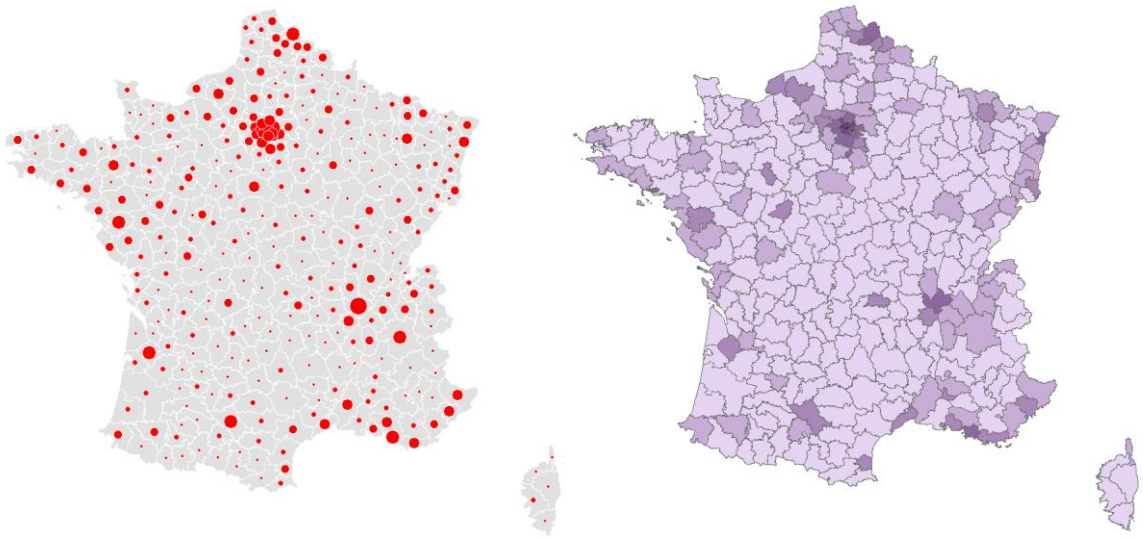
Introduction to Quantitative Cartography

Written by Patrick Florance for ArcMap 10.8.1. Second edition. 1/29/2021. Last updated by Marcia Moreno-Baez. 8/25/2021



Introduction and Objectives

In this tutorial, you will learn how to use the basic cartography tools for visualizing quantitative data to identify patterns. The way we use GIS can have great impact on the way we visualize, understand, and address problems and this is important because data visualization becomes a tool for communicating data sets and metrics into maps, charts, graphs and other visuals.

Cartography is a form of communication. For example, in cartography, the resulting representation of data makes it easier to identify and share spatial trends and new insights about the information presented. The communication is largely visual and relies on various, but stringent, application of rules and guidelines. While language is a less visual form of communication, it is useful to use the concepts of grammar and syntax as they relate to cartography. Unlike language, maps and cartography involve iterative and complex decisions about what to include on the map and how it should be included.

The learning objectives for this exercise are:

- Explore graduated symbols and graduated colors to represent quantitative data
- Describe data normalization
- Identify the different data classification methods
- Describe what color models are
- Describe the purpose of legends, scale bars and additional text needed to make a map

Data Sources

You will use data from the 2015 National Census of France.

France administrative boundaries - *Institut national de l'information géographique et forestière* (IGN); National Institute of Geographic and Forest Information of France
https://geoservices.ign.fr/documentation/diffusion/telechargement-donnees-libres.html

File names:

- *Admin00 - la République*
- *Admin01 - les Régions*
- *Admin02 - les départements*
- *Admin03 - les arrondissements*

France Census 2015 & 2019 - *Institut national de la statistique et des études économiques* (INSEE); National Institute of Statistics and Economic Studies
https://www.insee.fr/en/accueil

Natural Earth via the M: drive
https://www.naturalearthdata.com/

File names:

- *ne_10m_admin_0_countries_subset* – A subset of the original data; countries surrounding France.
- *ShadedRelief.lyr* - Shaded relief

Download Exercise Data

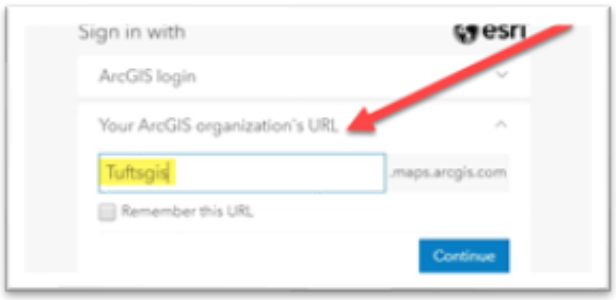
1. If you have not already done so, you will need to download and unzip the tutorial data into a folder on your Box drive. Do not include any spaces, hyphens or characters other than letters in the folder pathway names.
2. The data is saved here: https://tufts.box.com/s/07utoz3o3gfq2etdlnx66zwu1tkxh2qa
3. Right click on the *IntroQuantCart_Data.zip* file → 7 Zip → Extract All. Alternatively, you might not have 7-zip installed so just look for Extract here or Extract All or something similar. This unzips all the components that are contained within this GIS folder so you can use them in ArcGIS Pro.

Starting an ArcGIS Pro Project File

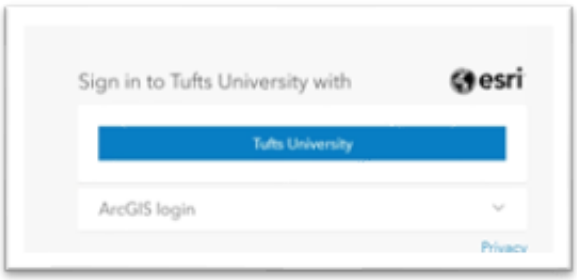
Identify where you will be saving all GIS data and project files. You have several options including **Tufts Box, your H Drive** (for Tufts students), **your Desktop or Documents folders** (if it's a personal computer) or an **external drive**. If you plan to use Tufts Box, you MUST be logged into **Box Drive** before starting the tutorial.

1. Open ArcGIS Pro and Sign In link in the top right to sign in with Tufts Organization's license.

2. Click **Sign in with <u>your ArcGIS Organization's URL.</u>** Type in **Tuftsgis.** If this is your personal computer, click **"Remember this URL".**



3. Click Sign into Tufts University with **Tufts University.** Enter your **Tufts Username** and **Password** and go through Duo Authentication.



4. Once you are signed-in, click on the option to start with a new blank **Map.**
5. Name your project "**IntroQuantitativeCarto".** Under *Location*, click on the **folder icon** and navigate to where you want to save your project.

   Note: this tutorial will use <u>Tufts Box</u>; alternatively, you might save it elsewhere such as the H drive or a USB.

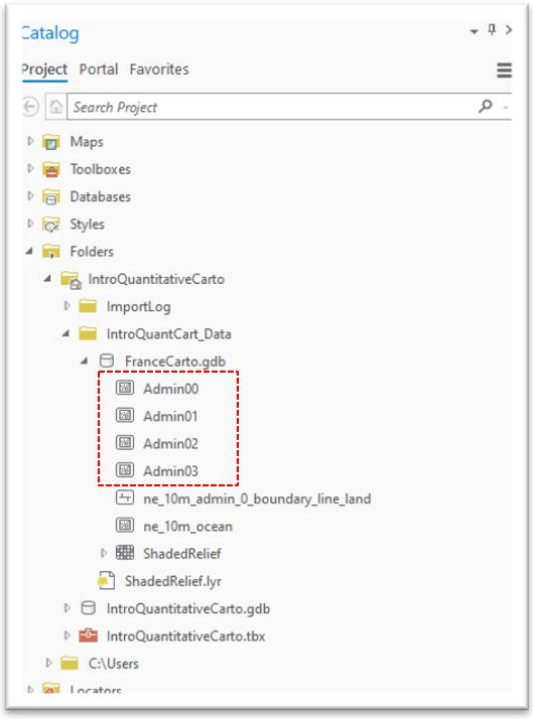
   Make sure **Create a new folder for this project** <u>is checked</u> so that it creates a sub-folder for this activity.

   Press OK.
6. A new blank map will open. On the left, you will see your **Contents** pane. That shows all layers currently in the map (in this case, nothing other than a base map). On the right, you will see the **Catalog** pane. This is where you can access everything associated with this project, including GIS data, saved maps, toolboxes, etc. Double click on **Folders** and you will see your connection to the *IntroQuantitativeCarto* Folder in Tufts Box.

Add data to your project

1. Find your Folders connection in the Catalog pane and navigate to where the downloaded material is. On the right side in <u>Catalog</u>, right click on the folder "*IntroQuantCart_Data*" and press **Refresh.** This will allow us to see any new geodatabases, files or folders added to our project.
2. Take a few minutes to add the files to your project and explore the spatial data, including the attributes that are available within each layer
3. Navigate to your unzipped tutorial data and add the following feature classes from the *FranceCarto geodatabase* to your ArcMap project:

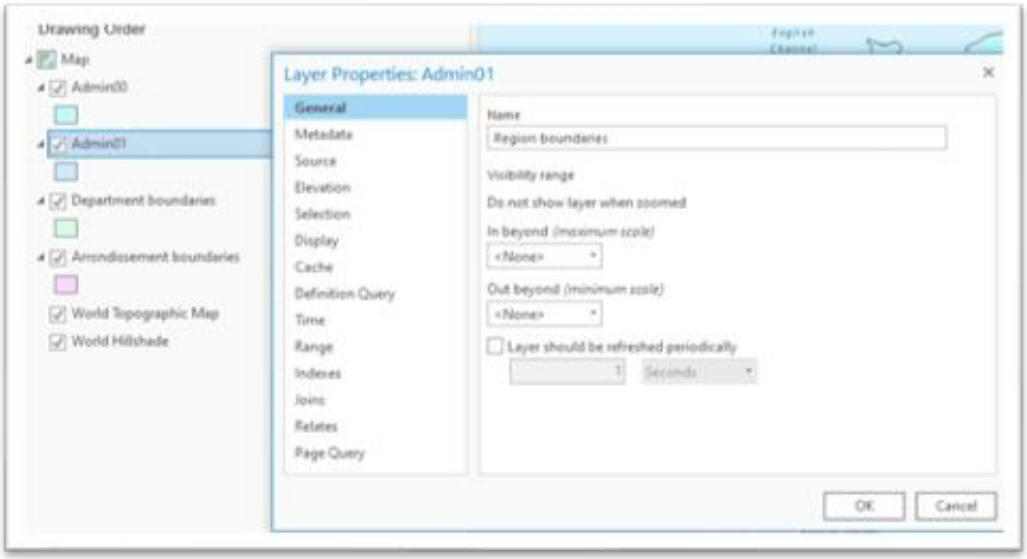
- *Admin00*
- *Admin01*
- *Admin02*
- *Admin03*



Note: you can add those four files at the same time by selecting them all (press the shift key) and dragging them to your map.

Map Project Preparation

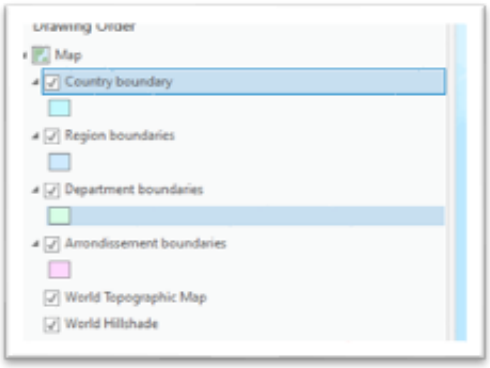
1. Rename your data layers. Select the individual data layer in the Table of Contents then click again to begin editing the layer name text. Alternatively, you can right click in each one of the **layers > Properties > General** and change the name under the *Name* section.

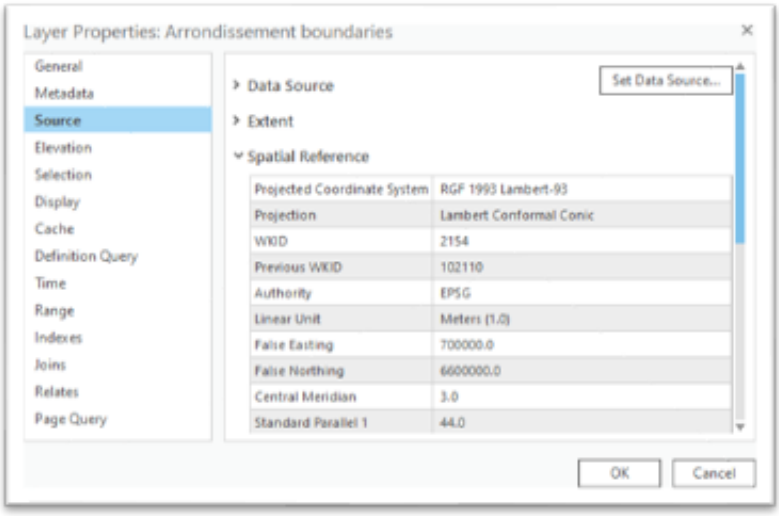


Enter the appropriate text as follows:

File Name	Rename
Admin00	Country boundary
Admin01	Region boundaries
Admin02	Department boundaries
Admin03	Arrondissement boundaries

2. Arrange the order of your data layers as follows and Save.
3. Spend a few minutes turning on (displaying) your data layers and opening and examining the attributes of each data layer. Specifically examine the attributes of the *Arrondissment boundaries* as you will use this layer extensively in this exercise.
4. Take note of the map projection/coordinate system of your project. Right click on **Layers** data frame in your **Contents** pane and select **Properties > Source > Spatial Reference**.
5. Projected Coordinate System: **RGF 1993 Lambert-93;** Projection **Lambert Conformal Conic**. This is a national projection for France.





Graduate Symbols & Graduated Colors

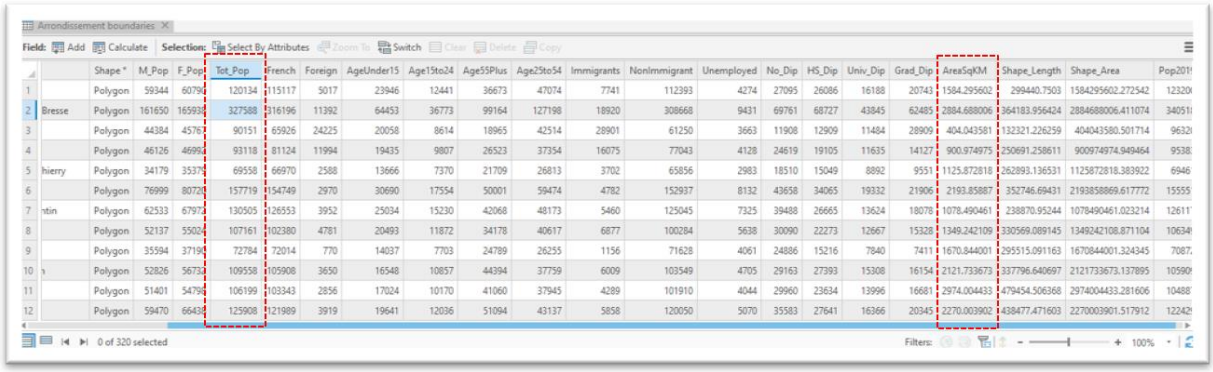
Visualizing Population

In this section we will explore two techniques for visualizing population:

1. **Graduate Symbols** for Total Population
2. **Graduated Colors** for Population Density (total population / area of administrative unit)

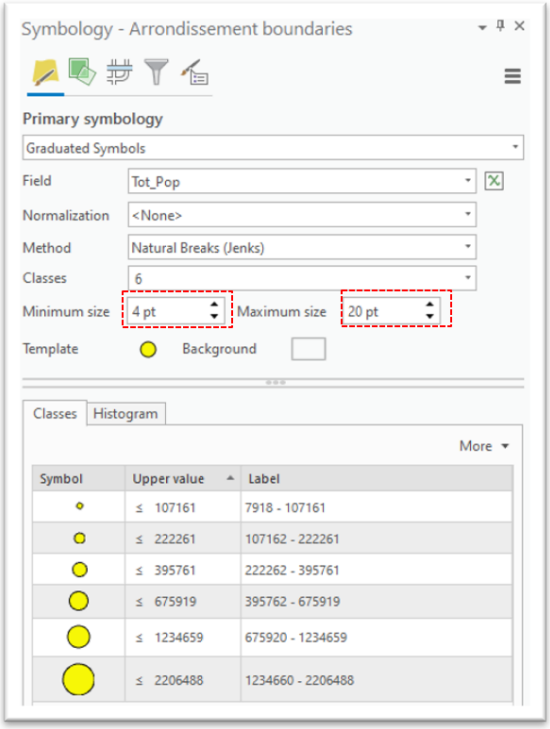
First, you will need to determine what attributes you will use to visualize French population. Open the attributes of the *Arrondissment boundaries* and note all the different fields. Most of these fields are derived from 2015 French Census data. The two fields you will use are:

- *Tot_Pop* – 2015 total population by arrondissment
- *AreaSqKm* – 2015 area of each arrondissment

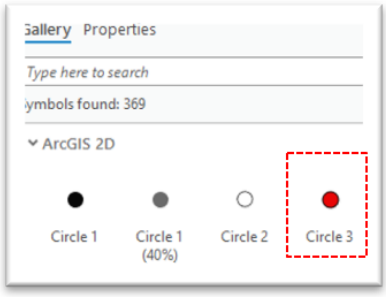


Use of Graduated Symbols to Visualize Total Population

1. Open Symbology – right click on the layer *Arrondissment boundaries* > **Symbology** tab.
2. From the Symbology Properties window, select **Graduated symbols**.
3. Then select the field from the drop-down menu you want to map: **Field** = *Tot_Pop*
4. Change the number of **Classes** to 6 and change the **Symbol Size** from 4 to **20**. For now, keep the default *Natural Breaks (Jenks)* classification method.
5. Next you will change the symbol color and the background color. Click the circle **Template**.
6. It will take you to **Gallery**.

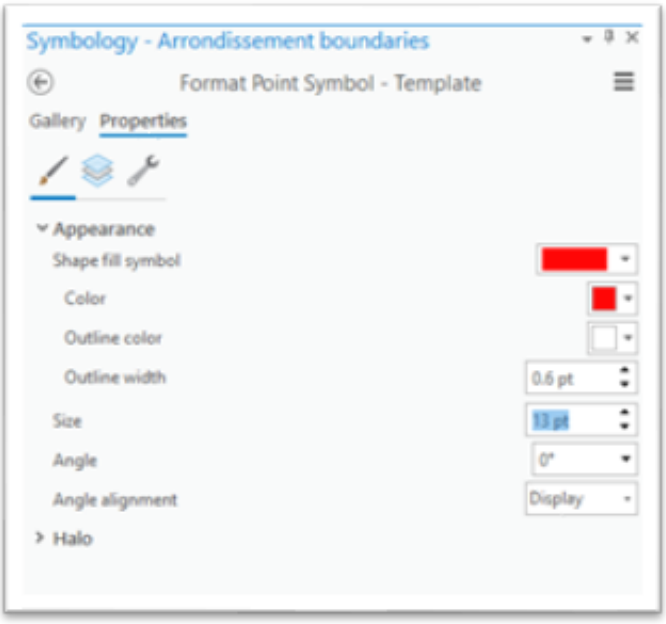


7. First, select the Circle 3

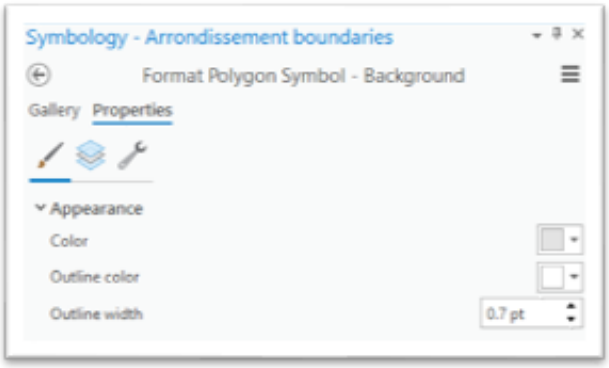


8. Next, go to Properties (the tab besides Gallery) and pick the **Color** to *Mars Red;* and the **Outline color** change it to *White*.

The use of a white outline will allow the circles to be differentiated from each other, but will reduce the outline from competing with the foreground of the red circle. A black outline will be too prominent and compete with the red circle in the foreground.



9. Click **Apply**.
10. To change the background color of the *Arrondissment boundaries*, go back to Primary symbology. Besides **Template**, click **Background**. The tool will take you again to the **Gallery**. On the **Properties** tab, click **Color** and select *Gray 10%* for the fill color. Then click **Outline Color** and select *Arctic White* for the boundary outlines. The light gray fill color and white outlines will ensure that your red graduate circles occupy the foreground and the light gray the background. You want to avoid a bright color for the background as it will compete with your data color

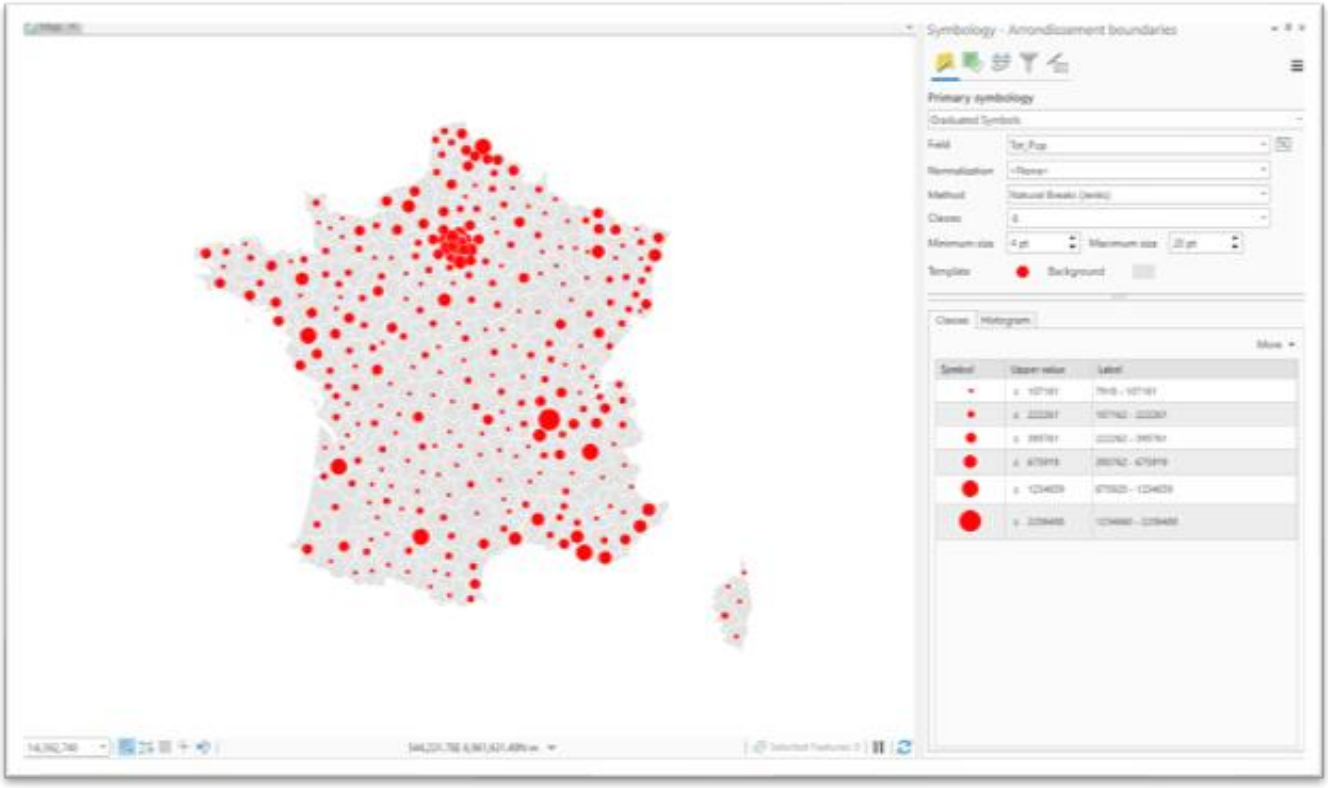


in the foreground, making the map more difficult to comprehend. You always want your data occupying the foreground.

11. Click **OK** and then **OK** again to return to your Data View window and examine your results.

Note: If you want to uncheck (turn off all) layers listed in the Contents at once, you can hold Control and click the checkbox. That will turn them all off. If you want to turn off all but keep one layer on, you can hold Alt and click the layer of interest to turn the rest off. Leave only the *Arrondissement boundaries* on.

Look at different areas of the map and assess the effectiveness of this technique in those areas. Feel free to try different symbol sizes and colors.

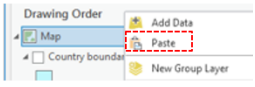


12. Save your project.

Use of Graduated Colors to Visualize Population Density

First, we will use the same layer: *Arrondissement boundaries.* However, we will make a copy of it such that we can keep the one we just worked on.

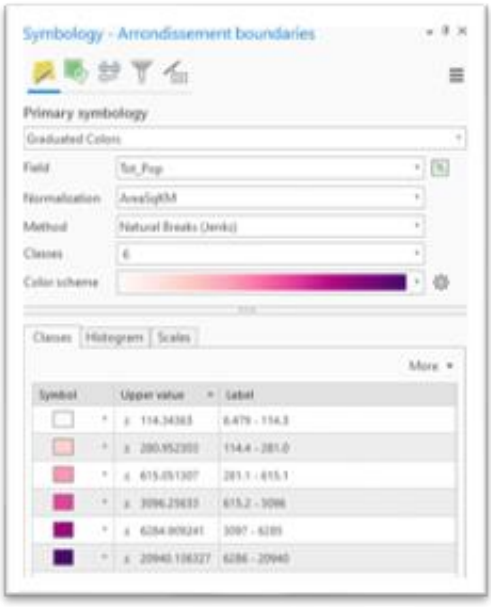
1. Right-click on the *Arrondissement boundaries* layer in your contents pane and select **Copy** from the pop-up list menu (first option).
2. Now, right click on Map > **Paste**



This will create a virtual copy of your *Arrondissement boundaries* at the top of your *Table of Contents*. You will use this copy to create a graduated color map of population density and compare it to your graduate circle map.

Note: This does *not* copy the data in the geodatabase. Rather, it duplicates the layer in the ***.aprx** document (ArcGIS Pro project), allowing you to query its attributes and changes its symbology without affecting the original layer.

1. Open the **Symbology Properties** for your new *Arrondissement boundaries*
2. Change the follow settings (see graphic example below) then click **OK**.
    1. **Primary symbology**: Graduate Colors
    2. **Field**: *Tot_Pop*
    3. **Normalization:** *AreaSqKM* – this divides the total population of each arrondissement by the area of the arrondissement, calculating the population density (number of people per square kilometer) for each arrondissement.
    4. **Method:** Keep the default *Natural Breaks (Jenks) classification*.
    5. **Classes:** *6*.
    6. **Color scheme:** select a sequential, single-color model



> ***Normalization (statistics):***
>
> For this particular case, we refer to normalization to name the process of dividing one numeric attribute value by another to minimize differences in values based on the size of areas or the number of features in each area[1].

When creating a graduated color map, it is critical to apply this process. This is because the area of the administrative boundaries varies significantly which skews the total count of the data. By calculating the number of people per area for each administrative boundary, you can now compare one administrative boundary population to another. **When conducting analysis with data by administrative boundaries, you should always normalize your data prior to performing your calculations.**

A. **Total Population** is normalized by **Area** of each administrative unit.
B. A **Portion of the Population** (Male Pop, Female Pop, Children Pop, etc.) is normalized by the **Total Population** of each administrative unit - calculating a **Percentage of the Population**, i.e., Percentage of Female Population.

3. Rename the two Arrondissement layers to **Graduated Symbol Map of Total Population** and **Graduated Color Map of Population Density** accordingly.

[1] https://support.esri.com/en/other-resources/gis-dictionary/term/98036b80-f66d-4fb1-a0d2-89aaa9cfd2bb

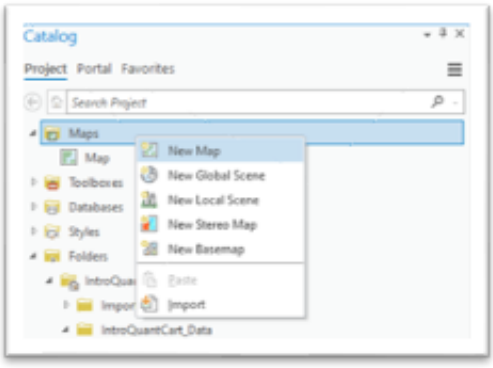
4. **Save** your project.

Linking 2 views

In ArcGIS Pro, you can use multiple views to see spatially related content side by side. If we want to examine both maps at the same time we can either turn on one follow by turning on the other one or, you can synchronize two views by linking them together. But first, we need to create a new Map.

1. Go to **Catalog**.
2. Go to **Map**. Right click. **New Map**.

You will see a new map (Map 1) added to your project.



3. Go back to your Map and **copy** the *Graduated Color Map of Population Density*.
4. Return to your Map1 and **paste** the map.

ArcGIS Pro will automatically take you (**zoom in**) to your data.

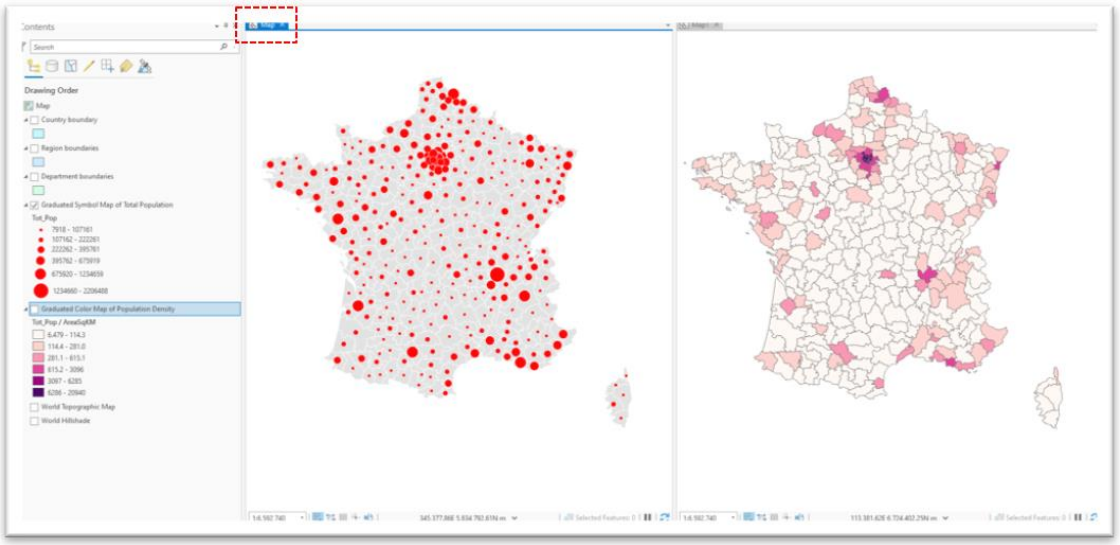
If we want to examine the new **Graduated Color Map of Population Density** and compare it to your **Graduated Symbol Map of Total Population** we can place them side to side.

1. Click the **Map1** tab (keep the click hold) and drag it to the center of the scene. A docking icon appears
2. Drag the **Map1** over either the left or right docking icon tab, and then release it to dock the window.

Note: Your map views may look different depending on the extent that your views were when you docked them.

Additional Note: If the map disappears, just open it again from the Catalog Pane.

3. On the **View** menu, in the **Link** group, click the **Link Views** down arrow and choose Center And Scale. You can turn off the base map such that both maps appear only with the data we are visualizing. Also notice that you will see the layers of the Map is active (the tab in blue, see image).



- *How is each technique effective? How is each less effective?*

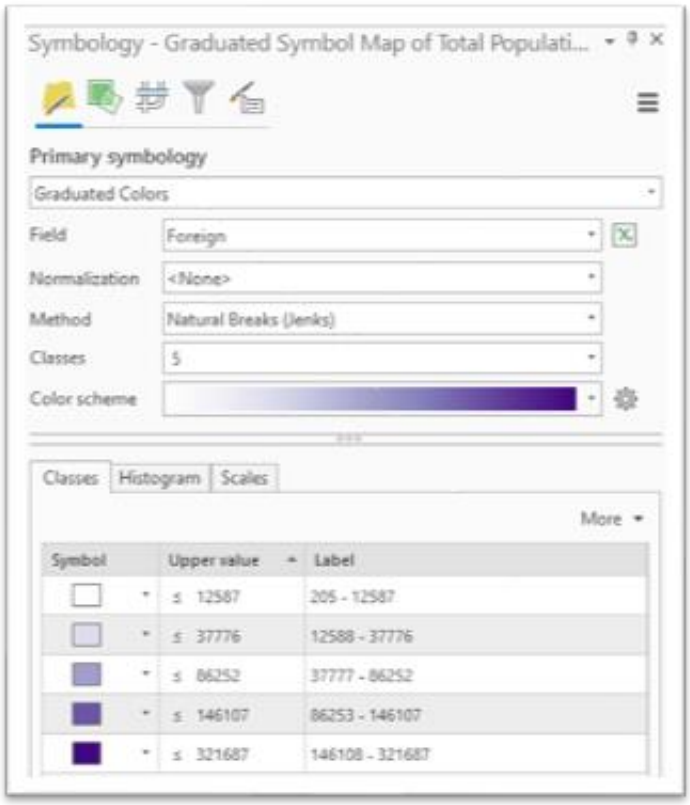
4. Using the skills that you learned earlier, pan either the map or the scene.
5. When you change the extent on one linked view, the other linked view automatically updates to match it.

Graduate Colors to Visualize Percentage of Foreign Populations

Make another virtual copy of your *Arrondissement boundaries* layer using the copy and paste method.

Open the **Symbology Properties** for your new *Arrondissement boundaries*. Be sure **Graduate Colors** is selected as the **Primary symbology** and change the following settings:

1. **Field**: *Foreign*
2. **Normalization:** *Tot_Pop* – This divides the **Total Foreign-Born Population** of each arrondissement by the **Total Population** of the arrondissement, calculating a **ratio (percentage) of Foreign-Born People** for each arrondissement.
1. **Method:** Keep the default *Natural Breaks (Jenks) classification*.
2. **Classes:** *6*.
3. **Color scheme:** select a sequential, single-color model



It is critical that you normalize the foreign-born population by total population because the total population of each arrondissement varies significantly. Areas with significantly higher total population will have higher totals of segments of the population (foreign-born, male, female, children, etc.). Total Population is essentially skewing your data. By normalizing your total foreign-born population by total population for each arrondissement, you can now compare one arrondissement to another.

Data Classification

Symbol color or size are an effective way to represent differences in magnitude of a phenomenon because it is easy to distinguish variations. However, for symbol color works better when if there are relatively few classes.

A range of seven colors is the approximate upper limit of colors that can be easily distinguished on a map. Avoid using too many classes, especially if you are using light colors. Although symbol color is applied from a color scheme, you can always do modifications for each symbol class.

The Primary symbology tab, has three subtabs to establish graduated color symbology:

- The **Classes** tab is where you manage symbols, manually assign values to classes, create descriptive labels, and group the symbol classes.
- The **Histogram** tab is where you view and edit the data ranges of the symbol classes.
- The **Scales** tab is where you specify the scale ranges in which each symbol class draws.

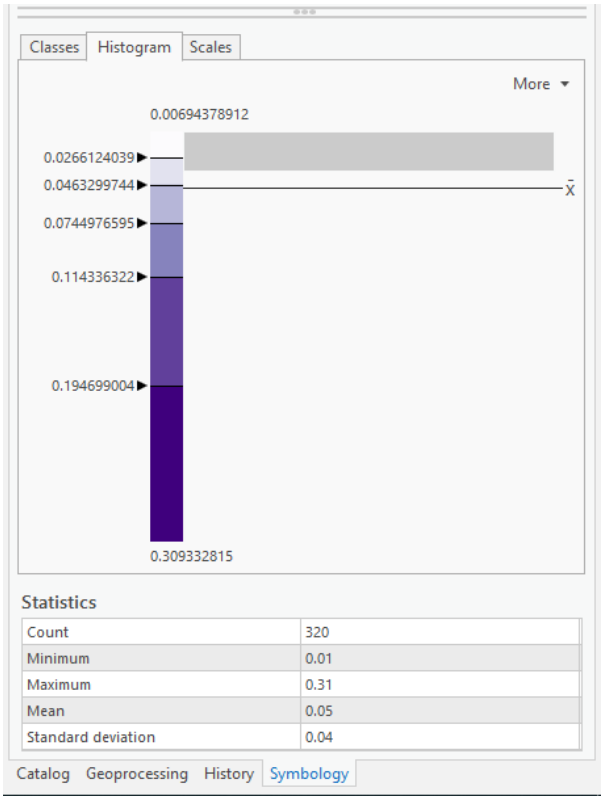
Currently there are **6 classes** selected with the default **Natural Breaks (Jenks) classification method**. The class numbers (1-6) have been added to the graphic above. The Classification window allows you to see how your data values are distributed into the different classes.

In order for us to see the frequency distribution of data of a single variable, we need to look at the **histogram**:

1. Click on the tab **Histogram**
2. On the upper right side of the histogram, click on **More** and select **Show Statistics**

As you can see, the data distribution of % of Foreign-born population is NOT a **normal distribution** but is **skewed** (see sample distributes below). Most of France has a low % of foreign population, but a few areas have a very high % of foreign population.

Note: To view the distribution of the data more easily, drag the expander bar above the histogram upward to make it larger in the pane.



3. Click the classification **Method** drop down menu and select **Equal Interval** classification method. Note how the distribution of your data values dramatically changes into the new classification scheme.

Equal Interval divides your range of data values (minimum to maximum) by the number of classes selected (6 in this example). Note how most your data values are distributed into the first class with very few data values populating the 4, 5, and 6 classes. **Equal Interval** classification is most effective for **Normal Distributions** of data; however, this distribution is **Right skewed** (look at the **histogram**) so the data values are grouped into classes disproportionally. As a result, it is not an effective classification scheme for your data.

4. Try two additional classification methods with this data

- **Quantile** – Divides the distribution so that an equal number of features reside within each class. An issue is that class breaks can occur between data with very similar values.
- **Defined Interval** – You determine your classification intervals and the number of classes adjust accordingly. Effective with a normal distribution.
- **Geometric Interval** - The algorithm creates geometric intervals by minimizing the sum of squares of the number of elements in each class. This ensures that each class range has approximately the same number of values in each class and that the change between intervals is fairly consistent.

- *How is each classification method changes the way anyone might perceive the information?*
- *What are your impressions when you using for example, the quantile vs. the defined interval method?*
- *Why do you think the selection of the classification method is important?*

5. Change the **Classification Method** to **Natural Breaks (Jenks)** again with **6 classes**. The **Natural Breaks** classification seeks to calculate natural groupings or breaks in the data. For this reason it can be very effective for skewed distributions of data; although the class thresholds may seem somewhat arbitrary. You will work with **Natural Breaks, 6 classes** but will modify the class break values just a bit to make the numbers appear less arbitrary.
6. To adjust the break values, double-click on it, type a number, and press Enter. If a value is outside the range of the maximum or maximum value in the histogram, it does not draw on the map, and the histogram reflects this by stretching the height of the horizontal columns.
7. Type in the following new break values on the histogram to round the Natural Break values just a bit. Afterwards, your classification method will automatically change to **Manual**.

   0.027

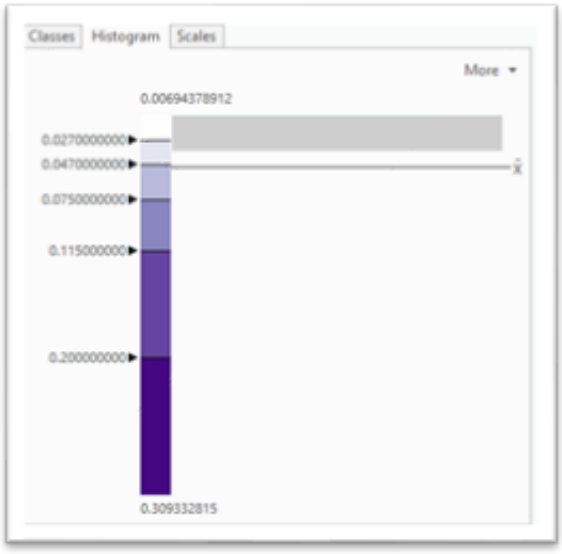
   0.047

   0.075

   0.115

   0.20

   Leave at 0.3093, which is the maximum value



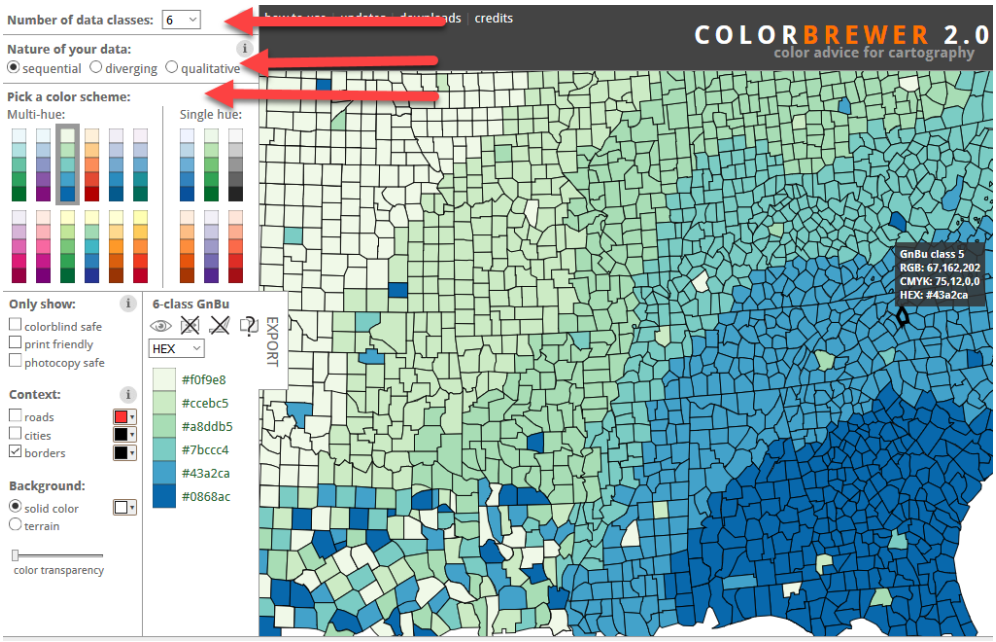
8. Rename this layer to **Arrondissment Foreign Population.**

Work with Color Schemes

Color schemes are ranges of color that are applied to various types of symbols and their components. Now that you've chosen an appropriate classification model for your data distribution, you need to select an appropriate color schemes to apply to your data type. You can select a color scheme directly within ArcGIS Pro or choose a scheme from **Color Brewer**.

Note: to learn more about Color Schemes visit: https://pro.arcgis.com/en/pro-app/latest/help/mapping/layer-properties/color-schemes.htm

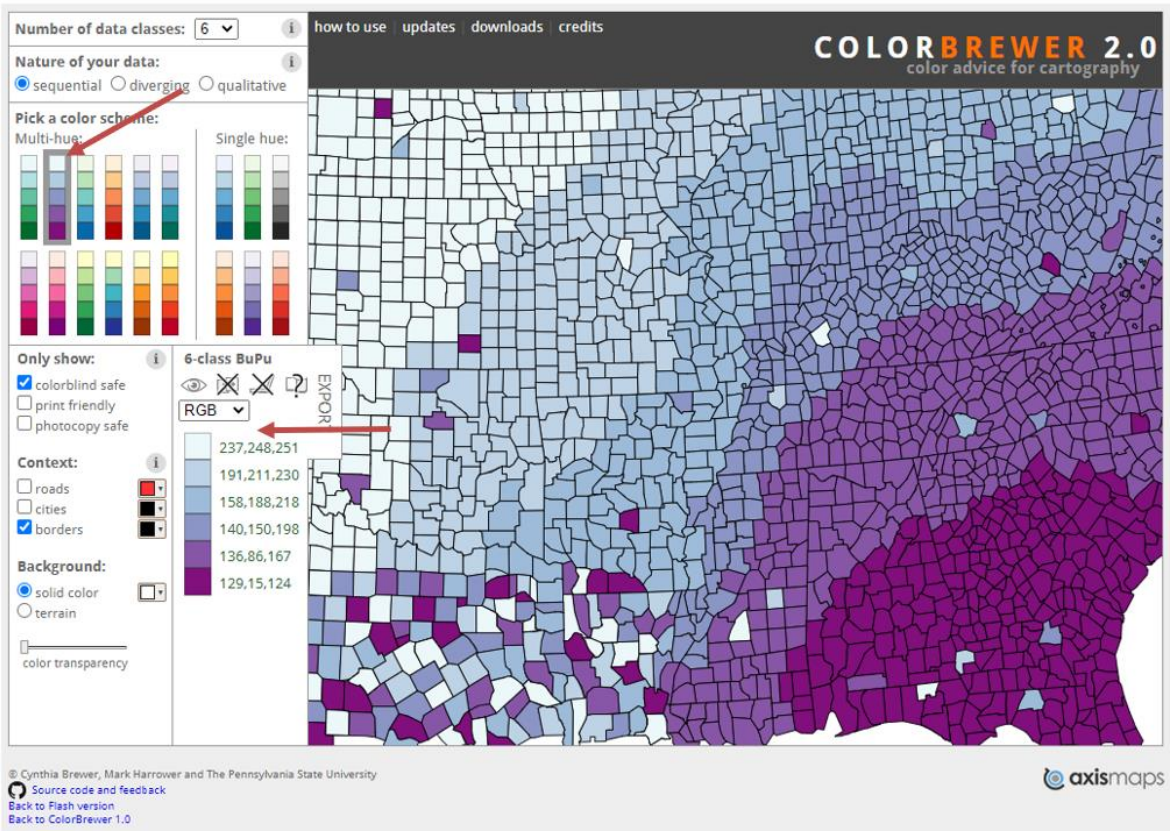
1. Open a web browser and navigate to **Color Brewer** - https://colorbrewer2.org/
   Color Brewer is a website to assist with selecting appropriate color models for your data types.
2. Adjust the number of **classes to 6**, try out the different **Data Types** and **different color schemes (color models)**. The different **Data Types** include:
   - **Qualitative** – categorical data such as political party, gender, ethnicity, etc.
   - **Sequential** – numerical data that ranges from low numerical values to high numerical values
   - **Diverging** – numerical data that diverges from a center such as change over time where there is positive change and negative change diverging from 0.



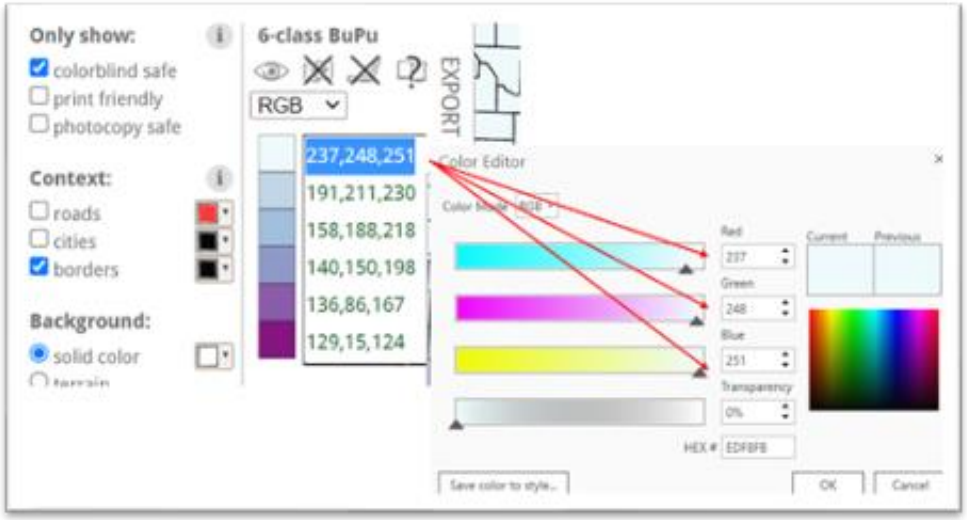
3. Select the following from the Color Brewer options:
   - **Number of data classes:** *6*
   - **Nature of your data:** *Sequential*. % of Foreign Population is sequential data.
   - **Pick a color scheme:** Select a *multi-hue*, *violet* color scheme (see graphic below).

   Note: you can always consider clicking on the colorblind safe bottom to consider those who have a disability.

   - In the **Export Tab (under 6-class BuPu):** Select *RGB*. This displays the Red, Green, and Blue combination used to make each color in the swatch. You will enter these values into ArcGIS to use this color scheme.



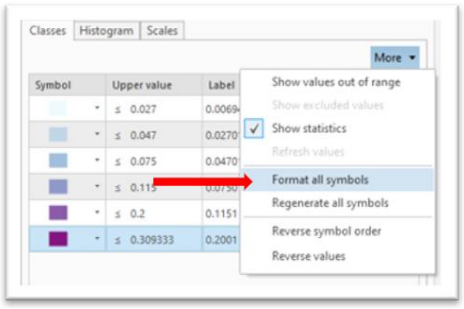
4. Return to ArcMap and open the **Symbology** window for your *Arrondissment Foreign Population Layer*.
5. You will manually change your color ramp under the **Classes** tab.
    1. Double-clicking on each color swatch which will open the **Properties** of the symbol window.
    2. Under **Color**, click on **Color Properties**
    3. In the **Color Editor** window, make sure the **Color Mode** is under **RGB**
    4. Now you can change the color and enter the R, G, and B values for the first swatch from Color Brewer. Click **OK** when complete. Then click **OK** on the **Symbol Selector** to change the color.



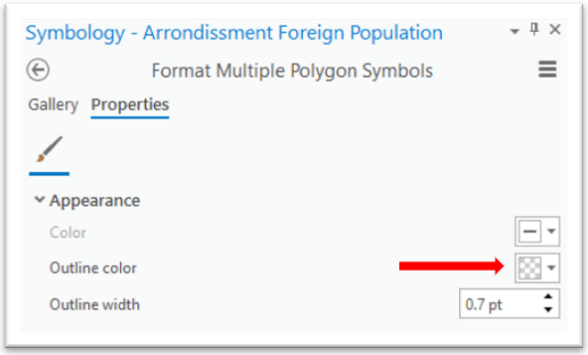
6. Repeat the process for the remaining 5 swatches. Then click OK and OK again on the Symbol Properties to apply the changes. Your map should look similar to the map below.

You will make one final change to the symbology of your data. Note that there are many polygons in this dataset with detailed outlines. In this instance, the outlines start to compete with the foreground. You will remove the outlines in order to bring your data more to the foreground. This should only be done when you have numerous very small polygons, like those around Paris.

7. Click again on **More** > **Format All Symbols**

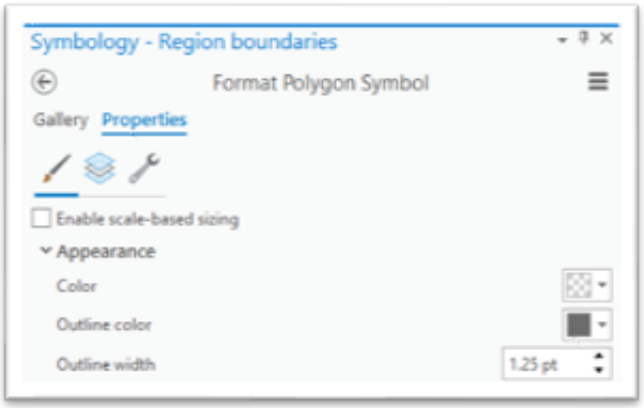


8. The **Format Multiple Polygon Symbols** window will appear. Click on the **Outline color** > and click No color.
9. Click **Apply**.

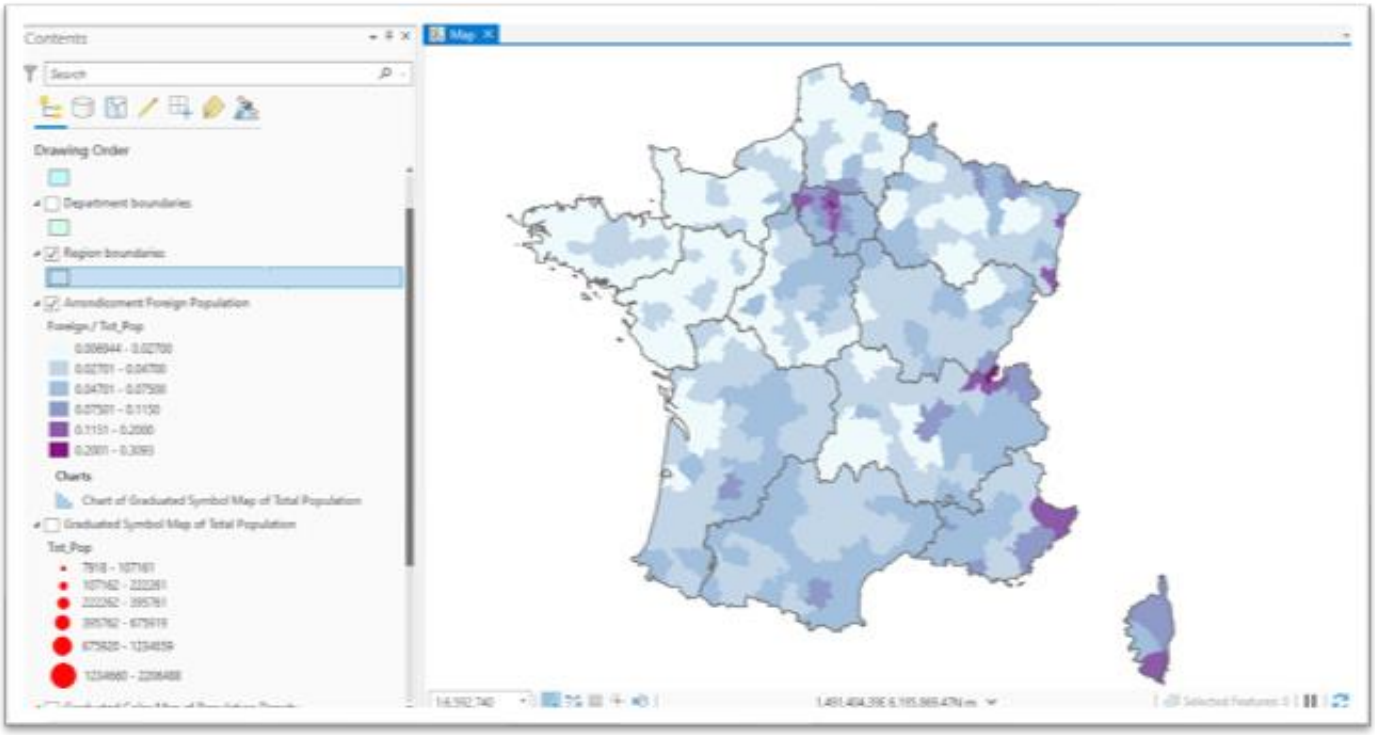


10. You will include a higher level of administrative boundaries for context. Drag your *Region boundaries* above your *Arrondissment Foreign Population* in your **Contents** pane.
11. Click the swatch pattern for *Region boundaries* layer to bring up the **Symbology** window.
12. Change the name of this layer to only *Regions.*

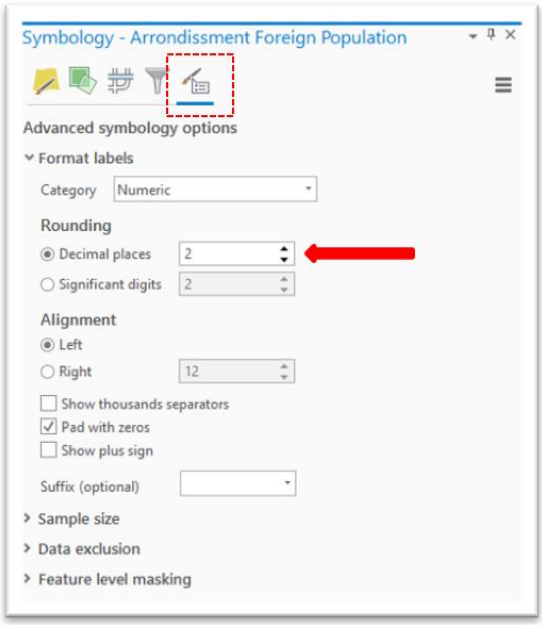
- Click **Color** and select **No Color** to make it hollow.
- For the **Outline color**, select **Gray 60%.**
- For the Outline width, enter 1.25 pt.
- Click **Apply**.



13. Your map should look something like this:



14. Back to Symbology, adjust the decimal places for your data. Click on **Advance symbology options** and change the Decimal places to 2. **Apply**.

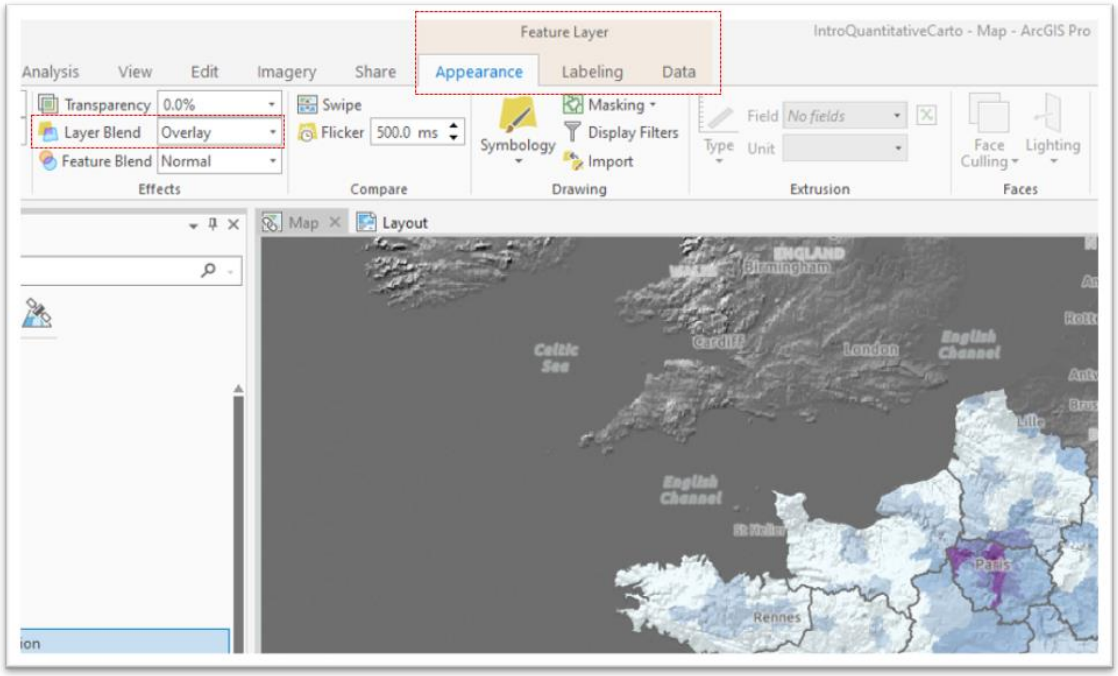


15. **Save** the project.

Apply Layer Blending

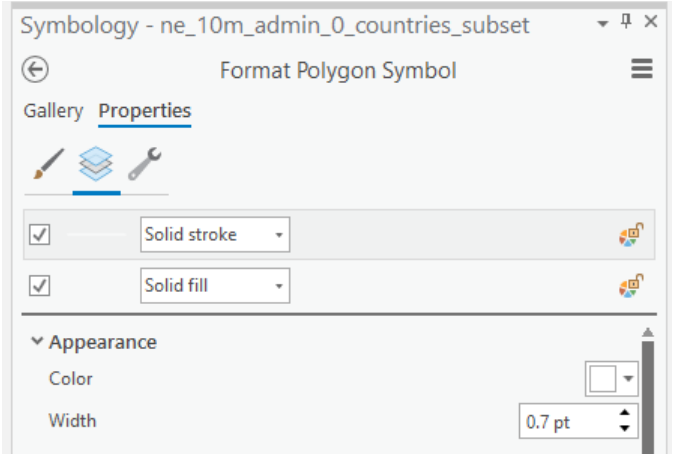
Layer blending draws the entire layer and blends it with the content below it in the drawing order (the background). Each blend mode follows a formula. You can use layer blending to accomplish various goals, such as drawing topography above background layers but keeping its labels visible.

1. Open **Catalog** and add the layer called *ShadedRelief*.
2. Click on the layer *ShadedRelief* in the **Contents** pane to highlight it.
3. Under the layer's contextual tab, click the **Appearance** tab.
4. In the **Effects** group, click the Layer Blend drop-down menu **Layer Blend** to choose a blend mode to apply to the layer. You can try some of the options but we want to select **Overlay**.
5. Also, you can turn off the base map. In this case, we added the *Light Gray Base* and the *Light Gray Reference*. Those can stay off.



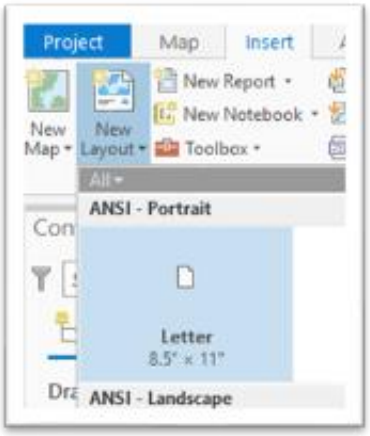
Blending is a computational process applied to the color values of the layer. It is performed on each color channel independently. For example, in an RGB color model, the red channel of the layer only blends with the red channel of its background. For more information, see Apply visual effects.

6. Before we start creating our layout, we will make sure we add our layer ne_10m_admin_0_countries_subset if is not added already.
7. We will change the symbology to a white outline with an Appearance white with a Width of 0.7 pt.



Creating a Layout

Remember that the original tutorial for Learning ArcGIS Basics (India) provides instructions on how to make a good map **Layout**. In this part of the exercise, take a few minutes to remember the **Layout** Tab and see the tools.



1. When you are ready to begin your layout, go to menu **Insert → New Layout.** In the dropdown menu, select **Letter (8.5" X11").**
2. This will open up a new window called **Layout** on a new tab. To get back to your map, you can click the Map tab.
1. Place the **Map** on the new **Layout**. To do so you need to be on the **Insert** tab, click on the **Map Frame** and select the image of our map.
2. Draw a box where you want the map to be placed on the paper. Make it ALMOST as big as the paper, leaving a little border for "printable margins".

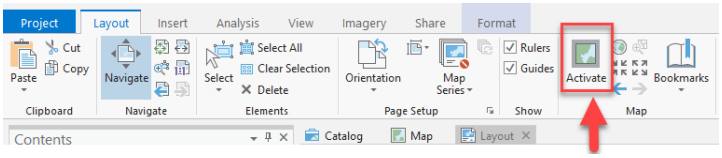
Note: you can always change the size by clicking on the **Map frame** and using the vertices on the corners of the map.

3. If your base map is turned on, it is time to turn it off as well as the Reference.

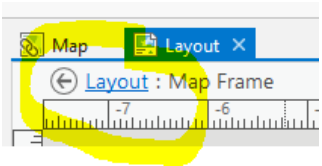
Note: *Basemaps* serve as a reference map on which you overlay data from layers and visualize geographic information.

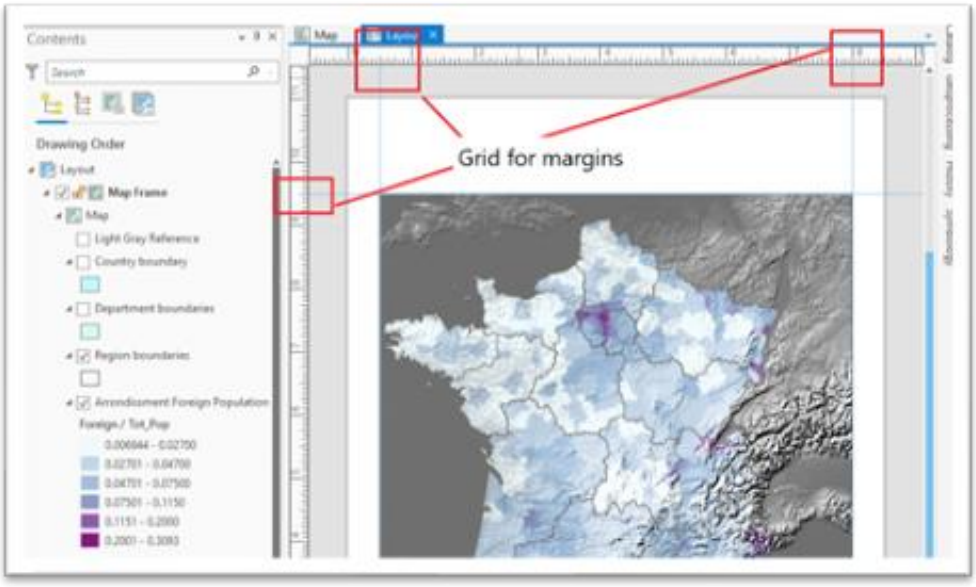
4. The **navigate** icon allows you to move the piece of paper. The **full extent** icon zooms so the whole page is in view. The 1:1 tool is particularly useful to see what the map features and text looks like at actual print size (100%).
5. To position the actual data (**Map**) within our **Layout,** we need to **Activate** the data frame. In the **Layout Tab,** click **Activate** to be able to interact with the map and zoom in/out and pan around.

Note: You can also right click to activate the map.



6. Once you are in **Active** mode, you can set the scale at 1:6,500,000 for the map. Then, use the **pan** to center the map.
7. To close the **Active** mode, you can simply click on **Layout**
8. The **Guides** are also very useful to positon the Layout in your printed sheet format. You can use 1.5' at the top, 0.5 inches on the sides and 2' at the bottom margins.





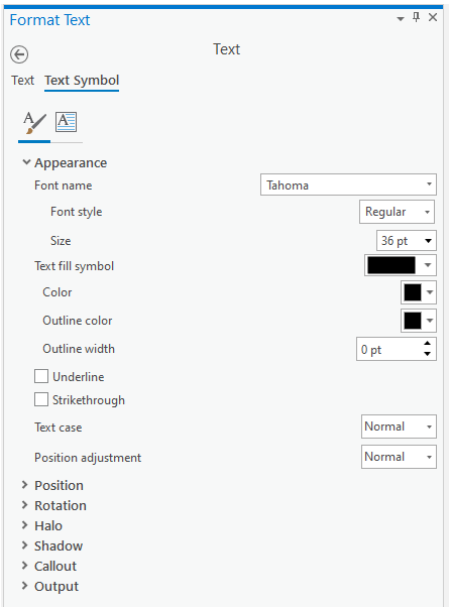
9. **Save** your project.

Title

10. Next, we will add the core map elements to the map. Click on the **Insert** menu to start:

    a. **Title**: Foreign Population, France 2015

If the font is too big, or you would like to change the Font type, etc. you can always click on the **Text Format** menu or right click to the element (Text) and click on **Properties**. Under **Text Symbol**, you can modify the Apperance, Position, etc, or the Formatting. There are two tabs.



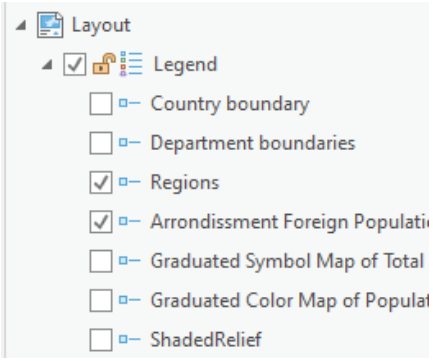
If the font is too big, or you would like to change the Font type, etc. you can always click on the **Text Format** menu or right click to the element (Text) and click on **Properties**. Under **Text Symbol**, you can modify the Apperance, Position, etc, or the Formatting. There are two tabs.

Legend

11. Under map Surrounds, select **Legend**. Draw a box where you want the legend to be placed. Draw the box under the map, within the margin left at the bottom (see final map at the end of the document for guidance). Click on the corner vertices to adjust the size and placement.

    Note: you can always use guides to place any element in your **Layout**.

12. To adjust the style of each layer in the legend, you can click on the **contents pane**. Check or uncheck the layers you want to see **on in your map.** Turning them off or off in the legend will define what layers will appear on the Layout's legend. Make sure to leave **ON** only the *Arrondissment Foreign Population* and the *Regions* layers.



13. Under **Legend**, you can re-order the different layers such that they appear in that particular order. For example, if you want to have the *Regions* below the *Arrondissment Foreign Population*, you can simply click on it and hold on it, to drag it below. The order of the elements in the **Legend** will change.

    You might want to adjust the font sizes/emphasis for the layer names, headings and labels. Right click on **Legend** and click **Properties**. This will bring up more options on the right to all the legend contents. You can also look at the format of each layer under the **Legend** by simply right clicking on it and selecting **Properties.**

14. Under **Legend**, you can re-order the different layers such that they appear in that particular order. For example, if you want to have the *Regions* below the *Arrondissment Foreign Population*, you can simply click on it and hold on it, to drag it below. The order of the elements in the **Legend** will change.

15. Next, while Legend is highlighted, click on **Text Symbol** and then change the drop down to **Layer Names.** Now, we can adjust the size and fonts for the layer names to bold and size 14. Click **Apply** to see changes.

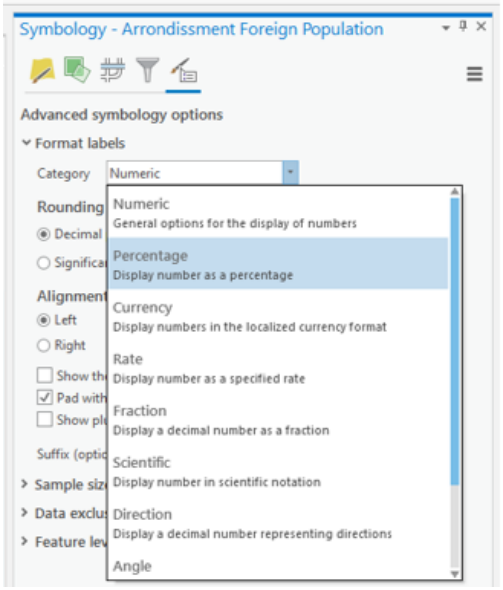
16. Lastly, change the drop down to "labels". This will edit the style of the text next to the symbols and you will assign regular font and size 12 with the matching font.

17. Let's change the **Heading** of the *Arrondissment Foreign Population* layer given that currently we have it as *Foreign / Tot_Pop*; let's change it to Foreign / Total Population. You will notice that now it changed in your Layout.

Another change we would like to do is to convert the decimal units to percentages to make the legend easier to comprehend. Since our Layout is connected to our Map - you can see the map as one of the Layout's elements – you can make changes there.

18. Select the layer *Arrondissment Foreign Population* and right click > **Symbology**. The Symbology window will appear.

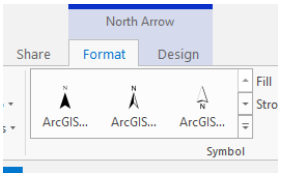
19. Click on **Advance symbology options**. Change from **Category** *Numeric* to *Percentages*.



20. Next, select under **Percentage**: Number represents a fraction. Adjust it to show as a percentage. Also, change the **Decimal places** to 1.

North Arrow and Scale Bar

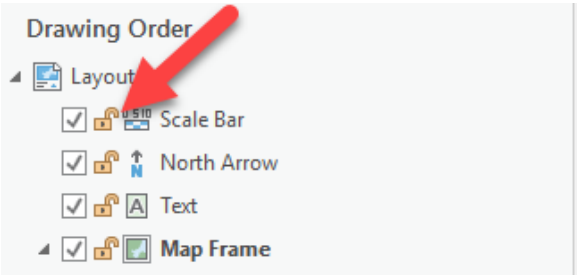
21. Click on the ***North Arrow*** dropdown**.** Select one that you like. You can adjust the size or change the style and the color; simply click on **North Arrow > Format** or **Design**.



22. Click on the dropdown options and pick a **Scale bar** that you like. Put it in the bottom corner or in a place where you think will provide some aesthetic balance to your **Layout**. If you don't like it, simply click once on it and press delete. Then reinsert a different one. Same as with North Arrow, you can change the format by clicking on the **Scale Bar > Format.**

23. In the upper menu, click on the **Scale Bar Design tab,** change the **Number of divisions to 1 and Number of subdivisions to 2.** This takes away all the junky numbers inside the scale bar and makes it cleaner. Also, since we are working in *India*, the units should be in **KM** not **miles**. Change the **Division Units to Kilometers.** Set if you want the label position above, below, etc.

24. Again, notice how in the Contents window, there are now "layers" for Text, North Arrow and Scalebar. You can now turn them on and off, like they are a layer. You can also click on the little lock, to lock the style in place so they can't accidentally be moved, edited, or deleted.



Note: A general cartographic principle is keeping your scale bar in an empty part of the map, like an ocean, and for this map scale, rounding the last number to a multiple of one hundred.

Cartographer Information, Data Sources and any other annotation

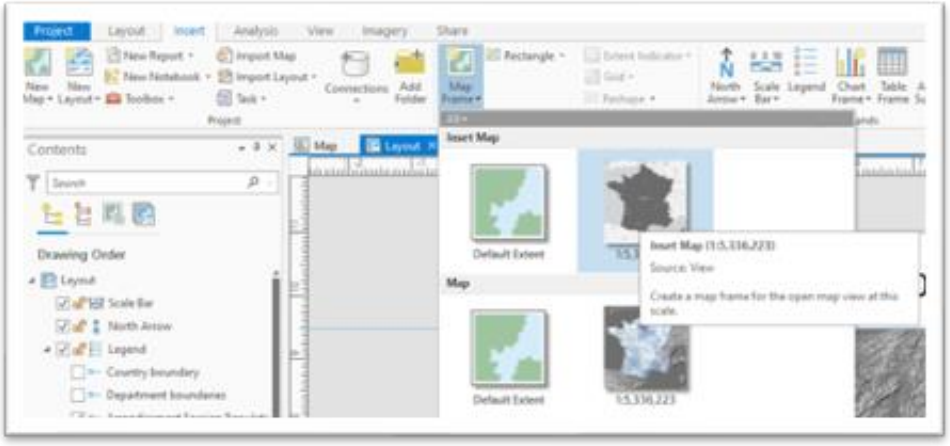
1. You will use the **Insert** tab again to insert your cartographer information. Click the **A** to insert a text box.
2. I**nsert Text** - Cartographer Information (name, date, class).
3. I**nsert Text** - Information (abbreviated) about the data sources (listed at the beginning of the tutorial)
4. Insert an additional data frame to create an overview/inset map
5. You can also insert text to for example, add some names like: Paris, English Channel, Mediterranean Sea… these land marks or ocean marks are always useful.

You could also use this to add any annotation for the map, such as any further explanation of the legend or perhaps an explanation of what the map is showing.

Locator Inset Map

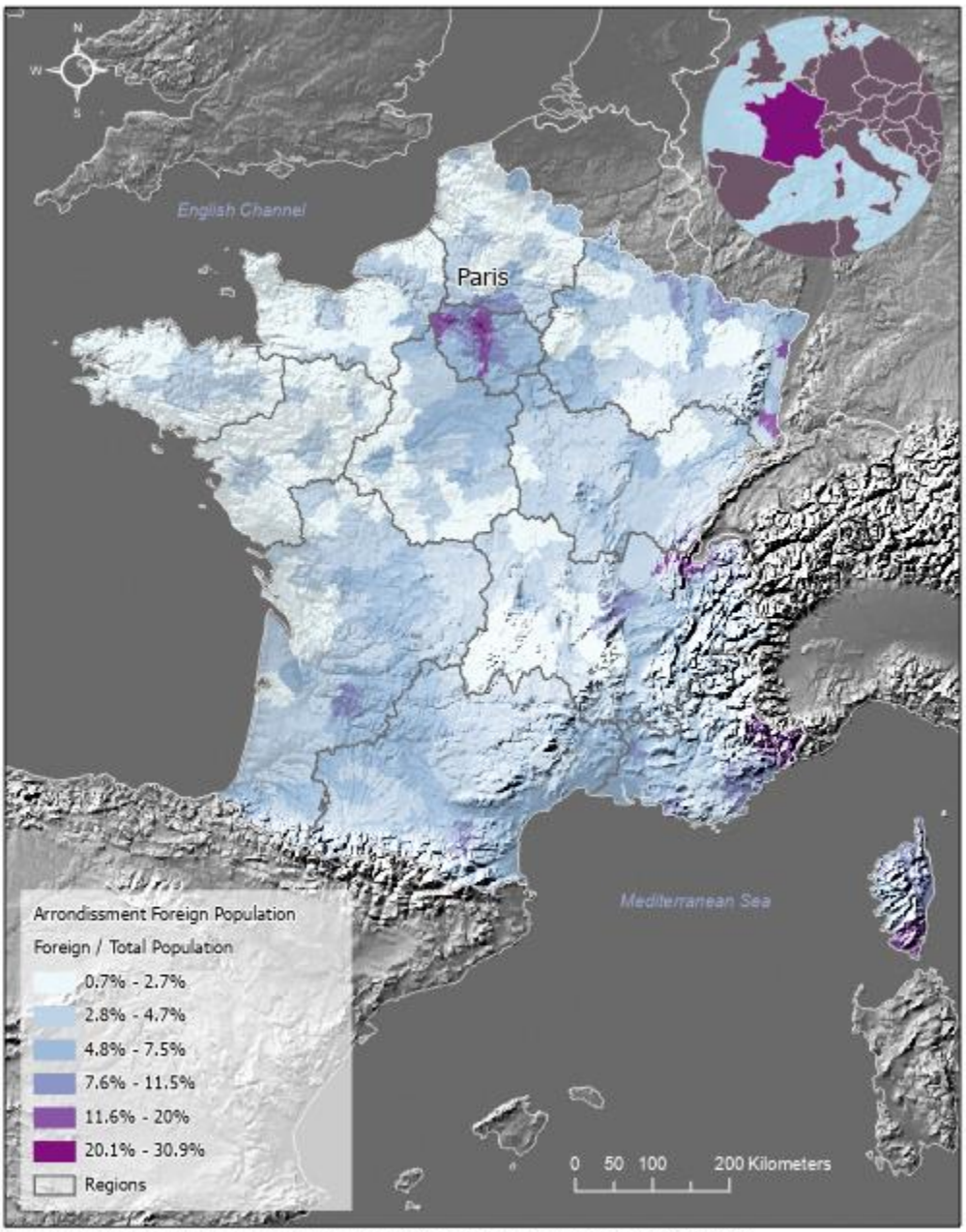
A second data frame for a locator inset map needs to be added to your Layout.

1. In Layout View, choose the menu **Insert → New Map** from the top. A blank new map will appear on the top tab. Click on this new tab and rename the **data frame** to **Inset Map** by clicking on the Data Frame in Drawing Order twice slowly.
2. Select the **Light Gray Canvas**.
3. Since you are making a map of France, you will bring some data again. Open **Catalog** on the right and drag in the Country (*Admin00*) from the *FranceCarto.gdb*.
4. Set a color for country. It can be a dark gray 60%.
5. **Save**.
6. Go back to your layout view of your final map. Click on the **Insert tab** then on **Map Frame. Select your new map and draw a smaller box in one of the corners where it fits nicely.**



7. You'll now likely need to adjust the zoom and position. Click on this new map and then in the Layout Tab, click **Activate**. Zoom in to the appropriate scale and center the map. If needed, adjust the size of the data frame by closing the map activation and moving it.
8. Also, you can rename all your texts and different elements in your Layout. This will allow you recognizing each element to lock it, turn it on or off, etc.

Foreign Population, France 2015



Cartographer: Marcia Moreno-Baez. Data Sources: IGN, INSEE, Natural Earth.. Date: 8/24/2021