

Introduction to GIS with QGIS

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This introductory session will focus upon the fundamental concepts and skills needed to begin using Geographic Information Systems software for the exploration and analysis of spatial data using the QGIS platform. Topics will include:

- What is GIS?
- Spatial Data Models and Formats
- Projections and Coordinate Systems
- Basic Data Management
- The QGIS User Interface
- Simple Analysis using Visualization.

GIS Resources:

Stanford Geospatial Center website – <http://gis.stanford.edu/>

Stanford GIS Listserv – <https://mailman.stanford.edu/mailman/listinfo/stanfordgis>

QGIS Current Version Download –

QGIS Current Version Help – <https://qgis.org/en/docs/index.html>

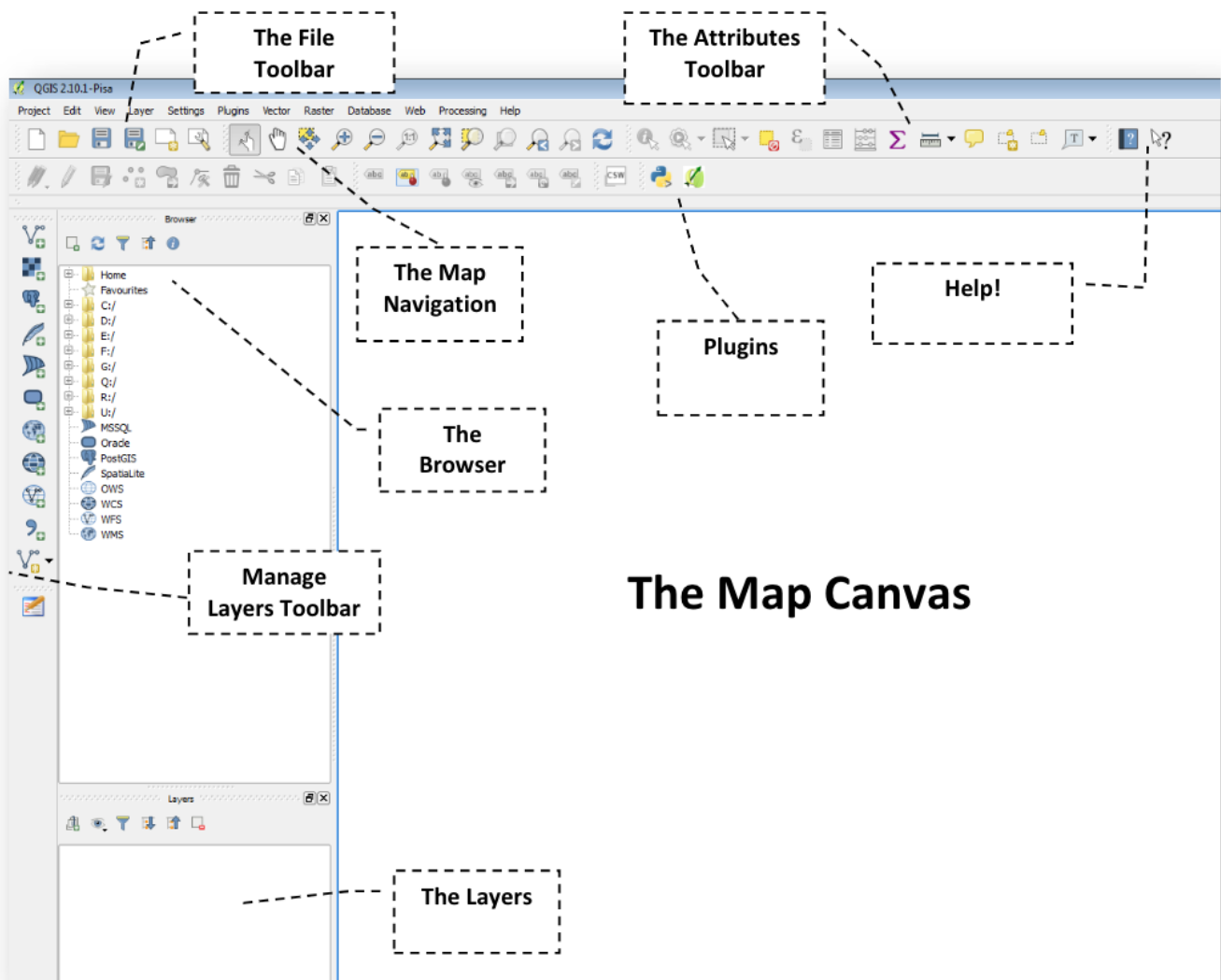
Download Tutorial Data

1. In a browser, go to <https://stanford.box.com/SGCIntroGIS> and click on the drop-down arrow to the right of each folder to download individual datasets. Save the Dataset to your Desktop.
2. Right-click on the resulting *.zip file and select Extract All...
3. Accept all defaults to extract the data file.

Open QGIS and Explore the User Interface

QGIS (Quantum GIS) is a free and open – source desktop geographic information system (GIS) application. The first thing we want to do is **Open** QGIS and get familiar with the Default User Interface.

1. In Windows, go to the Programs menu and find the QGIS Pisa, then select QGIS Desktop 2.10.1
2. You should be presented with the **New Document**. You should then be presented with something like the interface you see below:



The Basic Components of the QGIS Interface

The QGIS interface is made up of three basic components:

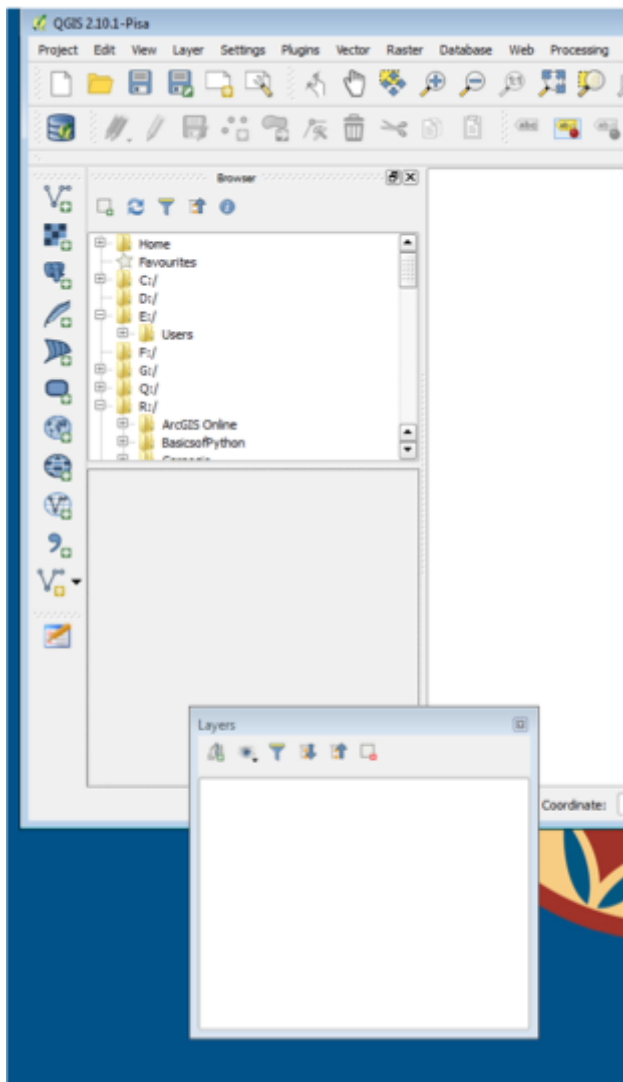
The Map Canvas – This is where the raster and vector layers are displayed.

Tabbed Windows:

- **The Browser Window** – Functions much as Explorer does in Windows. In this window, you can visualize your drives and folders. Is the equivalent of ArcCatalog in ArcMap.
- **The Layers Window** – This is where your added geographic and non-geographic datasets will show. This is similar to the Table of Contents in ArcMap.

General Menu Bars:
























- **File Bar** – Has the basic commands of any file: New, Open, Save, Save As. The New Print Composer and Composer Manager are to create and manage layout views.
- **Map Navigation** – Allows the user to Pan, Zoom to a Selected Feature, Zoom In, Zoom Out, Zoom to previous/next extent, and Refresh.
- **Attributes** – These tools allow the user to: Identify attributes, Select / Deselect features, Opens attribute table, measure distance/areas/angles, create spatial bookmarks.
- **Plugins** – QGIS comes with two default plugins: Python Console and QGis 2 Leaflet Webmap.
- **Help** – The question mark booklet is linked to the QGIS User Guide.
- **Manage Layers** – This bar is to add layers (vector, raster, new shapefile layer)



Interacting with Tabbed Windows

1. Move your cursor over the **Browser** dotted line. Click on the dotted line and drag the window to the bottom, below the **Layers** tabbed window.

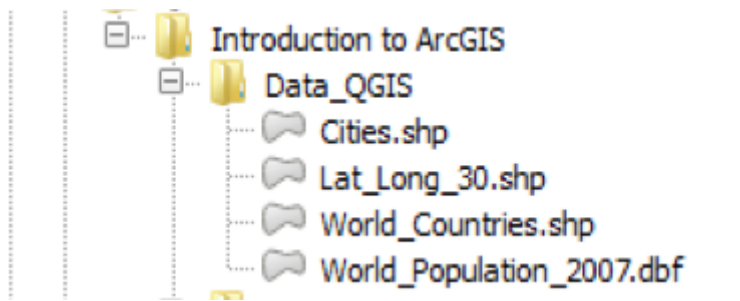
Explore the Browser

Name	Date modified	Type
 Cities.dbf	1/24/2011 1:08 PM	OpenOffice.org 1....
 Cities.prj	1/24/2011 1:08 PM	PRJ File
 Cities.sbn	1/24/2011 1:08 PM	SBN File
 Cities.sbx	1/24/2011 1:08 PM	SBX File
 Cities.shp	1/24/2011 1:08 PM	SHP File
 Cities.shp.xml	1/24/2011 1:08 PM	XML Document
 Cities.shx	1/24/2011 1:08 PM	SHX File
 Lat_Long_30.dbf	1/24/2011 1:09 PM	OpenOffice.org 1....
 Lat_Long_30.prj	1/24/2011 1:09 PM	PRJ File
 Lat_Long_30.sbn	1/24/2011 1:09 PM	SBN File
 Lat_Long_30.sbx	1/24/2011 1:09 PM	SBX File
 Lat_Long_30.shp	1/24/2011 1:09 PM	SHP File
 Lat_Long_30.shp.xml	1/24/2011 1:09 PM	XML Document
 Lat_Long_30.shx	1/24/2011 1:09 PM	SHX File
 World_Countries.dbf	1/24/2011 1:08 PM	OpenOffice.org 1....
 World_Countries.prj	1/24/2011 1:08 PM	PRJ File
 World_Countries.sbn	1/24/2011 1:08 PM	SBN File
 World_Countries.sbx	1/24/2011 1:08 PM	SBX File
 World_Countries.shp	1/24/2011 1:08 PM	SHP File
 World_Countries.shp.xml	1/24/2011 1:08 PM	XML Document
 World_Countries.shx	1/24/2011 1:08 PM	SHX File
 World_Population_2007.dbf	1/24/2011 1:10 PM	OpenOffice.org 1....
 World_Population_2007.dbf.xml	1/24/2011 1:10 PM	XML Document

Using the **Window Explorer**, browse to the **\\Introduction_to_ArcGIS\EX01_World** folder, where you extracted the **EX01_World.zip** file and browse into the **EX01_World\Data** Folder.

Note that, while there are 23 files in this folder, there are actually only 3 Shapefiles and a CSV Table here, as far as QGIS is concerned. This is because a Shapefile isn't really a *file* but a collection of files. *You* are looking at this folder in Windows Explorer in order to illustrate a very important point about many types of geographic data formats: Geographic datasets are often not easily manageable using software not specifically designed for handling GIS data. In the case of the Shapefile, for example, if you wish to rename or move a shapefile, you must move or rename ALL of its component files in exactly the same way, or you can corrupt the shapefile.


1. **Return to QGIS** and use the **Browser Tabbed Window** to expand the Home Folder.
2. **Expand the Home and Desktop** folder.
3. **Expand the Introduction to QGIS**, and then **expand the Data** Folder.



Note that the Shapefile is much simplified in the Browser Window. Although the Shapefile is still made up of several files, QGIS seems to know that it's not a good idea to make you deal with all that, so it simplifies things by only showing you the .shp file.

Finally, let's open a Map Document!

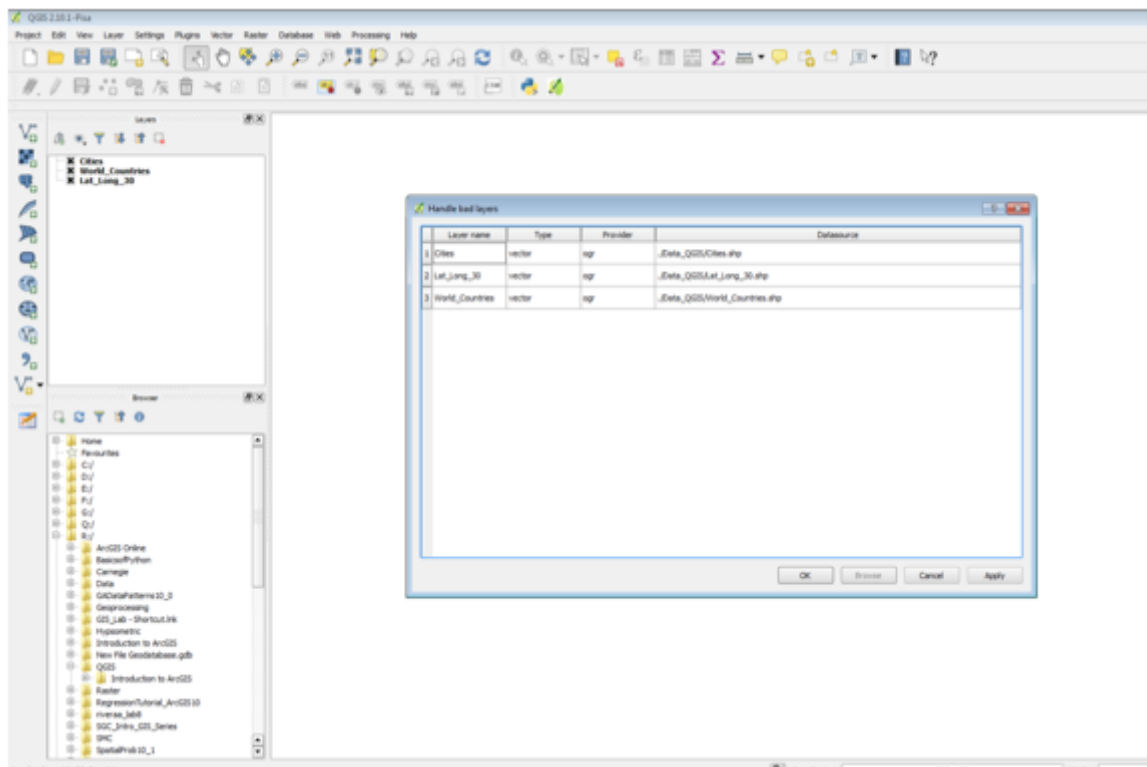
You should, in addition to a Data Folder full of shapefiles, have a Map Document in your

\Introduction to QGIS\ folder called... **EX01_World.qgs**. The icon looks like this: 

1. Drag the **EX01_World.qgs** Map Document into the **Map Canvas** to open it.

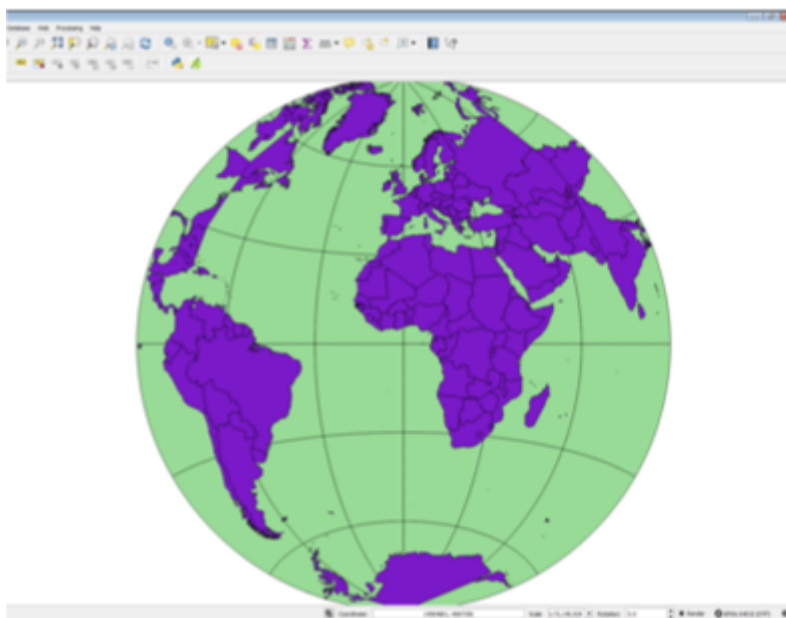
But Wait!

Has something gone awry? Do you see something that looks like this?



You are experiencing the dreaded "**Absolute Paths**" problem, endemic to GIS Softwares. To fix this issue, do the following:

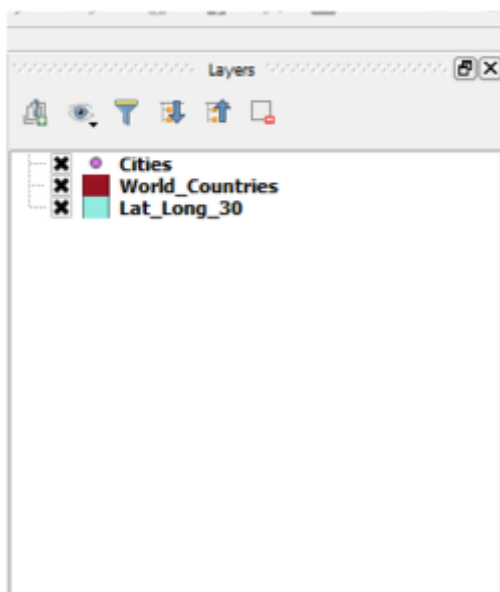
1. Press shift and click to select all the layers.
2. Click the **Browse** and browse to the **Data** folder and **select the folder**. Click OK.



You should find that (because they are all in the same 'workspace') all of your layers have been repaired and you should see something like the image on the above (it's likely to look quite "sketchy").

The Layers Tabbed window and its Properties

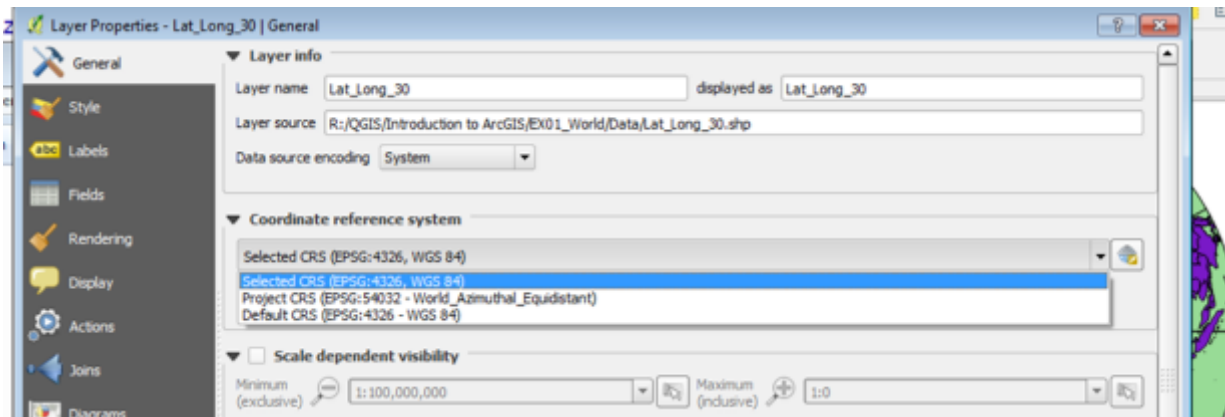
Now take a look at the **Layers Tabbed Window**. You should 3 Layers corresponding to the shapefiles in your Data Folder.



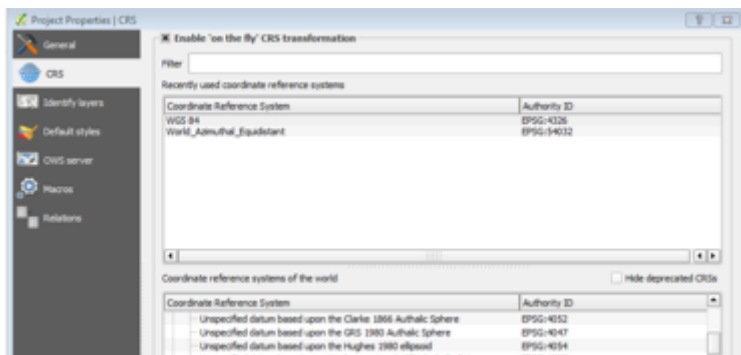
What you don't see is that **CSV Table**. Look for the **World_Population_2007** on the **Browser Panel**, select it and drag it to the **Layers Panel**.

Note that the **World_Population_2007** table has been added to the Layers.

Notice how Asia almost disappears? **Right-Click** on the **Lat_Long_30** shapefile. Select **Properties** and go to the **General Tab**. Under *Coordinate Reference System* (CRS) notice that the selected CRS is WGS 84*** If you click on it, you will see that the Project CRS is **World_Azimuthal_Equidistant**. This projection is useful for showing correct airline distances. So the layers in this document are displayed using World Azimuthal Distance.



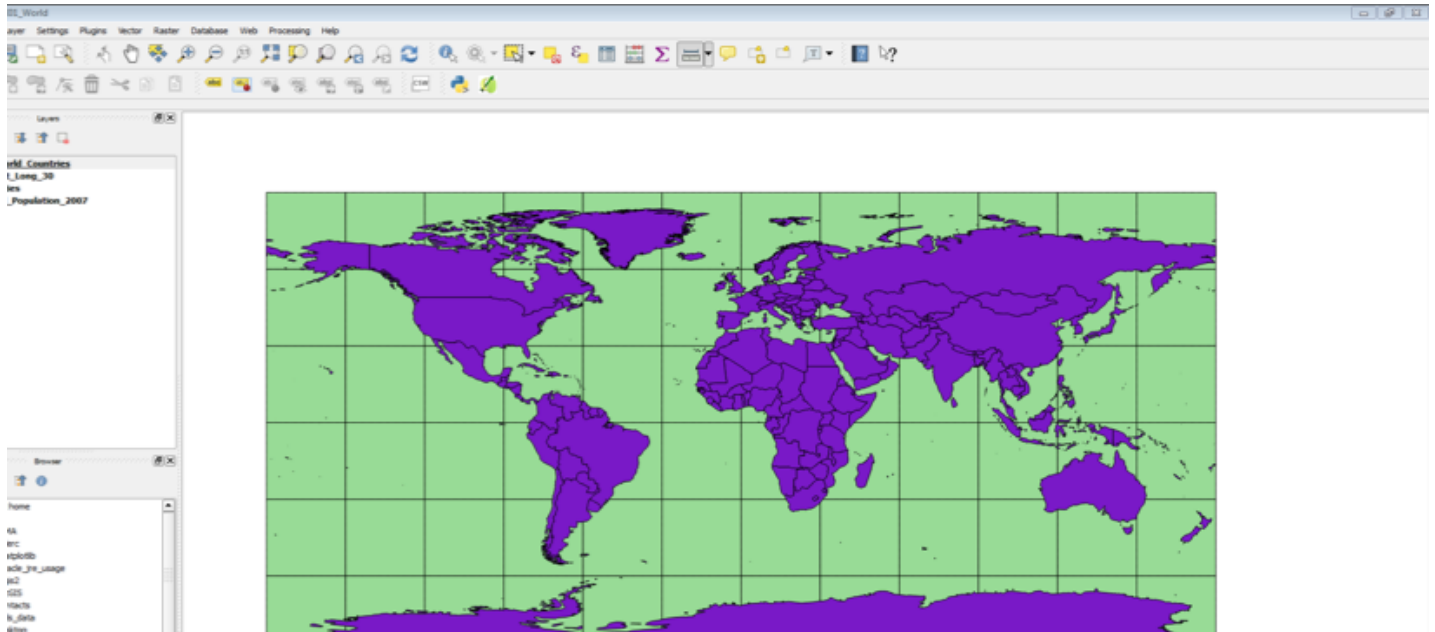
Change the project Coordinate System.



Close the **Layer Properties** and go to the **Project Tab** (Pull-down menu) and select **Project Properties...**

1. Click on the **CRS Tab**.
2. Filter and Select "EPSG:4326 (WGS 84)"
3. Click OK
4. Click Save

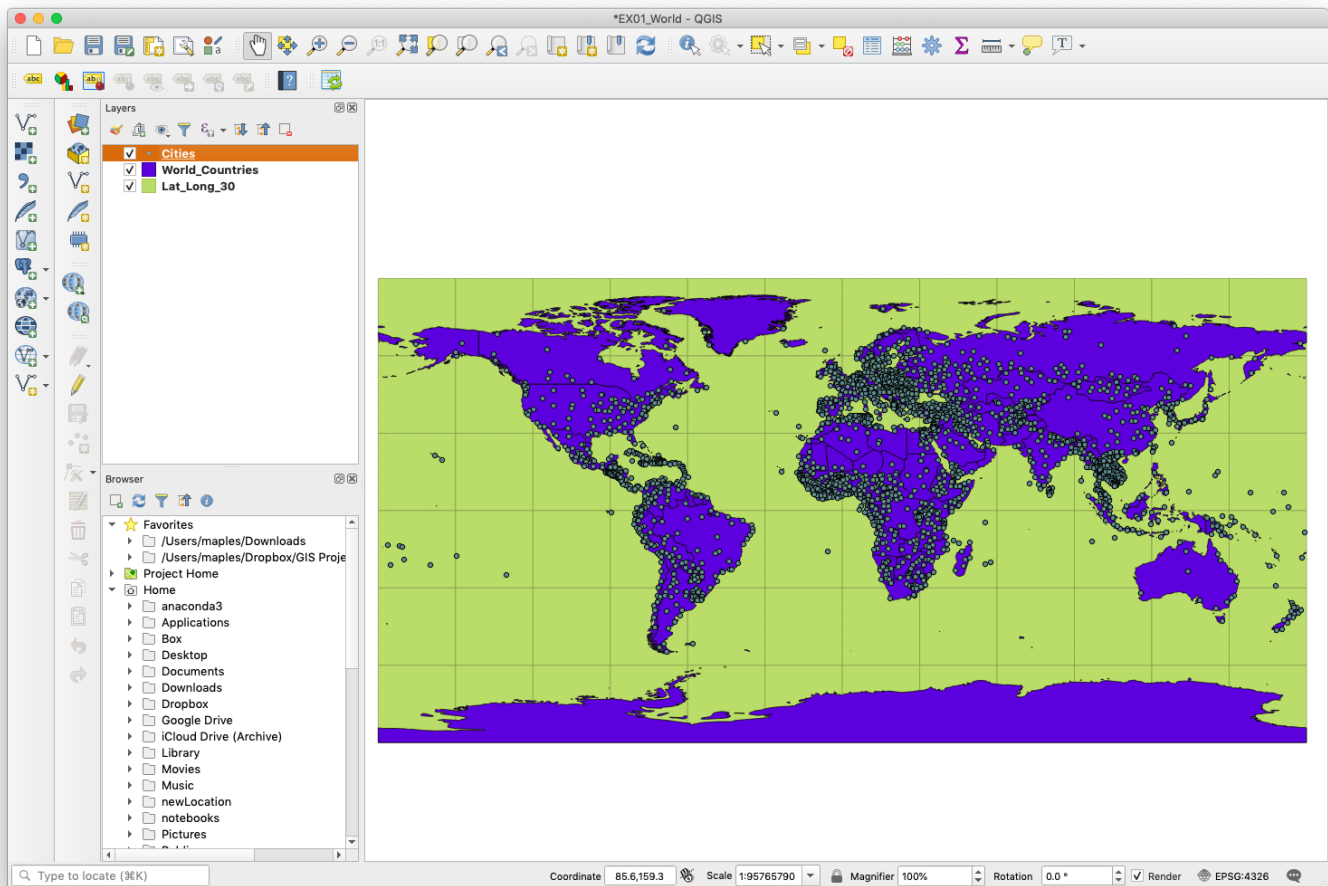
What you have just done is reassigned the coordinate system of the **Map Canvas** to that of the **Layers** in your **Map Document**. This (**GCS WGS 1984**) is actually the coordinate system of all of the layers in your **Map Document**, so you should experience an increase in drawing performance, since **QGIS** is no longer projecting these layers "on-the-fly" to the **World Azimuthal Equidistant projection** (which was chosen for its extremity, in this case). The result of this change should be a fairly substantial change to the view on the Map Canvas.



Change the Layer Coordinate System.

Where are the cities?

1. **Right Click** on the Cities Layer and **Zoom to Layer**. Notice how the cities are displayed.
2. **Right click** on the Cities Layer and select **Layer Properties**. Notice how the coordinate system is not WGS. Change the coordinate system to ******Project CRS EPSG:4326 (WGS 84)**
3. **Click OK**
4. **Click Save**



Explore Navigations Tools and Visibility in Data Frames

Before we begin to explore the properties of individual layer in the Map Document, we will first spend some time getting familiar with the navigation tools in ArcMap. Most of these tools can be found on the "Tools" toolbar, though some of the more useful ones involve right-click context menus of the layers.

Zoom to Layer

1. Right-click on the **Lat_Lon_30** Layer, in the **Layers Window**, and select **Zoom to Layer**.

Note that this should present you with the entirety of the Lat_Lon_30 Layer's extent.

Map Navigation Toolbar



The **Map Navigation Toolbar** provides the bulk of the tools for navigation in the **Map Canvas**. Most of them are fairly obvious. Take a moment to explore each of these tools, and how it works.



The **Touch Zoom and Pan** - Works if you have a notebook with touch screen. Zoom in and zoom out using double finger touch.




The **Pan Map** changes the Extent of Map Canvas, without changing the scale. Click on the Pan Tool and use it to move around the Map Canvas.



The **Pan Map to Selection** changes the Extent of your Map Canvas to the feature being selected, without changing the scale



The **Zoom In Tool** and  **Zoom Out** works exactly as you would expect. Click on the Zoom Tool, and drag a box to enclose the Continental United States. You can also single-click with this tool to use it as a Fixed Zoom Tools.



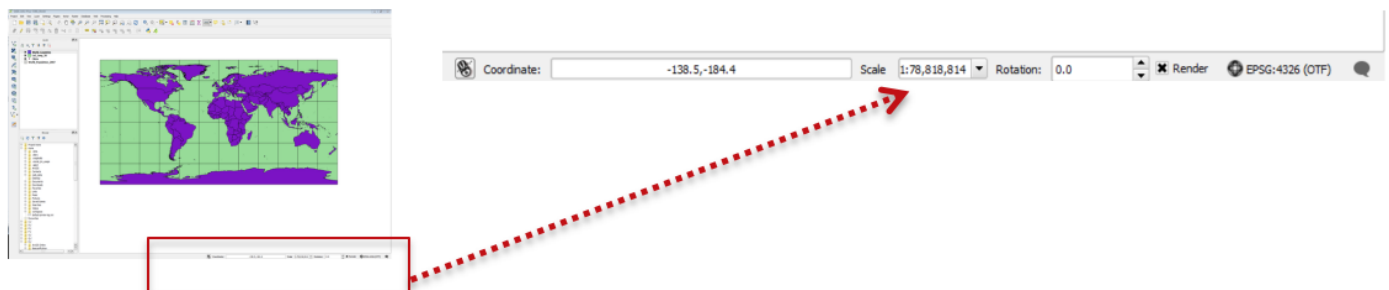
The **Zoom Full** zooms you to the full extent of the layer in your Map Project with the largest spatial extent. This can sometimes be problematic if you are working at a local level, but using one or more layers that are global in extent (for example, many of the network base map services).



The **Zoom to Selection** changes the Extent of your Map Canvas and zooms in or out to the selected feature.

Scale

When zooming in or out, the Scale Values at the bottom page change. Remember that the bigger the number (1:60,000,000), the larger the area being displayed. Although 60,000,000 is bigger than 60, a scale 1:60,000,000 is a small scale and 1:60 is a large scale because the division of $1/60,000,000$ is smaller than $1/60$.





The **Zoom to Layer** to a specific layer extent.



The **Zoom Last** and **Zoom Next** works as a Redo or Undo tool **ONLY** for the Scale/Extent in your Map Canvas. This tool is particularly useful if you change your Map Extent inadvertently.




The **Refresh Button** will reload your Map Extent

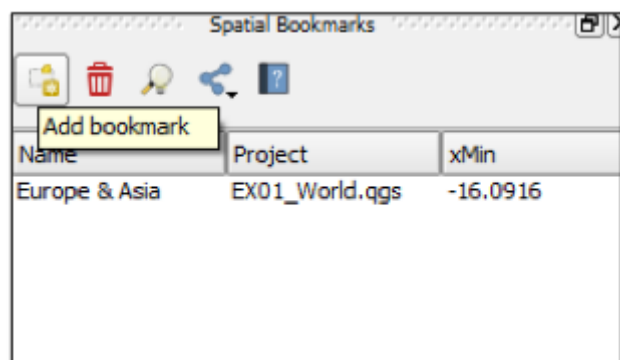
Bookmarks

One of the most useful navigation tools is the ability to create **spatial Bookmarks**.

Right Click on any grey area and select **Spatial Bookmarks**.

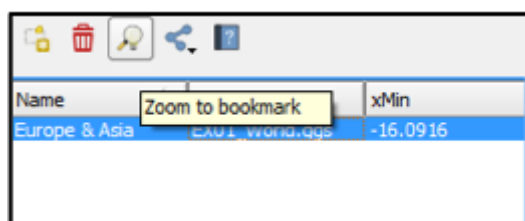
1. Using the **Zoom Tools** on the **Tools Toolbar**, **Zoom** your **Data Frame** view to the **European/Asian Landmass**.

2. Go to the Spatial Bookmark Tabbed Window and **Click on Add Bookmark**  and name it **Europe & Asia**



3. Click on the **Zoom Full button** 

4. Go to your **Spatial Bookmark** Window. **Select "Europe & Asia"** and **click the Zoom to bookmark**. You can also zoom to a bookmark by double- clicking on it.

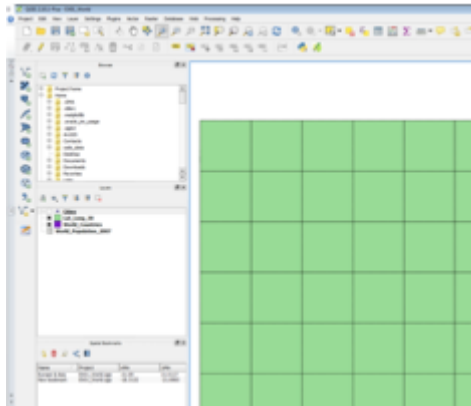


Bookmarks can even be easily shared or moved from one using the Import/Export tool Bookmarks, too. The bookmarks are saved as xml files that can be imported into other QGIS projects. Bookmarks can also be deleted or edited on its name or coordinates.

Display Order

The Layer Order in the Layer Window determines the order of display in your Map Canvas

1. If you haven't already, change your **Layers view**, **click and drag** the **Lat_Lon_30 layer** to the **top** of the **Layers Window**. Note that the other layers in your Map Canvas are now obscured.

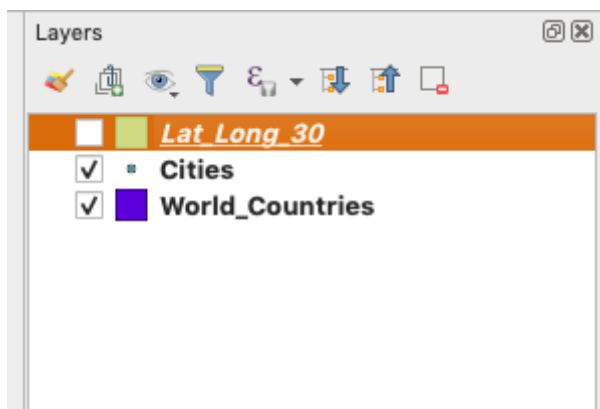


Working with Layers & Their Properties

Layer Visibility

The Table of Contents also controls Layer Visibility. You can toggle the Layer Visibility using the checkbox next to each Layer in the Layer Window.

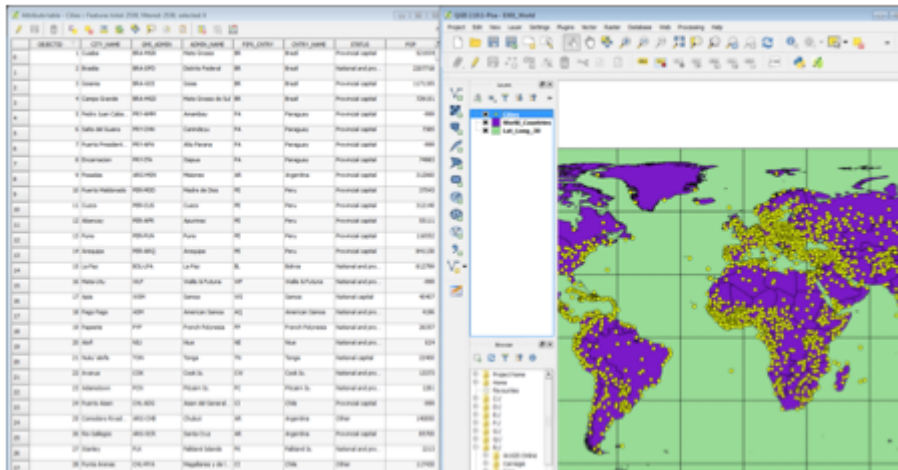
1. Use the **Visibility Checkbox** next to the **Lat_Long_30** Layer to **turn off** the **visibility** of the layer and reveal the other layers again.



Examining and Selecting by Attributes

The most basic method of analysis in GIS is selection and sub-setting of data by attribute values. Now that the Cities Layer is visible again, we can begin to address the fact that this layer is a bit overpopulated for our purposes. Let's say we are interested in visualizing the global distribution of cities with populations greater than or equal to 1 million. First we need to see if the data necessary to do this exists in our dataset.



1. **Right-Click** on the **Cities Layer** and select **"Open Attribute Table"** to open the **Attribute Table** of the layer.



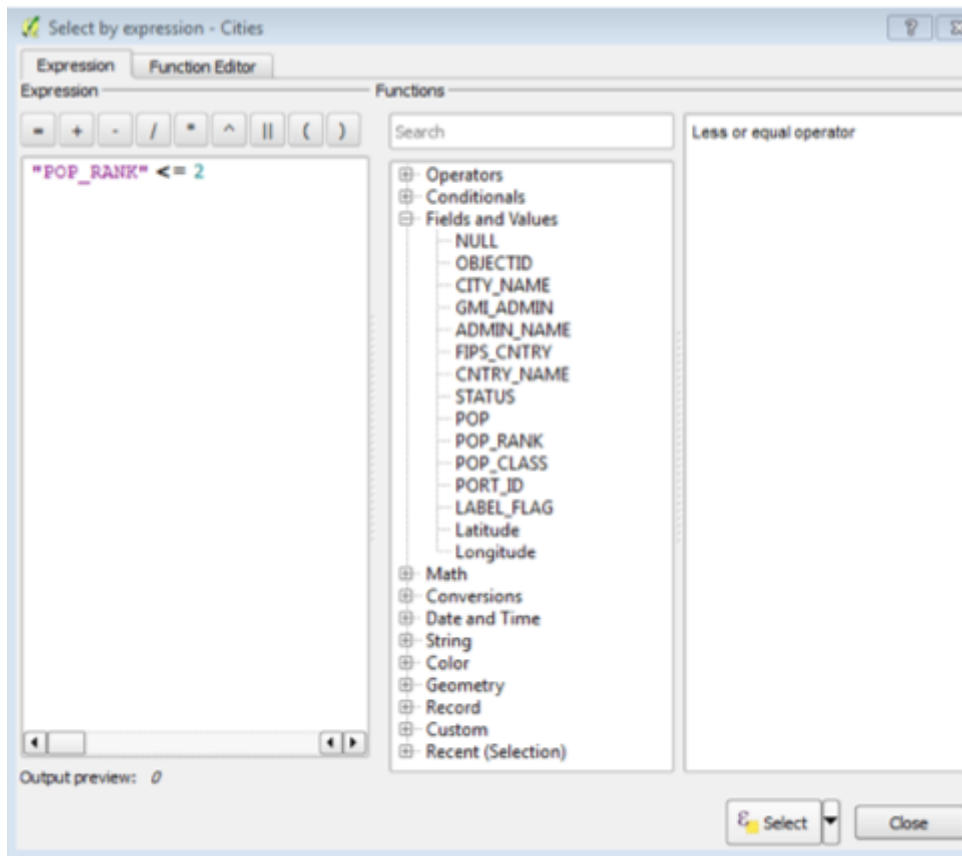
2. **Click and Drag** the resulting **Table Window** to the **bottom** of the **Map Document** and expand the entire width of the Window.
3. **Scroll** to the right until you can see the **POP**, **POP_RANK** and **POP_CLASS** Attribute Fields
4. **Click** on the **POP** Field Header and select **Sort Descending** (Arrow Down).
5. **Scroll** down through the **Attribute table** to examine the relationship between these three variables.

Selecting By Expression

What we would like to do is select all of the cities in this dataset that have a population of 1 million or greater. This can be accomplished using any one of these three of these variables, but we will use the POP_RANK variable for the sake of simplicity.

1. On the Upper left corner of the Attribute Table, find the **Select by Expression** button  and click on it.
2. **Expand** Fields and Values, and **Double-click** on the **"POP_RANK"**
3. **Type** **<= 2**
4. **Click** the **Select** button  and and Close.

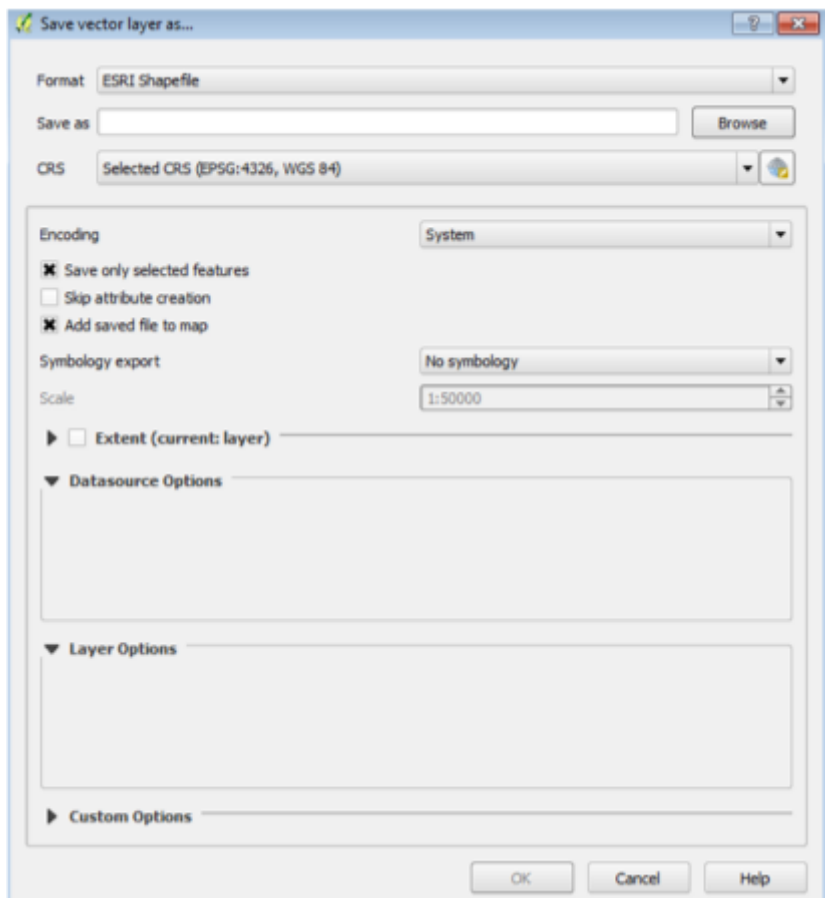
5. **Scroll** through the Attribute Table and note the records that are selected.
6. You can **observe** that the selection from the Attribute Table is also reflected in the Map Canvas.



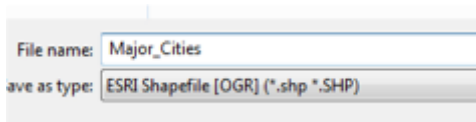
Exporting Data

Notice that the Selection looks more manageable than the full dataset. Now you will export this selection as a new shapefile, and bring it back into QGIS as a new Layer.

1. **Right-click** on the **Cities Layer** and select **Save As**.



1. Check Save only selected features.
2. Click on the **Browse Button** and Browse into the **Data Folder** to save the new shapefile as **Major_Cities.shp**.

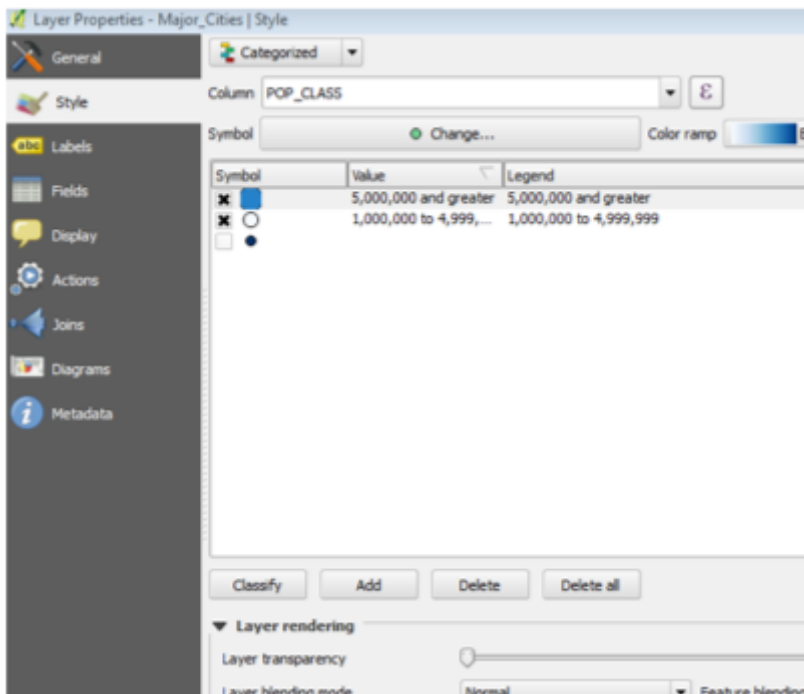


3. Click Save and OK.
4. Right-click on the original **Cities Layer** and select **Remove**.

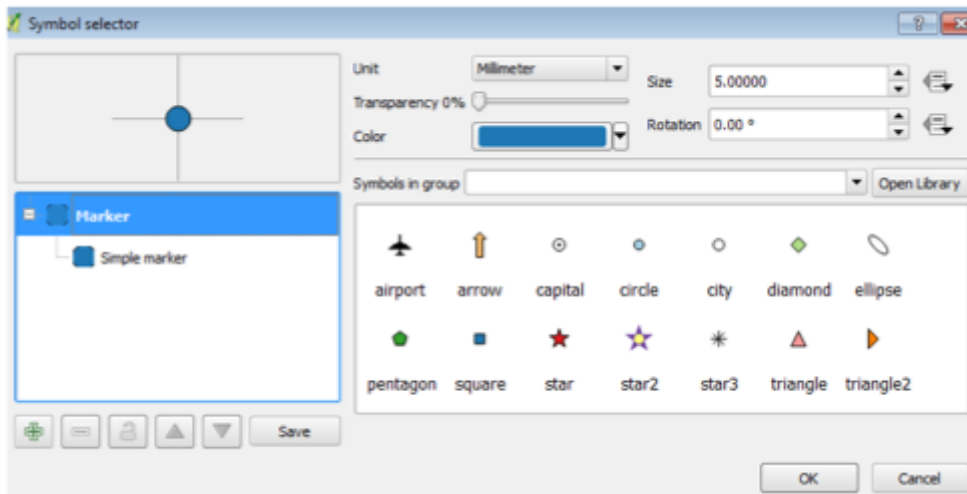
Change City Symbology

Now we have two classes of POP_RANK to work with, and would like to distinguish them from one another, visually.

1. **Right-Click** on the new **Major_Cities Layer** and **Open** its **Properties**



1. Click on the **Style Tab** and **Select Categorized**
2. On **Column**, select **POP_CLASS**
3. Click on **Classify**
4. **Double click** the point symbol.
5. In the resulting Symbol Selector, select Color Black and change Size to 1 for “**1,000,000 to 4,999,999**” item. Click OK



6. Using the same method, change the symbol for the “**5,000,000 and greater**” item to Color Black with a size of 3 **points**.
7. **Uncheck** the point with no value.

8. **Click OK** to close the Layer Properties Window.

9. **Click Save**



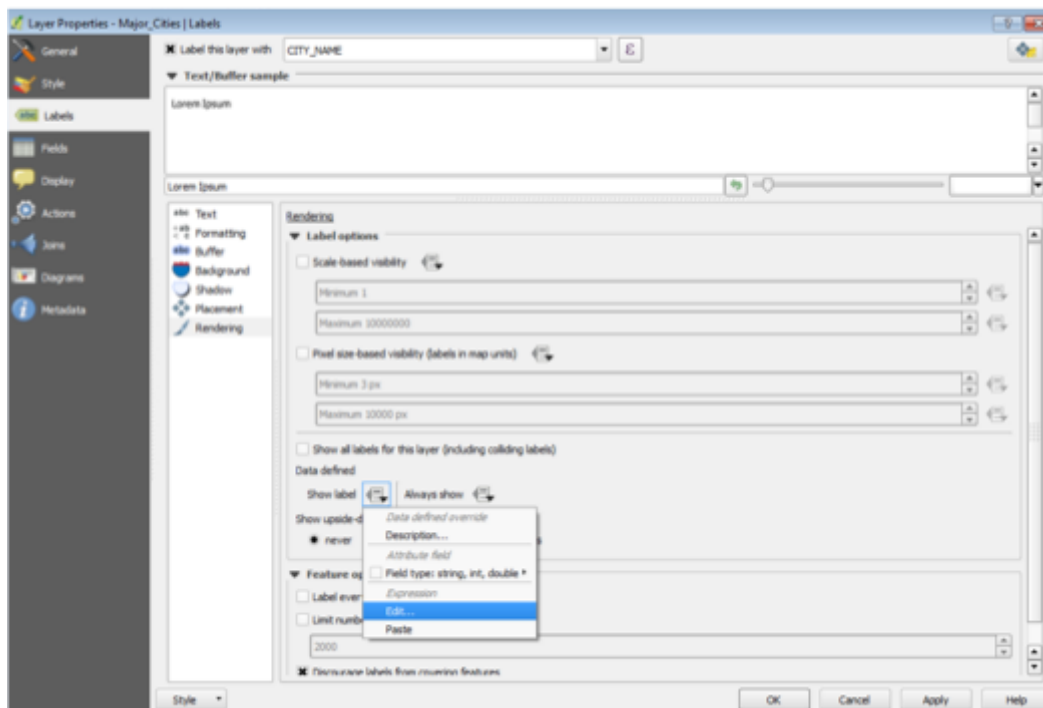
Label Cities

Another property of the layers in our Document that we might want to enable is the labeling of features. This can be accomplished, based upon an attribute value for each of the features. In many cases, this might be the name, or some other identifying attribute of the feature, but in some cases it might be a quantitative value associated with the features. It is even possible to use VB Scripting to assemble labels from several attributes and text elements. In this example, we will label only the cities with a POP_RANK value of 1.

1. **Right-Click** on the **Major_Cities Layer** and select **Layer Properties**.

2. **Click** on the **Labels Tab**.

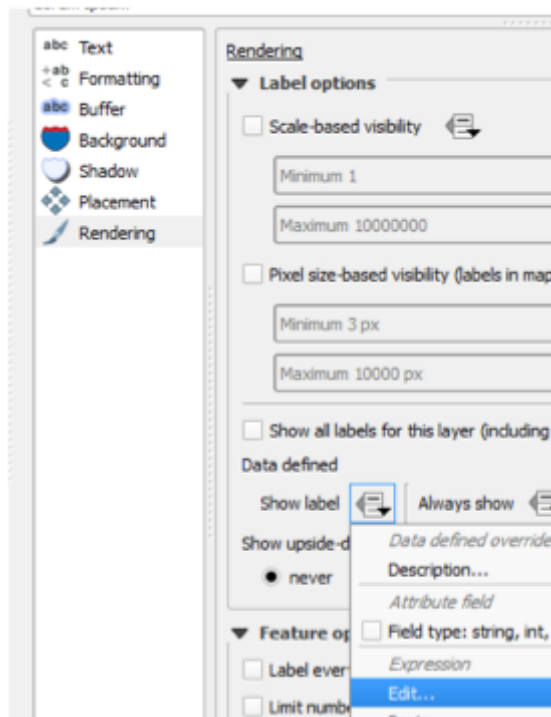
3. **Check** the **Label this layer with** to enable options and **Select** CITY_NAME and **Click Ok**.



Note that this turns on labels for all features and. Because there are so many visible features in this layer, this creates an unreadable labeling scheme. To remedy this, we will limit labeling to the largest cities in the Major Cities Layer.

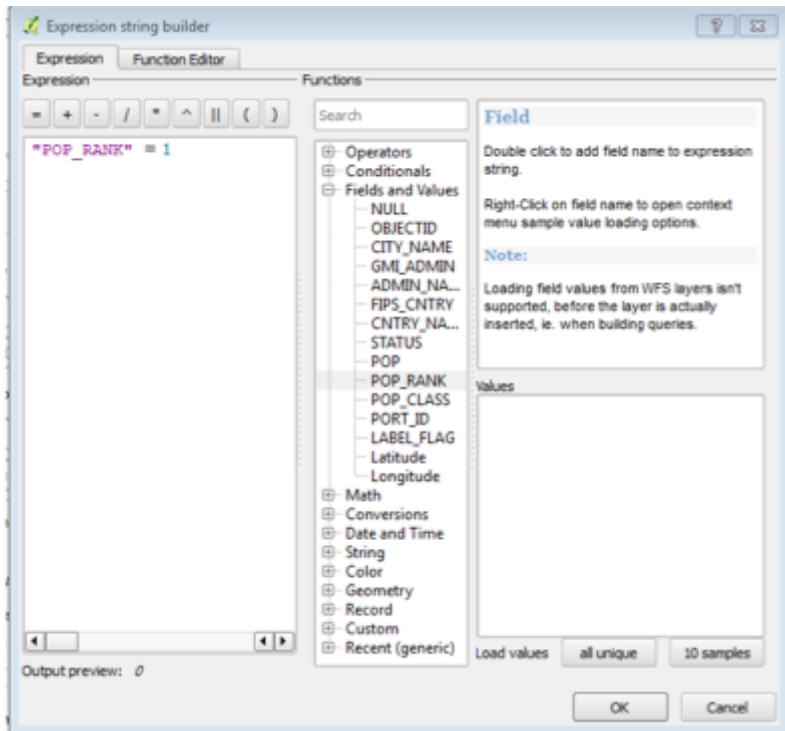
Label Cities with Expressions

1. Right-click on the **Major_Cities** Layer and select **Properties**. Go to the **Labels** Tab and Click on **Rendering**.



1. Click on the **Show Label** icon and **Select Edit** to open the Expression string builder window.

2. **Expand** Fields and Values and **Double Click** on POP_RANK.
3. In the **SQL Query** window, create a **SELECT** argument as follows:
"POP_RANK"=1



4. **Click OK**
5. **Go** to the **TEXT** Tab and **change** the **Label Size** to **7 points** and **Click OK** to apply this labeling scheme to the Data Frame.

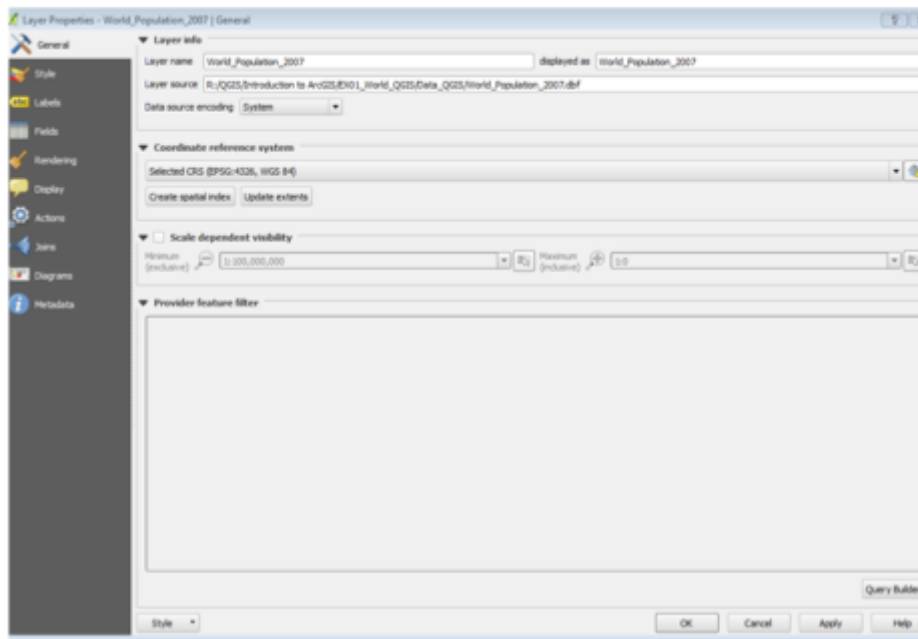
Definition Queries

1. **Right-click** the **World_Countries dbf** and open the **Attribute Table**.

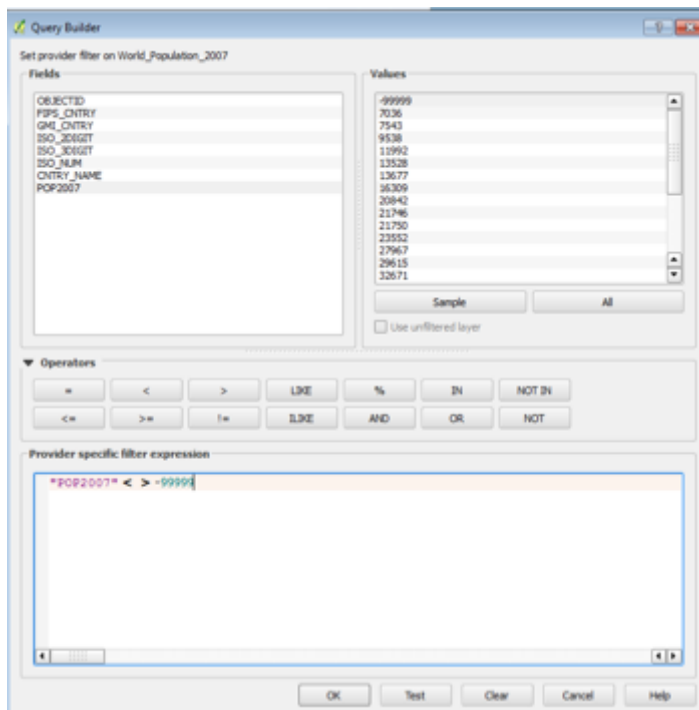
You may have noticed that many of the features in the World_Population_2007.dbf file had values of **-99999** for the POP2007 attribute. This normally indicates **NODATA** for the particular feature in demographic datasets. In this case, we would like to exclude this value from our Map Document. We could use the method used to subset the Cities layer earlier in the tutorial, but this time we will use another method called Definition Query. Definition Queries "define" a dataset, based upon a SQL Query, like the ones we have used to create the selection by attributes and the labeling class. In this case, the Definition Query "defines" a subset of the data layer that QGIS treats as the entirety of the dataset. It does not, however, require creating a new dataset (preventing redundancy in data storage) and does not alter the dataset being referenced, only our view of it in QGIS.

1. **Close** the **World_Countries** Attribute Table.

2. Right-click the **World_Population_2007.dbf** and open the **Properties Window**.
3. Go to the General Tab and Click on the **Query Builder** button at the bottom right***



1. On the Query Builder window create an **Expression** as follows:
"POP2007" < > -99999



1. Click OK twice to apply the **Definition Query**.
2. Click the **Refresh** button. Open the **Attribute Table** for the **World_Population_2007** Layer and notice how the **POP2007** Field no longer contains records with -99999 as a value.

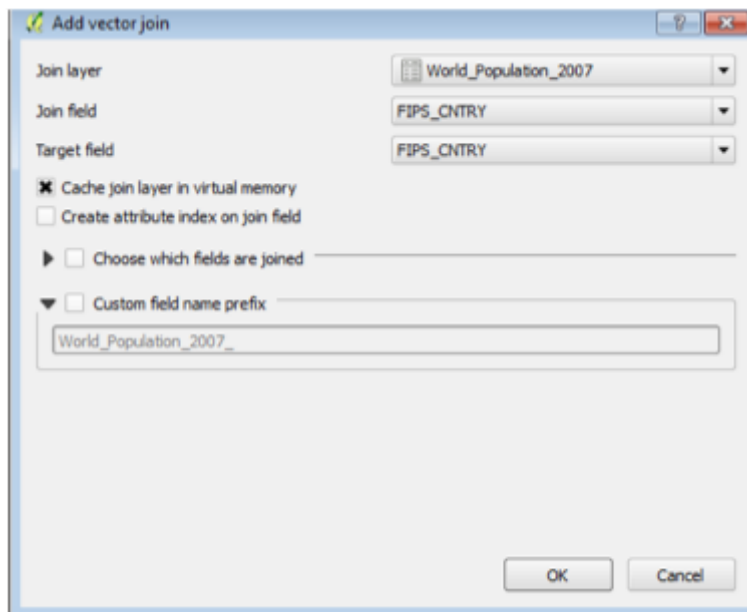
Join a Table to a Layer

Now we will turn our attention to the World_Countries Layer. Ultimately, we would like to visualize the layer based upon population density. However, the attribute table for this layer doesn't contain data on population. Fortunately we have a table in our Map Document with the necessary population attribute.

1. **Right-click** on the **World_Population_2007 Table** and select **Open**.
2. Scroll through the attributes and note the **FIPS_CNTRY** Attribute Field.
3. **Open** the **Attribute Table** for the **World_Countries Layer** and note that it also has a **FIPS_CNTRY** Attribute Field.

Since this attribute exists in both of these attribute tables, and its values are identical across the two datasets, we can use this attribute as the "**Key Field**" for our table join.

1. **Close** the **Attribute Table** for the **World_Countries Layer**.
2. **Right Click** on the **World_Countries Layer** and **Select Properties**
3. **Go to the Joins Tab** and **Click the Green Plus Sign** to open the **Add vector join** window.
4. **Select World_Population_2007** as the **Join layer** and **FIPS_CNTRY** for the **Join & Target** fields.



3. **Click OK** to close the Window and **Apply** to create the Join.


4. **Close the Layer Properties Window and Open the Attribute Table for the World_Countries Layer** and note the **POP2007 Attribute (along with all other attributes from the World_Population_2007 table)**.

Some values are NULL because they were dropped when we perform the definition query.

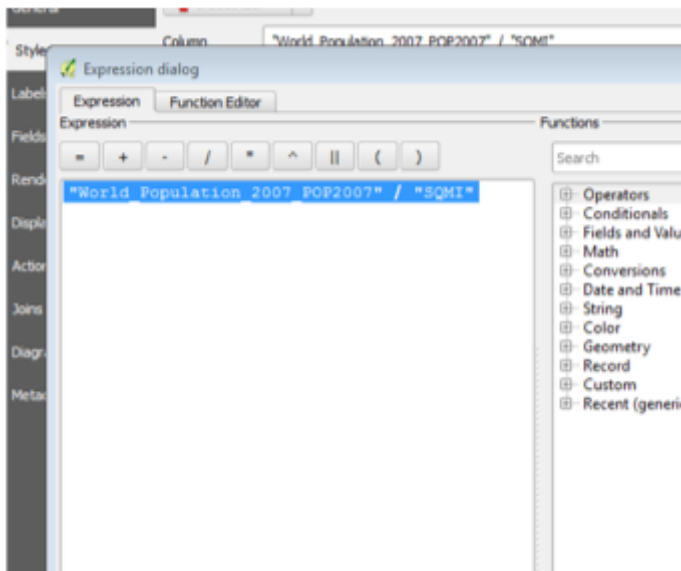
Symbolize Countries by Population Density

We can now use the POP2007 attribute to visualize population density. Even though the POP2007 variable is a raw counts variable, we can use the Style Tabs Normalization capability to divide the POP2007 variable by the area of the features to create the density value on-the-fly.

Open the Properties for the World_Countries Layer and click on the Style Tab.

1. **Select Graduated** and **click** the Expression Dialog button. 
2. **Expand the Fields and Values** and **double click** on the fields to **write** the normalization expression:


"World_Population_2007_POP2007" / "SQMI" and **Click OK**.



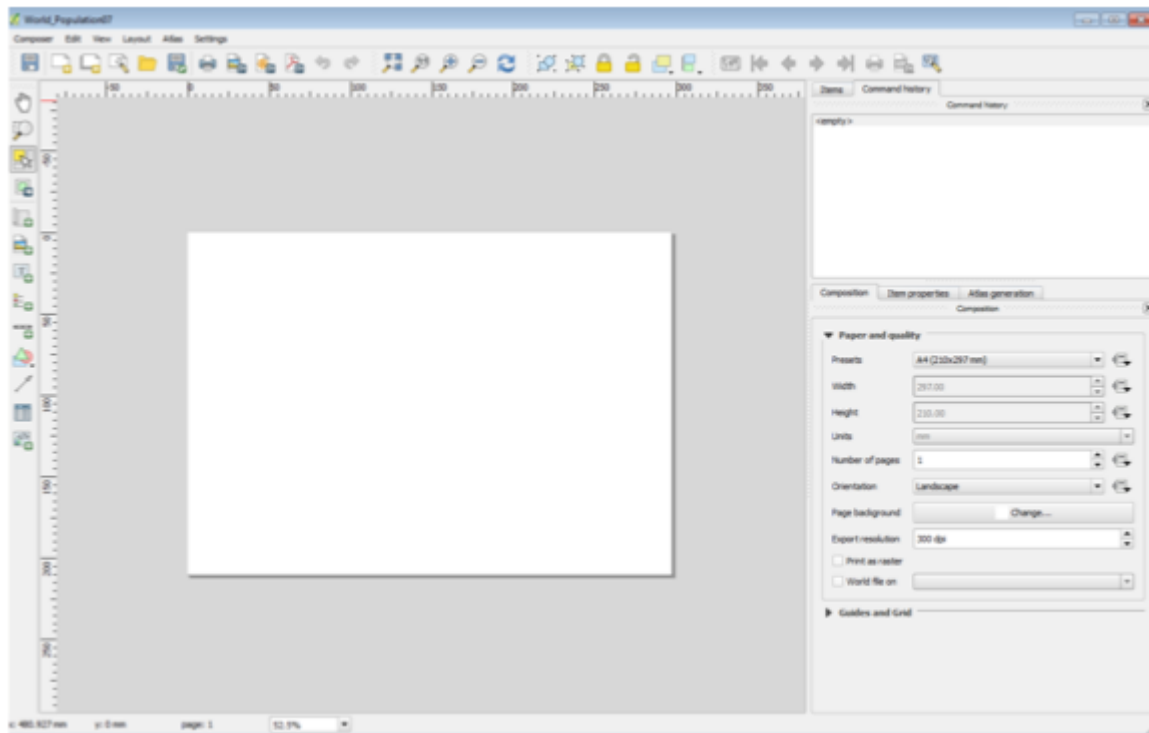
3. **Select Quantiles** as the classification mode and with **5 Classes**.
4. **Click OK**.
5. **Select a Color Ramp** and **Click OK** to **apply the Symbolology**.
6. **Uncheck the Lat_Long_30** shapefile


Note: When selecting your color ramp, be careful about selecting anything other than monochrome color ramps. This is because you want your map to “read well” in grayscale. In some of the 2-3 color ramps, the Intensity value of the colors at each end of the spectrum is the same, so that they produce identical grayscale values when converted, Xeroxed or printed in black & white.

Print Composer

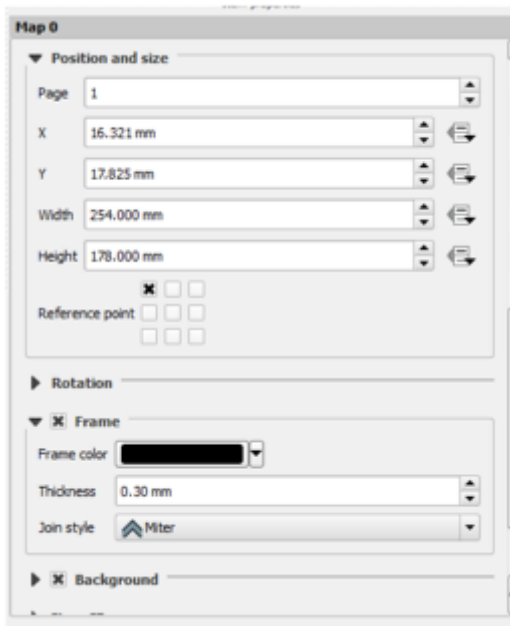
1. Click on **New Print Composer**  and name it **World_Population07**. Click OK.

Note that a new window opens. Take a moment to **explore** the **Composer toolbar**



1. Click the Add a new map icon  and place the mouse pointer over the blank sheet. Notice a crosshair pointer.
2. Click and hold on the left corner of the page and extend to the bottom right to draw a bounding box.

The Page Orientation and Size can be changed using the composition tab.




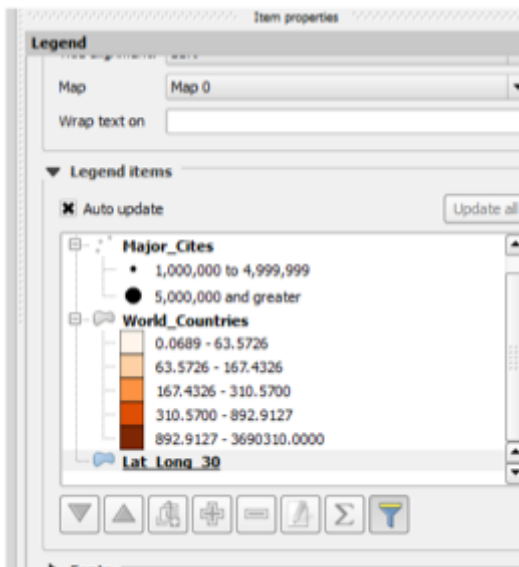
1. Click on the **Map Box** to select the item.
2. Go to the **Item Properties Tab** and expand **Position and Size**. Set the **Map Size** as **10 in wide by 7 in (254 by 178 mm)**.
3. Click on the **Frame Tab** and set the **Border weight** to **.50mm points**.
4. On the **QGIS Map Canvas**, go to **Bookmarks** and zoom to your **Europe & Asia** bookmark.
5. Go to the map composer > Item Properties > Extents and **Click** View extent in map canvas. To pan inside the map element **click the Move Item content** icon and pan inside the map.
6. **Check** the Background option and select a light blue as color background

Adding Map Elements

Legend

Click the **Add new legend** button  and draw a bounding box inside the map.

1. On the Legend items **click the Filter by content** icon 
2. Expand the Spacing Tab and set the box space to 5.0 mm.



3. Give the **Legend** a **Border** of .50 mm and **Background** (white is a good choice).

4. Click **Next>** to accept all remaining default settings and insert the Legend.

5. Use the **Select move item tool**  to reposition the **Legend**


6. Go back to the Map Document and **Open** the layer properties. **Rename the layer Major_Cities to "Major Cities"** removing the underscore, and **click Ok** to commit the change.

7. Go to the map composer and click the **Refresh** button.

Note that the change you have made to the name of the Layer is also reflected in the Legend.

1. Make changes to the other Text Elements of your Layers so that your Legend contains properly formatted and reasonable text descriptions and labels.

Scale Bar

1. Click the Add new bar scale tool 


2. On the Item properties change the **Style** to Line Ticks Up.

3. Change the Units to Feet.


4. Set the **Segments** left 0 and right 2

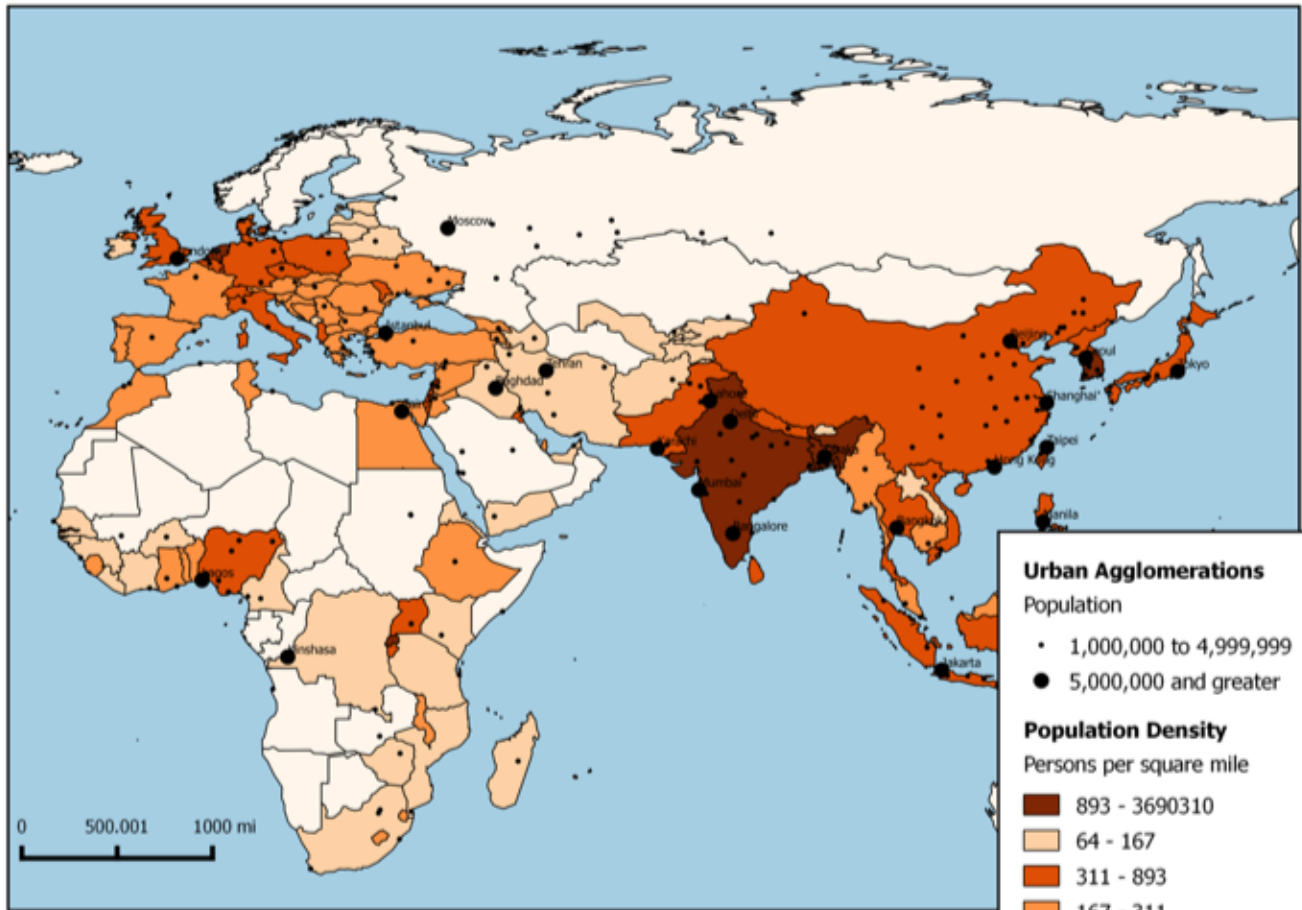
5. Use the **Select Elements Tool** to **resize** and **reposition** the **Scale Bar**.

Neat Line

1. Click the Add figure  and **select** add a rectangle.
2. Be sure to draw it around all elements.
3. Go to its Item properties and change the style to transparent fill and border width 0.50.
4. Click **OK** to add the **neatline**.

Exporting Your Map

1. Save your Map Composer
2. Click on the **Export as Image Button** 
3. Save as type to **PNG(*.png)** and name it **EX01_World**
4. Click **Save**.
5. **Browse** to the Workshop Folder and double click on the **EX01_World.png** file to view it in the default image viewer.



Urban Agglomerations

Population

- 1,000,000 to 4,999,999
- 5,000,000 and greater

Population Density

Persons per square mile

- 893 - 3690310
- 64 - 167
- 311 - 893
- 167 - 311
- 0 - 64