Learning Objective

To introduce the principles and techniques of thematic mapping, including dot density, proportional symbol, and choropleth mapping, as well as data classification and basic map design. As a demonstration, you will acquire and map spatial data from the 2010 U.S. Census.

First, complete the tutorial by following the steps below. Then, using the skills you've learned in the tutorial, complete the assignment given following the tutorial.

TUTORIAL

Acquire State Population Data from the U.S. Census Bureau

1. In a web browser, navigate to https://www2.census.gov/geo/tiger/TIGER2010DP1/.
2. Scroll down and click on 'State_2010Census_DP1.zip' to download.
3. Copy the downloaded zip file into your workspace and unzip it.

Create a new project in ArcGIS Pro and view the spatial and attribute data for the State_2010Census_DP1 shapefile in the catalog view.

Convert the Shapefile to NAD 1983 Contiguous USA Albers

While in the catalog view, search for the **Project** tool and use it to convert the state data you just acquired to a new shapefile that is in the `NAD 1983 Contiguous USA Albers` projected coordinate system.

Call the new shapefile 'State_2010Census_DP1_Albers' (you can search for this CRS in the search text box). Be sure to send the new shapefile to your workspace.

Select and Export the 48 Contiguous United States

1. Insert a new map, remove the basemap layers and add the State_2010Census_DP1_Albers shapefile.
2. In the map, select all the objects in the shapefile except the following: Alaska. Hawaii, Puerto Rico, the District of Columbia. You can do this by opening the attribute table and performing a **Select by Attributes** operation, through graphical selection, through manual selection, or by

some combination. The **Switch Selection** button `Switch`, which reverses the selected and unselected records, may also be useful. **Note:** Once you have several records selected in the attribute table or in the map, you can de-select records by pressing and holding Ctrl and clicking on the records you wish to de-select.

- There should be 48 states (rows) selected.

3. Export the 48 selected states to a new shapefile by right clicking on the name of the shapefile in the **Contents** pane, going to **Data**, and then **Export Features** to open the **Feature Class to Feature Class** Geoprocessing pane.
    - For **Input Features** make sure that State_2010Census_DP1_Albers is chosen.
    - For **Output Location** choose the workspace folder for Lab 3.
    - For **Output Feature Class** call the new shapefile 'Contiguous_States.shp'
4. The new Contiguous_States shapefile should be added to the map once the export is complete. Remove the State_2010Census_DP1_Albers shapefile.
5. Zoom to the Full Extent.

Explore the Attribute Table

In the map view, open the Contiguous_States attribute table and review the field names.

- The `GEOID` field is a unique numeric code for each state used by the U.S. Census Bureau.
- The `STUSPS10` field is the two letter U.S. Postal Service code for the state.
- The `NAME10` field is the name of the state.
- The `ALAND10` field is the land area of the state in square meters.

Note that most field names use a code composed of a set of letters and numbers, e.g. `DP0010001`.

In Microsoft Excel (not ArcGIS), open the Excel file 'DP_Table Descriptions.xls', which should be located in the same folder as your original shapefile. Here you will see the definition of each of the field names in the Contiguous_States attribute table.

The fields contain measures of the population of each state, including the total population, and population counts broken down by age, sex, race, Hispanic ethnicity, and household characteristics (e.g. types of families, renters versus home-owners, etc.)

Note two other important fields we will use in the lab assignment:

- The `DP0010001` field is the total population of each state.
- The `DP0100002` field is the Hispanic population of each state.

Return to the Contiguous_States attribute table in ArcGIS.

It is often useful to *sort* the table based on a field's values, say, from highest to lowest.

As an example, you will sort the table based on the total population, where states with the highest population will be at the top and those with the lowest at the bottom.

To do this, right click on the total population field (`DP0010001`) and choose **Sort Descending**.

Note the table is now in the order of states from the highest population (California - 37,253,956 people) to the lowest (Wyoming - 563,626 people).

By repeating this step, this time selecting **Sort Ascending**, you will see Wyoming is now at the top and states are ranked from smallest to largest with respect to population.

Make an Area-Class Map of the States

1. In the **Contents** pane of the map view, right click on the Contiguous_States shapefile and choose **Symbology**.
2. The **Symbology** pane will open on the right side of the window. Click on the **Primary Symbology** tab if it is not already active. Here, we will assign a unique color to each state.
3. Change the symbology type to **Unique Values**, under **Symbolize your layer by category**.
4. For **Field 1** choose `STUSPS10`. Your map window will automatically reflect the new symbology.

You should see a map that looks something like this:
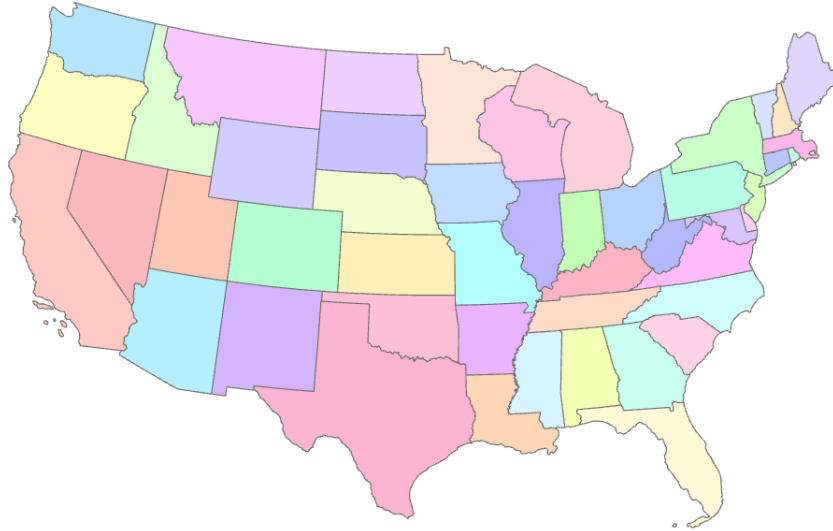
Add State Name Labels

Now, we will set our preferences to label each state with its appropriate two letter code.

1. Click on the Contiguous_States layer in the **Contents** pane, then click on the contextual **Labeling** tab on the ribbon.
2. In the **Label Class** group, for **Field**: choose STUSPS10.

Now, we will display the state code labels.

3. Click the **Label** button to turn on labeling for the states layer.

Labels of the state code (e.g. PA for Pennsylvania) should appear on each state.

Make a Proportional Symbol Map of Total Population

1. Turn off the **Label Features** option so the labels do not appear, by right-clicking on the Contiguous_States shapefile in the Contents pane and clicking **Label** to toggle the labels off.
2. Open the symbology for the states layer.
3. Change the symbology type to **Proportional Symbols**, under **Symbolize your layer by quantity**.

4. For **Field**: choose the field that contains the total population - `DP0010001`.

You should see a map that looks something like this:
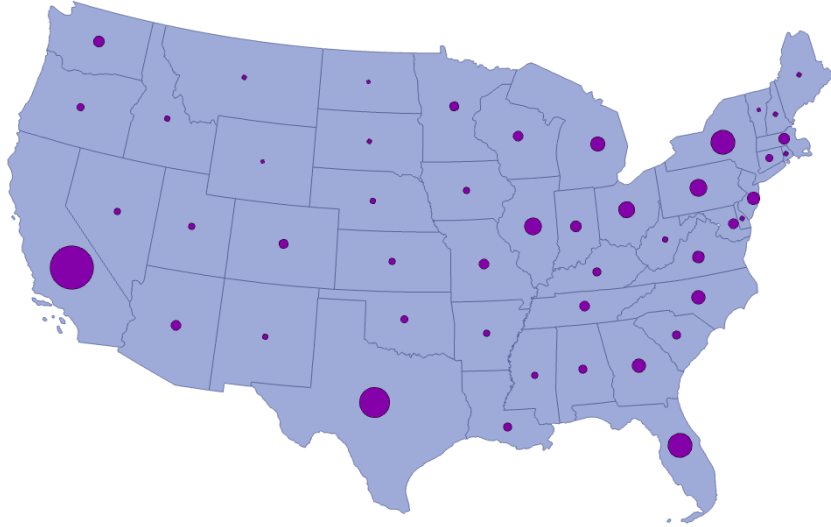
On the **Symbology** pane, clicking on the glyph next to **Template** allows you to customize the proportional symbol. You can also customize the background of your polygons by clicking on the box next to **Background**. Additionally, you can adjust the minimum and maximum size of your point symbols so that they are visible, yet completely contained within the polygons they represent.

Experiment with different background colors, symbol colors, and symbolization to change the look of the map. Cartographers recommend sizing the symbols so that they overlap slightly in the densest part of the map (which for maps of the continental U.S. will usually be the high population density Northeastern states).

Make a Dot Density Map of Total Population

1. Open the symbology for the states layer if it is not already open.
2. Change the symbology type to **Dot Density**, under **Symbolize your layer by quantity**.
3. In the first selection box under **Fields**, choose the field that contains the total population.

You should see a map that looks something like this:
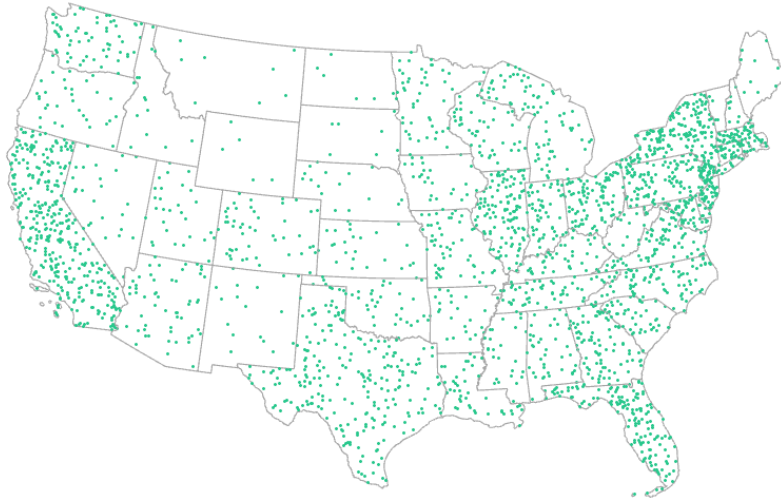
Note the dots may be faint depending on the color scheme you've chosen (or defaulted).

On the **Symbology** pane, clicking on the glyph next to your field name allows you to customize the dot symbol. You can also customize the background of your dots by clicking on the box next to **Background**. Additionally, you can change the dot size and value in the options in the middle of the pane.

Experiment with different background, size, value, and color symbolizations to change the look of the map. Make sure the least populous states have two to three dots, and that the dots coalesce in, but don't completely cover, the most populous states.

Make a Choropleth Map of Population Density

1. Open the symbology for the states layer if it is not already open.
2. Change the symbology type to **Graduated Colors**, under **Symbolize your layer by quantity**.
3. For **Field**: choose the field that contains the total population.

Here, we will map the population density - the total population divided (or 'normalized') by the land area of each state. The population density yields a measure of people per unit area (e.g. people per square mile). Thus, population density shows the concentration of population, accounting for the fact that given two states with the same total population, if one is much larger in area than the other, the population will be more sparsely distributed on average.

4. To map population density, place total population (`DP0010001`), under **Field**. Under **Normalization** choose the field that contains the land area of each state - `ALAND10`. This will map the value of each state's total population divided by its land area (in square meters). The units you see in the map are therefore people per square meter.
5. For **Method**, choose **Quantile**.

A **Quantile** classification keeps approximately the same number of records (states) in each class regardless of the range of the attribute values.

The bottom box of the pane shows the classes generated by this method and the symbols, values, and labels of each one.

Classes	Histogram	Scales

More ▼

Symbol		Upper value ▲	Label
🟨	▾	≤ 0.000013	≤0.00001347
🟧	▾	≤ 0.000026	≤0.00002621
🟧	▾	≤ 0.000059	≤0.00005941
🟥	▾	≤ 0.000109	≤0.0001090
🟥	▾	≤ 0.000462	≤0.0004616

The **Histogram** tab of this box shows you a histogram of population density values.
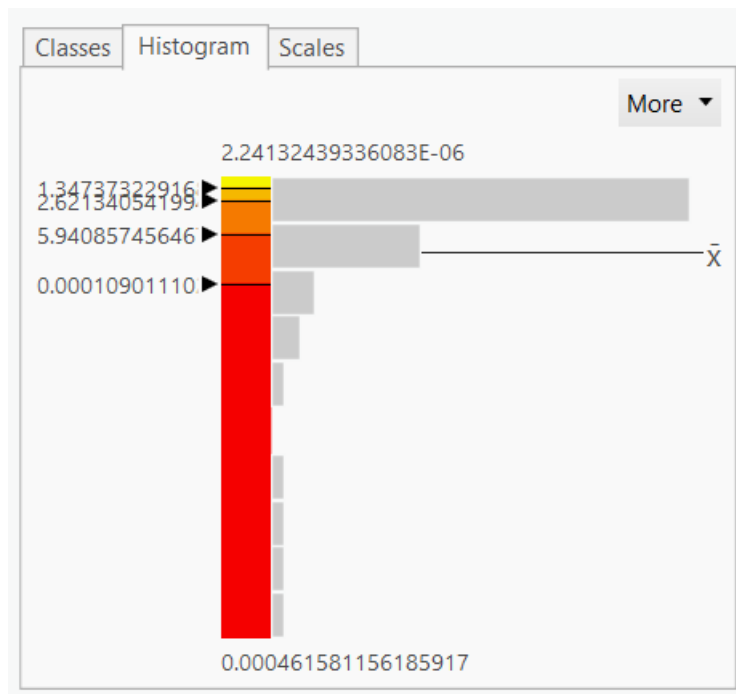
Break values for the different classes are reported as black lines in the histogram and in text on the left side of the box. These are generated automatically by the classification method you choose (here, **Quantile**).

You can also change these manually by dragging the black lines or entering numbers as text in the **Upper value** boxes of the **Classes** tab (though this would change the classification scheme from **Quantile** to **Manual**).

6. You can also choose a different color ramp under **Color Scheme**. Choose a blue sequential color scheme.

You should see a map that looks something like this:
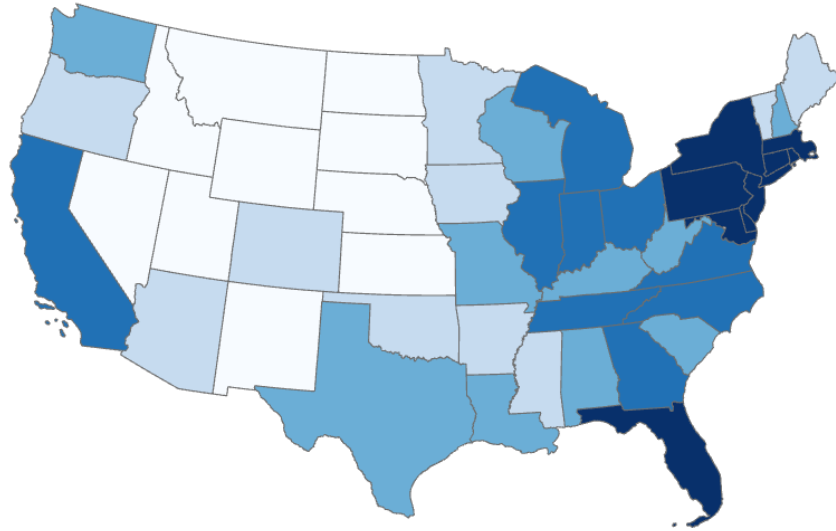
On the **Symbology** pane, experiment with the equal interval and natural breaks data classifications. Note that the classification schemes can represent the underlying data in dramatically different ways.

Experiment with creating your own data classification by manually changing the class break values by grabbing and moving the black lines shown on the histogram.

For each data classification you choose, note the differences in the class breaks as expressed on the histogram and consequently the changes in the map.

You can also experiment with different color ramp options. Note, however, that only sequential or diverging color schemes are appropriate for continuous data such as population density.

Design a Map Layout

Once you have created a map of population density with an appropriate data classification and color scheme, you can design a map layout and add other essential elements such as a legend, scale bar, etc.

1. Insert a new layout with a landscape orientation.
2. On that new layout, insert a map frame.
3. Insert a legend onto the map frame by clicking the **Legend** button on the **Insert** tab, then double-clicking on the map frame to place the legend.

Note that the legend is a graphic object that can be grabbed and moved, changed in size, etc., as is the map frame in the layout.

It is also related to the legend in the **Contents** pane. If you change the symbolization in the map view, the legend will automatically adapt.

For instance, let's change the number of displayed significant digits in the population density to make them easier to read.

4. Open the symbology for the states layer and click on the **Advanced symbol options** tab. Expand the **Format labels** section.

5. Under **Rounding**, change the number of decimal places to 5.

Notice the change in the both the **Contents** pane and the legend.

In order to format the legend properly, it is often easier to break it into smaller graphic pieces. **Note, however, that this also breaks the relation to the legend in the Contents pane. If you change the layer properties and want the legend to reflect the new symbolization, you will have to delete the graphics-converted legend and add a new legend based on the layer.**

6. Select the legend in the layout, right click on it, and choose **Convert to Graphics**.
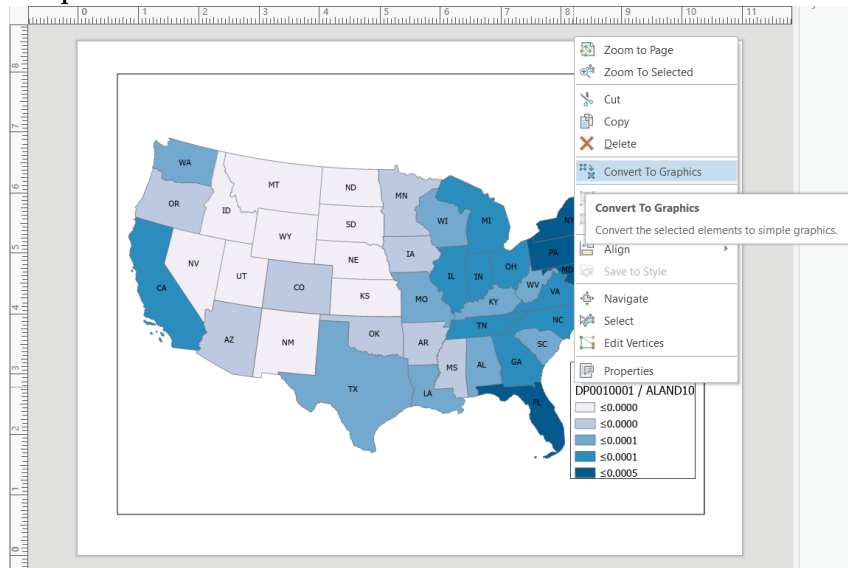
7. Then, right click on the legend again and choose **Ungroup**. This will break the graphic into its graphic and text components.

Double-clicking on a text object allows you to edit the text. Double-clicking on a graphic object allows you to edit the color and size of the object.

Alter the legend so it appears something like this:

People per square meter

≤0.00001
≤0.00003
≤0.00006
≤0.00011
≤0.00046
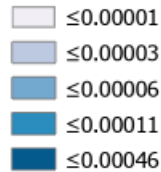
8. Insert a scale bar by going to the **Insert** tab and choosing **Scale Bar**.

9. Clicking on the button will choose the default scale bar, or you can pick from other options by clicking the down arrow to open the menu.
10. Once the scale bar is chosen, click on the map where you would like to place it.

The scale bar is related to the zoom of the map frame, so if you activate the map and change the scale of your map (i.e. zoom in or out), the scale bar will also change automatically.

11. Grab and change the size of the scale bar so that it has a round number (e.g. 1000 miles across).
12. Insert a North Arrow by going to the **Insert** tab and choosing **North Arrow**. Like the scale bar, clicking on the graphic button will select the default North Arrow, but you can click the down arrow for more options.
13. Click anywhere in the layout to place the North Arrow you have chosen.

You can also insert a title by going to the **Insert** tab and choosing a text option from the Text group. The default option is **Rectangle**, which creates a text box that can be resized to fit more text but will retain the same font size. The **Text** option creates point text that will change size when the object is resized. Either can work for a title, but the point text may be easier to manipulate.

Drawing tools to insert shapes and other graphic objects are available in the **Graphics** section of the **Insert** tab. These behave similarly to graphics handling in many other software packages, such as MS Word.

Arrange the legend, scale bar, and North Arrow aesthetically and efficiently on the map. A simple and reasonable layout could look something like this:

Population Density by State in the Contiguous U.S.
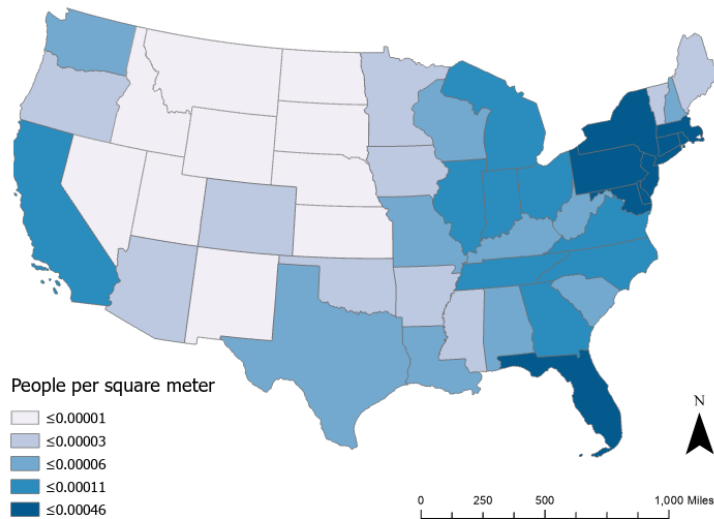
You can export your map as an image file so that it can be inserted in other documents, such as a MS Word document or MS Powerpoint presentation or posted to a website.

To export your map go to the **Share** tab and choose **Layout**.

In the **Export Layout** pane you can give the image file a path and file name and choose a format. A common image format is .png, though .jpg, .eps, and other formats are available. A .png resolution of 300 dpi is advisable for use in your lab reports for this course.

ASSIGNMENT

Objective

Describe the spatial distribution of the Hispanic population in the contiguous U.S. by state, according to the 2010 U.S. Census.

Deliverables

Turn in a report in the format described in the syllabus.

Be sure to include the following information:

1. The five states that have the highest number of Hispanics, and the Hispanic population of each.
2. The five states that have the lowest number of Hispanics, and the Hispanic population of each.
3. The states whose Hispanic population is greater than the total population of the least populous state in the U.S.
4. A proportional symbol map or a dot density map that shows the distribution of the number of Hispanics in each state.
5. A choropleth map, using a sensible data classification of your choice, that shows the percentage of Hispanics in each state.

The **Introduction** section should state the research objective.

The **Data and Methods** section should state the data sets used in the analysis, from where those data were acquired, the GIS operations employed, and the mapping techniques employed (i.e. state and justify why you chose specific mapping options, such as the type of map, color scheme, the particular data classification for your choropleth map, and so on).

The **Results** section should state the results, i.e. a description of the spatial distribution of Hispanics in the U.S. – where in the U.S. do Hispanics tend to concentrate and where are there few Hispanics? Be sure to include the five pieces of information listed directly above. The two maps should be cited in the text here (e.g. Figure 1, Figure 2).

The **Discussion** section should interpret your results by briefly interpreting why Hispanics may be concentrated in particular states and regions of the U.S. State the limitations of the analysis (e.g. looking at the state level may not reveal within-state variation in Hispanic population), and how this analysis might be improved (e.g. by examining county level data).

The **Figures and Tables** section should contain the proportional symbol/dot density and choropleth maps, each on a separate page and with a caption. The maps should be cited in the text.

Getting Started

All the data and operations you need to complete this assignment are described above.

You will need to identify the field in the attribute table that contains the Hispanic population (it is noted above in this lab document). The field names can be confusing – be sure to carefully select the correct field!

You can use the **Sort Descending** option in the attribute table to identify the states with the highest and lowest Hispanic population.

To create a choropleth map of the percent Hispanic population for each state, you can use the **Normalization** option in the layer symbology to map the Hispanic Population / Total Population (which yields the percent of the total population that is Hispanic in each state).