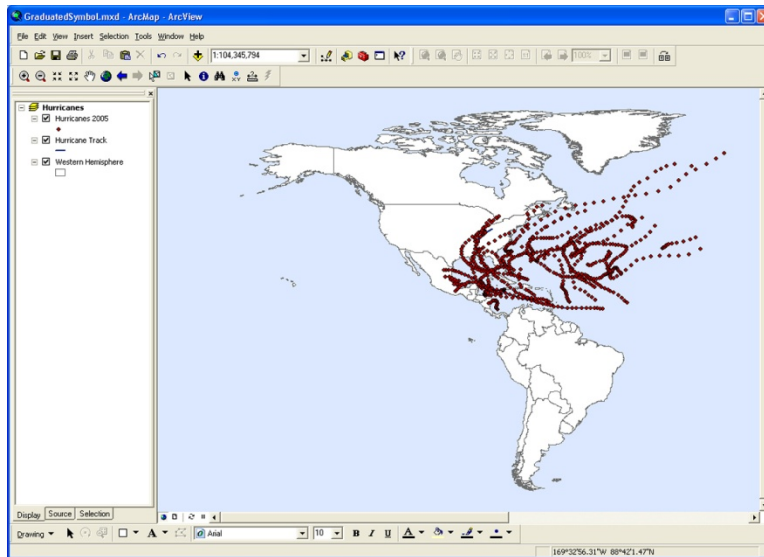


Figure 7. Your map with 2005 hurricane points.

You will focus the map on the Caribbean Sea, but before you do so, you will establish a projection for the map. You will choose the Mercator projection.

- Right click the **Hurricanes** data frame name at the top of the Table of Contents and select **Properties**. The **Mercator** projection is found in **Predefined >Projected Coordinate Systems >World** in the “Select a coordinate system” box.
- Make the map scale 1:17,500,000 and pan so the map displays the Caribbean Sea and Gulf of Mexico. You may wish to turn off Hurricanes 2005 to zoom into the area.

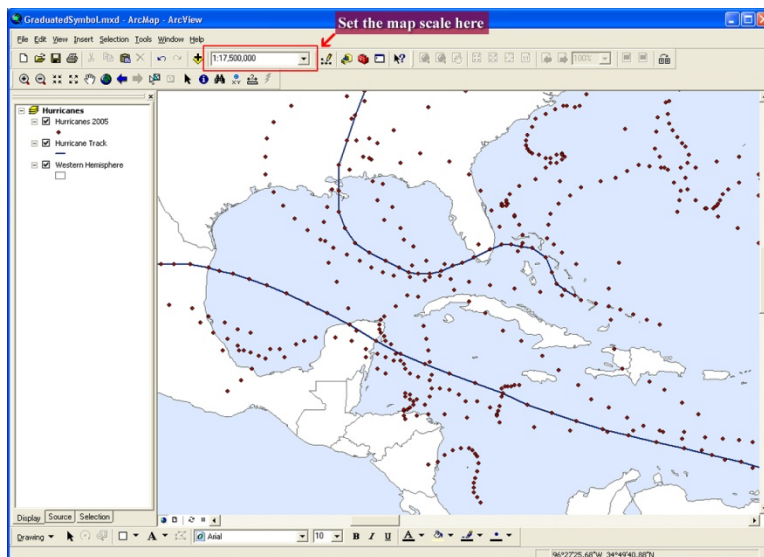


Figure 8. Change the map scale and pan to this part of the map.

- Create a **Bookmark** for this extent (**View >Bookmarks >Create**).

Before you change the class limits, you will recall that you will be mapping two hurricanes. The first is Hurricane Katrina, which devastated portions of the Gulf of Mexico coast in August, 2005. In addition to specifying the class limits, you will also be limiting the display of this layer to Hurricane Katrina.

To display only Hurricane Katrina, you will use the Definition Query.

- **Right-click** the **Hurricanes 2005 layer** in the Table of Contents and select **Properties**.
- Select the **Definition Query** tab.
- Click the **Query Builder** button
- You will now use a query to exclude all hurricanes **except** Katrina. Use the field names, buttons, and values to create the following statement: **"NAME" = 'KATRINA' OR "NAME" = 'EMILY'**
 - Double-click "Name"
 - Single-click the equals button
 - Click the "Get Unique Values" button
 - Double-click 'KATRINA'
 - Click the Or button
 - Double-click "Name"
 - Single-click the equals button
 - Click the "Get Unique Values" button
 - Double-click 'EMILY'

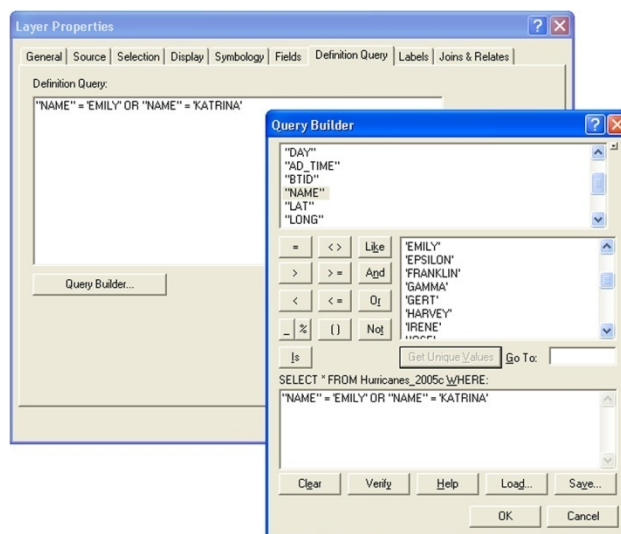


Figure 9. Using the Definition Query to display Hurricanes Katrina and Emily.

i When using the query builder to select multiple items from within the same field, you must type a complete query for *each* item ("NAME" = 'KATRINA' as well as "NAME" = 'EMILY' *not* "Name" = 'KATRINA' or 'EMILY'). You must also use **Or** to connect the items. You are stating that you wish to display records where the name is *either* Katrina *or* it is Emily. If you use **And**, you are stating that wish to display records that have a name of *both* Katrina and Emily. You have only *one* name used in the field, so using And in this instance will result in a query where no records meet the criteria you have established. For further information, consult the ArcMap Query help menus.

- Click **OK** to close the Query Builder. Click **Apply** to register the change. Do not close the Properties window yet.
- Your map will now display only the Hurricane Katrina and Hurricane Emily symbols. Move the properties window if necessary to see that the data view displays the two hurricanes.

You will now proportionally scale the symbols to represent earthquake magnitudes.

- With the Properties window still open, select the **Symbology** tab.
- Click **Quantities** and select **Graduated symbols**.
- Change the field **Value** to **WIND_KTS**. This is the wind speed in knots. You will see that there are five classes displayed.

Hurricanes are categorized using the Saffir-Simpson scale according to wind velocity. The following table portrays the categories of storm.

Table 1. The Saffir-Simpson Scale

Category	Wind Speed	
	Knots	Miles per Hour
Tropical Depression	20 – 34	25 – 38
Tropical Storm	35 – 63	39 – 73
Hurricane, Category 1	64 – 82	74 – 92
Hurricane, Category 2	83 – 95	96 – 110
Hurricane, Category 3	96 – 113	111 – 130
Hurricane, Category 4	114 – 135	131 – 155
Hurricane, Category 5	>136	>155

While you generally want to use four or five categories for range graded graduated symbol maps, you will use all seven categories in your classification.

- Click the **Classify** button. Change the number of classes to **7**. You do not have to change the method as you will manually enter the upper limit of each class. The Classification window opens.

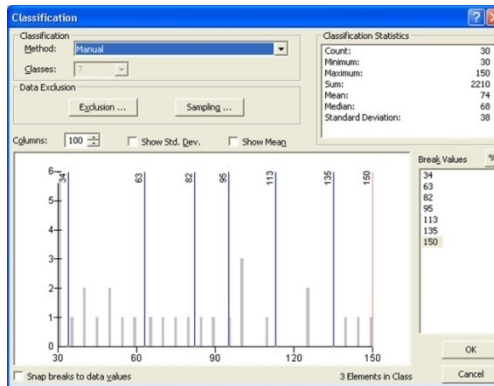


Figure 10. The classification window.

- Now, using the values in the table above, **change the Break Values** to the **upper limit** of the Saffir-Simpson scale classes **except** the largest value – leave the highest value, 150, as is. In the Break Values box, click on the first value and replace it by typing 34. Repeat this procedure for the next five values (changing to 63, 82, 95, 113, and 135 respectively).
- Click **OK** to return to the Properties window.

i You may also change the upper limits of class ranges in the Symbology tab of the Properties window. To do this any of the ranges in the Range column and enter the new upper limit.

- Next, change the symbol sizes to match the **first seven** sizes shown in Figure 11. (Start with 3.60 for the smallest circle and 54.72 for the largest.) Double-click on each symbol to open the Symbol Selector window. Change the size and click OK to register the change.

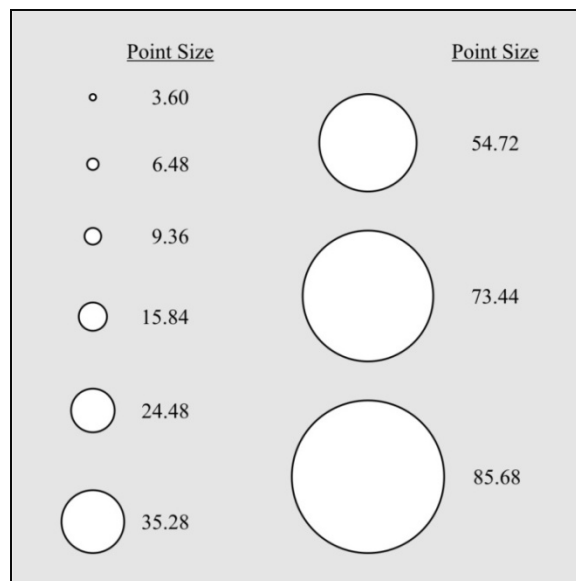


Figure 11. Recommended circle sizes for range graded maps.

- When you have changed the sizes of all the symbols, click **Apply** to register the changes.
- Next, change the **labels** for each class to match the classification (Tropical Storm up to Hurricane, Category 5) presented in Table 1. Click **Apply** to register the changes.

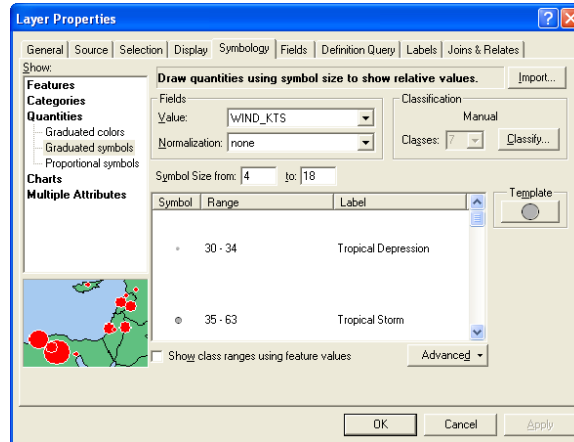


Figure 12. Change the label to the appropriate storm type by clicking on the appropriate label and typing the new label.

Next you will change the fill pattern for the circles. You will use *redundant coding*—using both graduated colors and symbols.

- As seen in Figure 13, you will use yellows for the tropical depression and tropical storm, oranges for Category 1 and 2 hurricanes, and reds for Category 3, 4 and 5 hurricanes. Double-click the appropriate symbol to open the Symbol Selector window and change the color of the symbol. Repeat until all symbol colors have been changed.

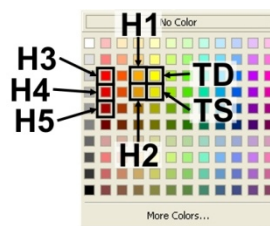


Figure 13. Color schemes for tropical depression, tropical storm and hurricane categories 1-5.

You now have graduated symbols with redundant coding representing the various storm strengths along the path of the hurricanes.

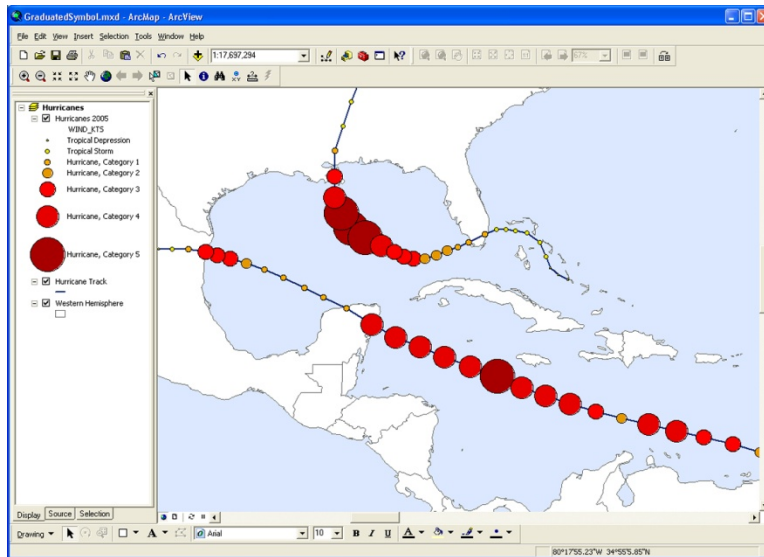


Figure 14. Hurricane strengths represented by graduated symbols and colors.

- Next, **label the countries on the map** (right-click the Western Hemisphere layer and select **Label Features**).
- Next, **label each hurricane track** (“Hurricane Katrina” and “Hurricane Emily”). Rather than using the automatic label feature for the layer, simply **insert text** (**Insert >Text** or use the **New Text** button on the **Drawing toolbar**) and type the labels. Do not reorient the labels to be parallel to the track.
- Adjust the properties of these labels to make them distinct from the country labels by highlighting the text and adjusting the properties on the Drawing toolbar (you can also double-click on the text and use the Change Symbol button in the text properties window).
- Place these labels near their respective hurricane paths.

Creating the Layout

- Switch to the **Layout View** (**View >Layout View**).
- Using the **Page and Print Setup** menu item (right-click outside the page in the layout view to get the context menu where this is located), make sure the layout is oriented as **Landscape** rather than portrait. Also make sure the **Use Printer Paper Settings** and **Show Printer Margins on Layout** boxes are checked.

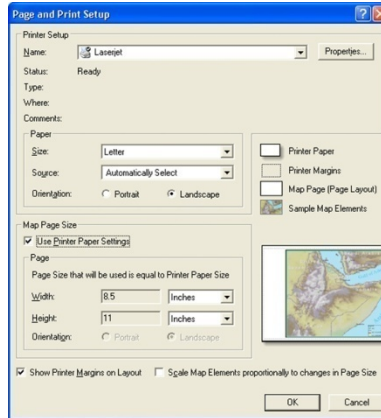


Figure 15. Page and Print Setup dialog.

Do not adjust the size or placement of the data frame at this time.

- Insert a **neatline** (Insert >Neatline). Make it **2 points** thick and place it inside the print margins with a **5 point** gap.
- Next, you will add a graticule to the map. To do this, right-click the data frame (mapped area) and select **Properties**.
- Click the **Grids** tab and select **New Grid**.
- **Accept the defaults** in the next window (Graticule radio button selected and Grid name) and click **Next**.
- In the “Create a graticule window” (Figure 16) change the “Place parallels every” to **10 degrees**.

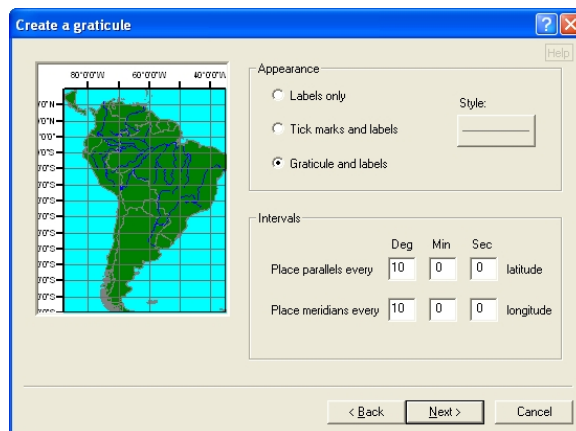


Figure 16. Here you define the appearance of the graticule.

- Click **Next** through the remaining windows, accepting the default properties until you get to **Finish**.

- Click **Finish** to return to the Data Frame Properties window.
- Click **OK** to return to layout. You now have a graticule around the mapped area with the latitude and longitude lines labeled (Figure 17).

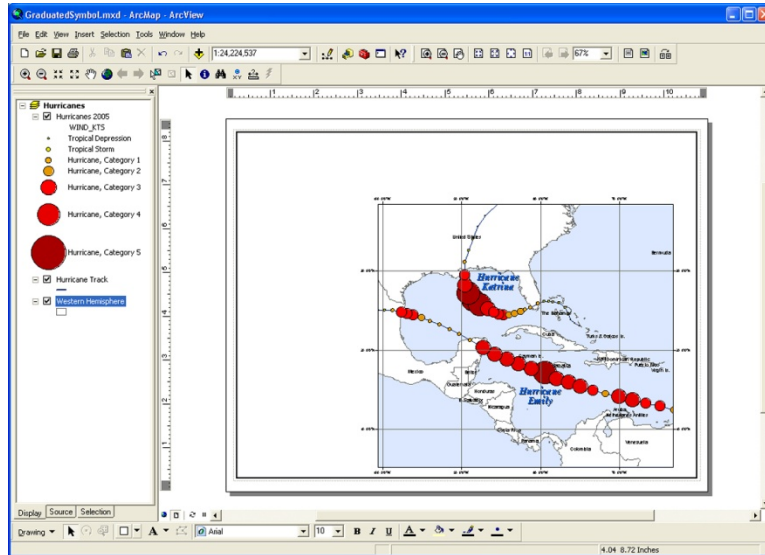


Figure 17. Your mapped area with the graticule.

- If needed, adjust the position of the mapped area so the labels of the graticule do not extend beyond the neatline.

You will now insert a legend in your layout. Show *only the Saffir-Simpson categories* in the legend (no other layers).

- Select **Insert > Legend**. The Legend Wizard window appears.
- You want **only** the Hurricanes 2005 layer to be the only item in the Legend Items box. It doesn't matter which as the circle sizes and labels are identical.

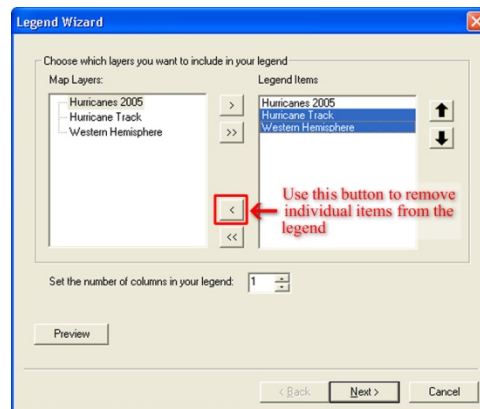


Figure 18. By default, all items in the Table of Contents appear in the Legend.

- To remove the unwanted legend items, select them and click the single left-pointing arrowhead. Click **Next** to go to the Legend Title window. **Delete** the word “Legend” from the Legend Title box.
- Click **Next** through the remaining items, and click the **Finish** button to close the wizard and return to the layout. If necessary, move the legend into the blank space to the left of the mapped area.

You may notice that there are a few minor issues with your legend. First, you see Emily (or Katrina) and WIND_KTS in the legend, which you do not need. Second, the labels for the large circles appear to be out of alignment with the symbols. Third, the symbols do not appear to be aligned vertically. Finally, the label for Hurricane, Category 5 appears that it will overlap the symbol if it is aligned with the center of the symbol.

You will adjust the legend to fix all of these issues. You will need to convert the legend to individual graphics items to do so, however.

- Convert the legend to graphics by right-clicking it and selecting **Convert to Graphics**.

i When you insert a legend in the preceding manner, it is linked to the Table of Contents. Having this link means that if you make changes to map layers (e.g., symbol type, size, or color), the legend automatically updates. When you convert the legend to graphics, you sever this link to the Table of Contents. If you make changes to the map at this point, you will either have to re-add the legend or manually change the graphic elements to reflect the changes.

There will not appear to be any change to the legend, but it is now a **group** of individual graphics. To make changes to the legend items, you will need to **ungroup** these items.

- **Ungroup** the legend items. Select the legend (it may already be selected) and, using the Drawing button on the Draw toolbar, select Ungroup. The Draw toolbar is at the bottom of the ArcMap window by default. If you do not see the Draw toolbar, right click a toolbar and select Draw from the context window.

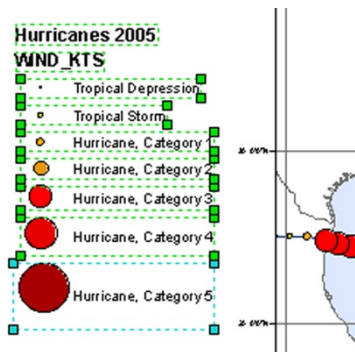


Figure 19. Legend items as ungrouped graphics.

- Click anywhere outside the layout to deselect the graphics.

- **Delete Hurricanes 2005** and **WIND_KTS** so you are left only with the circles and the labels.
- Ungroup the symbol/label pairs so each symbol and label is an individual graphic.
- Select the largest symbol (the Category 5 symbol) by clicking on it **once**. Nudge the symbol to the left until it is aligned with the symbol above it. Use your left arrow key on your keyboard—four or five increments should do the trick.
- Now select the **Hurricane, Category 5** label and nudge it upwards until it is aligned with the center of its symbol. **Repeat** this process for the **Category 4** and **Category 3** labels.
- Select all of legend circles and their labels. You may either hold down the shift key and click on the individual items or click-and-drag a box around the items—be careful not to select the mapped area or neatline when you do this.
- With these items selected, **group** them. Using the Drawing button on the Draw toolbar, select Group.
- Move your legend upwards so it is aligned roughly (but not higher than) the mapped area.

You will now put a scale bar on the map.

- Click **Insert >Scale Bar** and select the **Single Division Scale Bar**. Before clicking OK, click the **Properties** button.
 - In the **Scale and Units** tab:
 1. Set the “When resizing...” to **Adjust Width**.
 2. Set the “Division Units” to **miles**.
 3. Set the Division Value to **1000** mi,
 4. Set the “Label Position” to **after labels**.
 - In the **Numbers and Marks** tab
 5. Set the “Frequency” to **single label**.
 6. Set the “Position” to **Center on bar**.
 - On the **Format** tab
 7. Change the font color to **white**.
 8. Change the bar color to **Grey 60%**.

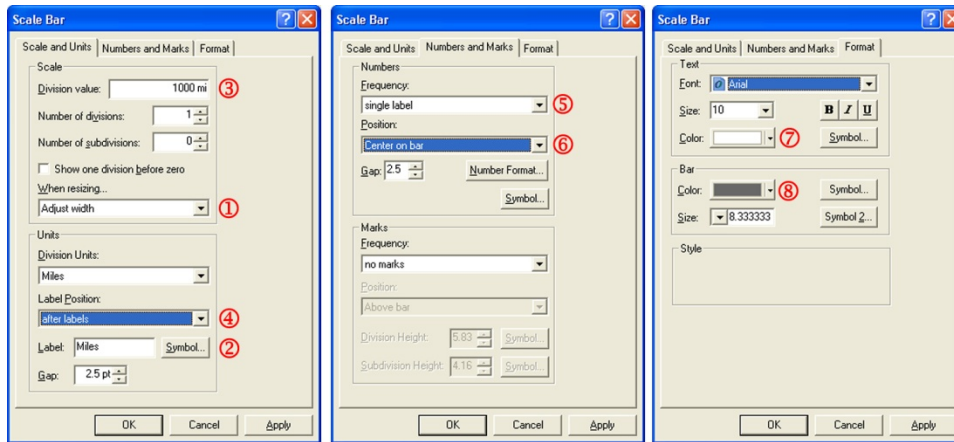


Figure 20. Scale Bar properties.

- Click OK to place scale bar on the map.

You will now add a few supplemental text items.

- To the left of the mapped area and below the legend, place the following text items (left-aligned):

HURRICANE KATRINA

Formed August 23, 2005

Dissipated August 31, 2005

Highest wind speed: 175 mph (152 kts)

Fatalities: 1,836

Damage: \$81.2 billion

The costliest Atlantic Hurricane in history

The sixth strongest Atlantic hurricane on record

The third strongest hurricane to make landfall in the United States

HURRICANE EMILY

Formed July 10, 2005

Dissipated July 21, 2005

Highest wind speed: 160 mph (139 kts)

Fatalities: 15

Damage: \$550 million

The strongest hurricane ever to form before August

The earliest Category 5 hurricane ever recorded in the Atlantic Basin

- Adjust the font size so the text fits in the available space.

- In the lower left-hand corner of the page, below the supplemental text you just added, add the cartographer information (two lines, left-aligned):

Your name
Today's date

You may need to adjust the position of the supplemental text and/or legend to accommodate this text.

- Come up with an appropriate **title (Insert >Title)** for the map. Adjust the placement of the objects in the layout as appropriate to achieve good balance and avoid large empty spaces.

To print a hard-copy of the map:

- Click on the **print button** or select **File >Print** (you may also print preview using **File >Print Preview**)

To create a PDF document (for digital submissions):

- Export the map by selecting **File >Export Map...**
- Change the **Save as type:** to **PDF (*.pdf)**.
- The Resolution should be **300 dpi** and the **Output Image Quality** should be **best**. Keep these settings unless directed otherwise.

Exercise Questions

1. How do you change the background of your mapped area in the Data View.
2. What tool do you use to convert a data table with latitude and longitude values to a shapefile?
3. When converting a data table to a shapefile, how do you define the coordinate system for the file?
4. Where can you refine your layer to display *only* records that meet criteria defined by you (for example, displaying only the cities of New York and Los Angeles)?
5. Assume you have a *Cities* map layer for the United States that you wish to display only the cities of New York and Los Angeles. Write the query you would use to display only those two cities (the field name in the attribute table is called CityName).
6. How can you manually change the upper limit of a class range?
7. When creating classes, can you use labels in your layer's legend that are different from the values that ArcMap automatically calculates? If so, how?
8. What is redundant coding?
9. How do you add a graticule to your data frame in the Layout View?
10. How do you insert a legend into your layout that displays only *some* of the map layers that are in the Table of Contents?