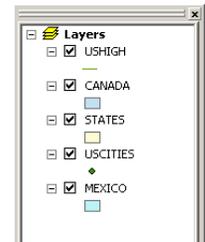


Demo 03: Vector Data Models

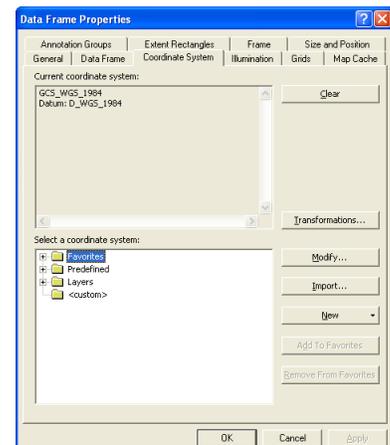
Demo 2 is intended to introduce you to the display and manipulation of vector data in the ArcMap component of ArcGIS. You should become familiar with various types of shapefiles and how to create layers in a map with them. You will also learn how to control the ways these layers are displayed. Finally, you will create selections of features based on their spatial and attribute properties.

- I. First, download the data (**Demo03_Data.zip**) for this lab.
 - a. Extract it as outlined in Demo 01. You should try to follow the naming conventions discussed in Demo 02.
 - b. Add data to a new map document.
 1. Launch ArcMap
 2. Add vector data
 - i. Select **File**→**Add Data** or click the Add Data button () on the toolbar.
 - ii. Just another brief clarification: Most vector data in ArcGIS are stored as shapefiles. (*.shp). These come in three basic “flavors” with different icons when you add each.
 - a. Points 
 - b. Polylines 
 - c. Polygons 
 - iii. Add **canada.shp**, **mexico.shp** and **states.shp** from the unzipped data; hold down the CTRL key as you click to add multiple files simultaneously.
 3. Practice using the zoom and pan tools in the tools menu to zoom in and out and move around your data frame (the sliding bars at right and on the bottom help too). Note that you can use the magnifying glasses either by just clicking, or by drawing a box. You do need to click on the “regular” arrow when you are done.
 4. Add point and polyline vector data
 - i. Add US highways and cities (**uscities.shp** and **ushigh.shp**) from the same directory.

- c. Manipulating layers in a map
 1. Layers appear in the map in the same order that they appear in the Table of Contents (left side of the window).
 - i. Move USCITIES so that its name appears below STATES.
 - ii. This layer is no longer visible because it is *beneath* another layer. Move USCITIES so that it is above the polygon layers.
 - iii. In general, you will want to display polyline and point layers *above* polygons.
 2. Layers can be turned on or off by checking the box to the left of the layer name.

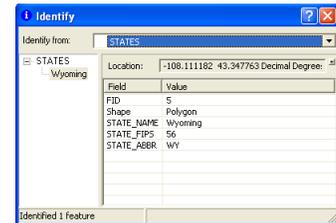


- II. Manipulating the Data Frame
 - a. There are many properties of the overall map (the data frame) that can be edited; for the purposes of this lab, we will only look at a few of these options.
 - b. To display the Data Frame properties, select **View**→**Data Frame Properties** or double click on the word Layers in the Table of Contents
 - c. **Coordinate System** tab.
 1. The coordinate system is the geographic coordinate system, i.e., latitude and longitude, UTM or State Plane; this information is encoded within the shapefile or raster
 - i. Even if it is unknown or unprojected
 - ii. We will discuss these in more detail next week.
 2. Note that vector data can be reprojected “on the fly” in this manner; raster data, because it consists of pixels instead of points, is not as flexible.
 - d. **General** tab

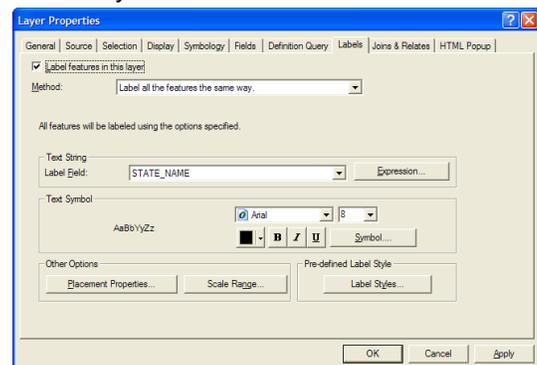


1. Here you can change things like the type of units being displayed and if you wanted to rotate the map
 2. You can experiment with changing the display to Degrees Minutes Seconds
 - e. **Data Frame** tab, lets you set a custom extent for your map. We will do this much later in the semester
 - f. **Frame** tab: lets you change the background color for the map (under Background) and a few other options we will work with when we create printable maps.
 - g. **Grids** tab lets you had a reference grid to the map.
 - h. The other tabs are less frequently used, but you can find documentation on them in the help files
- III. Displaying attribute data for a shapefile
- a. The map display shows the geographic shape of each entity, but each feature has other data called attributes.
 - b. To view a layer's attributes, you must open its Attribute table through the Table of Contents
 1. Right-click on the USCITIES layer and select Open Attribute Table.
 2. In the attribute table, each feature (represented by a point on the map) has a row; each column is a field for which there is data for each feature. In the case of USCITIES, the fields contain data for the city's name, its state, and various aspects of its population.
 3. It is possible to derive statistics from these data if they are numeric
 - i. For example, right-click the POP1990 column heading and select **Statistics...** The display will show basic statistics for this field, including sum, which in this case is the total population of all of the cities.
 - ii. If you try the same thing for STATE_NAME, you will see that the Statistics option is grayed out, because it is not a numeric field
 4. Close the attribute table and return to the map.
 - c. Displaying attributes for a single feature.

1. To see attributes for only one feature, select the Identify tool . A window will appear giving instructions and allowing you to choose which layer contains the feature(s) you want to identify. Click on the feature in the map.
2. You can dock this window just like the Image Analysis window. I like mine as a Tab on the right side.
3. In the Identify Results window, all of the fields and their values are displayed for the selected feature. In addition, the location where you clicked is displayed.
4. Note that if you try to click on a feature that is close to other features, you might accidentally click on an unintended feature. You may have to zoom in or out so that you can click on the correct feature.

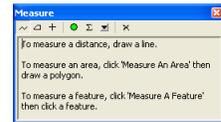


- d. Labeling features based on an attribute
 1. You can designate a field from the attribute table to be the label for the feature on the map. In this example, you will label the STATES layer.
 2. Turn off the display of USCITIES and USHIGH by unchecking the box next to their layer names.
 3. Display the layer properties for STATES by right-clicking the layer and choosing Properties (or simply double-click the layer name); then select the labels tab.
 4. Note that the field STATE_NAME is already selected as the text string Label Field. Check the box next to Label Features in the layer and click Apply. The full state name will appear centered on the appropriate feature.
 5. You might conclude that there isn't enough room for the full state name, and it would be better to use just the two-letter abbreviation. In the Label Field box, select STATE_ABBR and click OK.
 6. Once you have set the label field, you can turn labeling off by right-clicking the layer name and checking or unchecking Label Features.



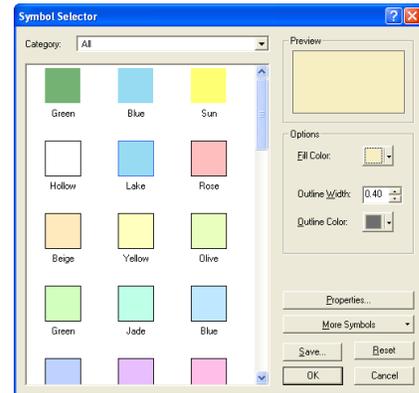
IV. Displaying distance between features.

- a. Using the measuring tool , you can manually display the distance between two or more features.
- b. In the Measure window, select the line tool, click on the first feature, then hold the cursor over the second feature. The distance will be displayed.
- c. If you click on the second feature and then hold the cursor over a third feature, the total distance and the distance of the most recent (second) segment will be displayed.
- d. Click the “x” button to reset the measure tool.
- e. Note that the displayed units are in meters. The unit of measurement for either distance or area can be changed in the drop-down list next to the sum (Σ) tool in the Measure window.

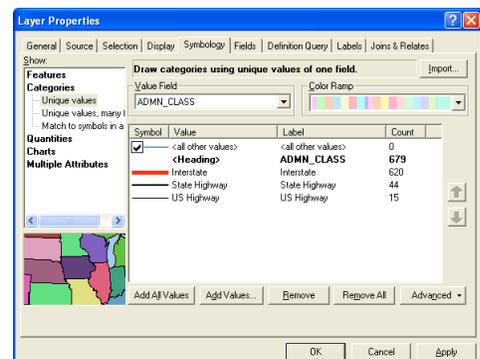
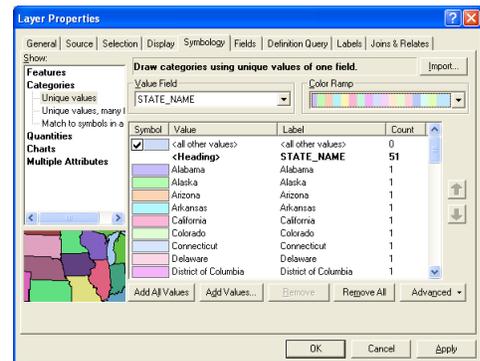


V. Manipulating the display of features

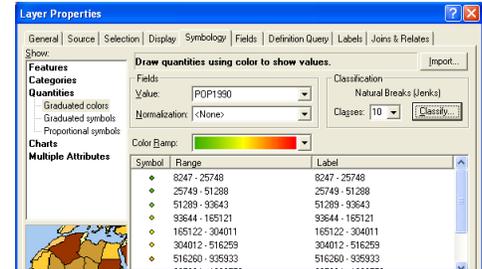
- a. Changing display properties for all features in a layer
 1. Click the symbol beneath the layer name in the TOC (a colored rectangle for polygons, a line for polylines, a symbol for points).
 2. The Symbol Selector window will appear (at right is the window for polygon layers, such as the STATES layer). In this window, you can select various fill and outline colors, line thicknesses, etc.
 3. For any layer, choose a new combination of color and line or outline thickness and click OK to see its effects.
- b. Changing display properties based on attribute data: Unique Values
 1. Right-click on the STATES layer name and select Properties... (or double-click the layer name); then select the Symbology tab.
 2. On the left, click on Categories and then Unique Values.
 - i. Make sure the Value Field is set to STATE_NAME;
 - ii. Click Add All Values to add the state names;
 - iii. Select an appealing Color Ramp;
 - iv. Click OK to see the results.
 - v. You have applied a color to the state based on the value of the STATE_NAME field; any two features which had the same name would have been displayed in the same color. This color scheme is further editable: you can edit the symbol for any individual symbol by double-clicking it (as in V.a).



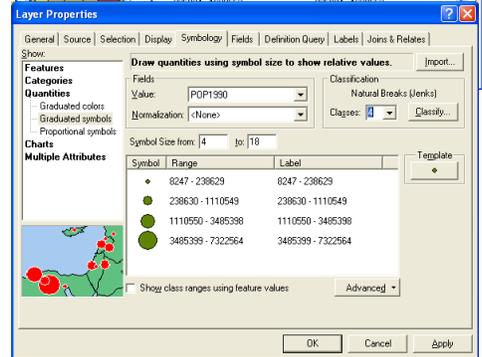
- c. Display different categories.
 1. If they are still not visible, turn back on the USCITIES and USHIGH layers.
 2. Open the Layer Properties for USHIGH and select the General tab; change the layer name to something more descriptive, like “US Highways.”
 3. On the Symbology tab:
 - i. Select Categories→Unique values;
 - ii. Set the Value Field to ADMIN_CLASS;
 - iii. Click Add All Values;
 - iv. Modify the symbols for each type of road to match the dialog to the right, or some other scheme of your choosing;
 - v. Click OK to see the results.



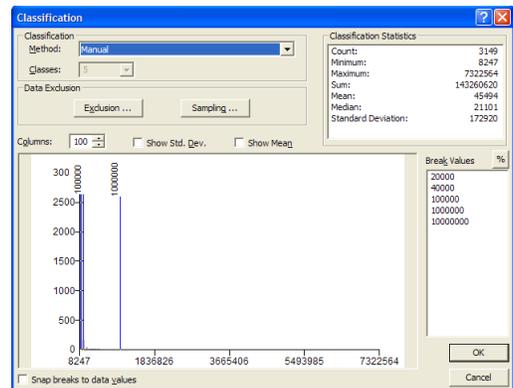
- d. Display symbols in graduated colors based on quantities
 - 1. Zoom in on New York
 - 2. Display the symbology for USCITIES
 - i. Select Quantities→Graduated Colors;
 - ii. Select POP1990 as the Value Field; a default classification (five classes based on natural breaks) is assigned;
 - iii. Change the number of classes to 10;
 - iv. Select a new color ramp;
 - v. Click Apply to see the color of the symbol represent the cities' populations.
- 3. Experiment with different types of classifications by clicking the Classify... button and changing the classification method.



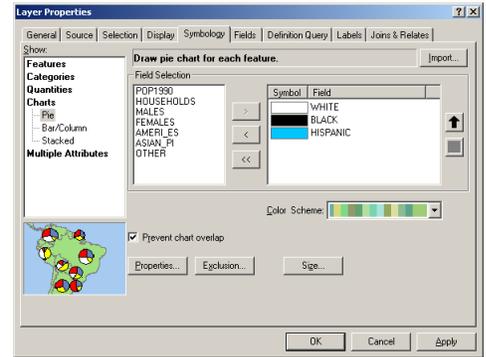
- e. Display Symbols in graduated symbols based on quantities
 - 1. In the USCITIES symbology tab, choose Quantities→Graduated Symbols
 - 2. For the value field, choose POP1990;
 - 3. Set the number of classes to 4;
 - 4. Note that you can set the range of symbol sizes (in points) and change the symbol itself by clicking Template.
 - 5. Click Apply; note that Boston's dot is much larger than anything surrounding it.
 - 6. Put HOUSEHOLDS in the Normalization field to display the total population divided by number of households (i.e., the average household size for each city). Click OK.



- f. Display graduated symbols with user-defined quantity classes.
 - 1. Reopen the symbology for USCITIES.
 - 2. Remove the normalization by resetting it to <NONE>; set the number of classes to 5.
 - 3. Click the Classify... button. Under Break Values, type in the intervals to match the window to the right.
 - 4. Click OK in the Classification window, then click Apply in the Layer Properties window.
 - 5. In the General tab, rename the layer "Urban Populations" and click OK.

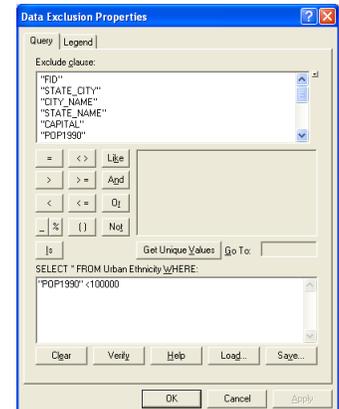


- g. Display information from multiple fields with charts
 1. Add a second version of USCITIES to your map  and turn off the visibility of the first version.
 2. Open the Layer Properties for this new layer and change its name to "Urban Gender"
 3. Select the Symbology tab, select Charts→Pie.



4. This display is a bit chaotic, so adjust the properties further to increase the interpretability of the display.
 - i. Uncheck "Prevent chart overlap" and click Apply. The lead lines that connected the charts with their geographic location are gone, and the charts are directly atop the cities.
 - ii. Click Size, change the Symbol Size from 32 to 15 and click OK. In Layer Properties, click Apply. The charts are now smaller and overlap less.
 - iii. Click Properties, uncheck Display in 3-D, and click OK. In Layer Properties, click Apply.
 - iv. To set the size of the chart based on population, click Size. Check Vary size using a field, select POP1990 as the field, and click OK. This makes Boston enormous, so you'll probably want to undo this before proceeding.

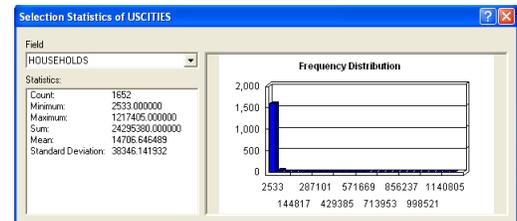
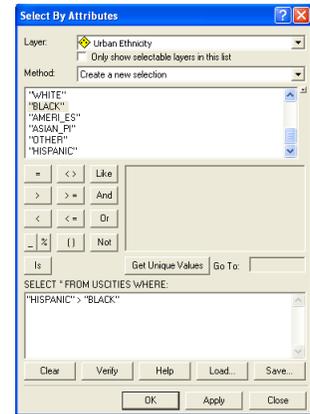
5. Excluding data based on an attribute value
 - i. Your map will be clearer if you limit the display to features with certain values, for example, only cities larger than 100,000.
 - ii. Set the projection back to one appropriate for the continental US and zoom out so that all states are visible.
 - iii. Open the symbology tab for the "Urban Gender" layer and click Exclusion.
 - iv. Build an expression by double-clicking "POP1990", then clicking the Less Than button (<) and then type in "100000". Your exclusion expression should look like the one on the right. Click OK.



6. Navigate around your map.
- h. Creating layer files
 1. Formatting layers can take a lot of time, so it is useful to save the formatting properties so that they can be applied in other maps and to other (similar) vector datasets.
 2. Right-click on Urban Gender and select Save as Layer File...
 3. Navigate to an appropriate folder on your drive and save the layer.
 4. **The layer file contains no data on its own**; it is a reference to the data file (shapefile) and the rules for displaying them.

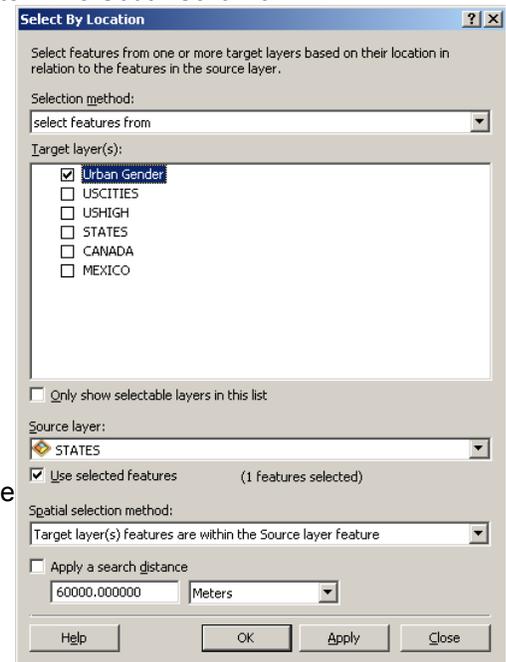
VI. Selecting features based on attribute data

- a. For example, to select all cities where Females outnumber Males, select Selection→Select By Attributes...
- b. In the Select By Attributes window, build the appropriate expression:
 1. Make sure the layer is Urban Gender;
 2. Double-click on FEMALES in the Fields box;
 3. Single-click on the Greater Than (>) symbol;
 4. Double-click on MALES in the Fields box; your expression should look like the one to the right.
 5. Click Apply; certain cities will appear in cyan, which indicates that they have been selected. Click Close.
- c. View the attributes for selected features
 1. Right-click Urban Gender and select Open Attribute Table.
 2. The selected features will be highlighted in cyan. To ignore unselected features, click Show Selected at the bottom of the window.
 3. To get quick statistics on the selected features, right-click the column heading for any numerical field and select Statistics...
 4. Counts, minimums and maximum values, sums and means, etc. are displayed. Note that these figures include cities of all populations; we excluded smaller cities from being displayed only.
 5. Close the attributes table.
- d. To clear a selection for a single layer, right-click the layer and select Selection→Clear Selected Features; to clear all selections for all layers, select Selection→Clear Selected Features.



VII. Selecting features based on their spatial location

- a. For example you might want to select all cities in a particular state. Like South Carolina.
- b. Select South Carolina with the Select Features tool .
- c. Select Selection→Select By Location. In the dialog:
 1. Under **Selection Method** it should say “select features from”;
 2. Check the box next to Urban Populations;
 3. Select STATES as the **Source Layer**
 4. Under **Spatial Selection Method**, choose “Target layer(s) features are within the Source layer feature”
 5. Check the box next to Use selected features to use the selected state (Wyoming) instead of all states.
 6. Click Apply and then Close.
- d. You can check the statistics for your selected cites (see Section III.B above). ArcGIS will always default to a using a selection over the whole file. How many cities are there? What’s their average population?
- e. Clear the selection by choosing Clear Selected Features from the Selection menu.



VIII. Working with selections

- a. It is possible to make selections based on both location and attributes. In this example, you will find how many cities with populations greater than 100,000 are within 100 miles of Washington DC.
- b. Zoom in on Washington and select it using the Select Features tool .
- c. Choose Select by Location from the Selection menu. Choose the options to match the dialog box to the right. Note that in this example, a buffer around the selected feature is being used. When you have set the options, click Apply. 161 features should now be selected. Click Close.
- d. Now create a sub-selection of the selected points based on attribute data (i.e., population greater than 100,000) by choosing Select By Attributes from the Selection menu. Compose the selection query to match the example at the far right. Make sure that the Method is Select from current selection. Click Apply and then Close.
- e. Choose Zoom to Selected Features from the Selection menu to adjust the scale and view to encompass all of the selected features.
- f. Open the attribute table for Urban Populations to see the names of the selected cities.
- g. When you are finished, save the map.
 - 1. Note that this only saves links to the shapefiles, how they are displayed and the scale and projection of the map. If you move the files, even in ArcCatalog, you will get errors

