Getting Started with ArcGIS Pro

UNIVERSITY OF WATERLOO

GEOSPATIAL CENTRE

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This tutorial is designed to introduce you to the basics of GIS and how people use it to visualize and interpret geospatial data. GIS enhances our understanding of the world, and this tutorial will illustrate the depth of information contained in each layer and how that information can be accessed and understood using Esri ArcGIS Pro. The accompanying data for the tutorial is the Canada_Ecozones_V5b_31s_15M_simplify.shp freely available from the Canadian Council on Ecological Areas (CCEA).

Contents

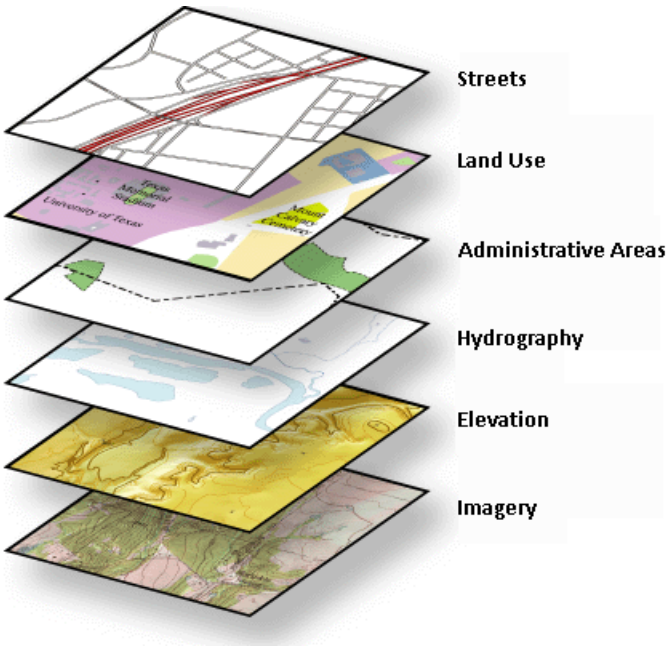
What is GIS?

The simplest answer to this question is that GIS is an acronym that stands for *geographic information systems*. Here's an overview that covers the major concepts.

GIS Defined

GIS combines hardware, software, imagery and tabular data in order to collect, manage, analyze, and display geographically referenced information.

GIS uses a concept known as **layering** to view, analyze, and interpret data. The idea behind layering is that you stack different **layers** on top of one another to see how they relate to one another. This visualization of the data reveals patterns and trends that contribute to improve workflows and the decision-making process.



Various layers of data covering the same geographic area. (Image source: Esri, Inc.)

For example, many people use maps to look for distinct features such as schools—that's one layer. But in order to figure out how to drive to the school, you need to see the roads. That's another layer. And perhaps you'd like to know what district that school is in. That's another layer Maps are used to visualize data in a manner that can be quickly and easily read and understood.

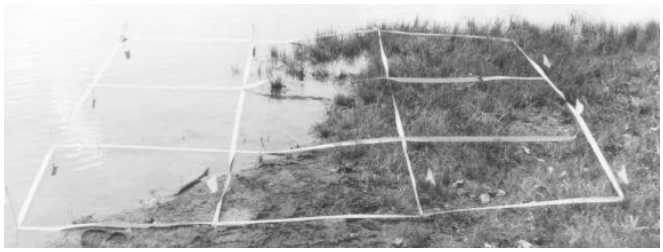
Geographic Data

Another name for layers is, quite simply, *data.* Among GIS users, data may also be referred to as *datasets, geodata,* or *spatial data.* GIS data can be broken down into three main types of data: **vector**, **raster** and **tabular**. Vectors represent features with distinct boundaries, and these are drawn using only three different types of geometry: points, lines, and polygons. The layers just mentioned—schools, roads, districts—are examples of vector data.

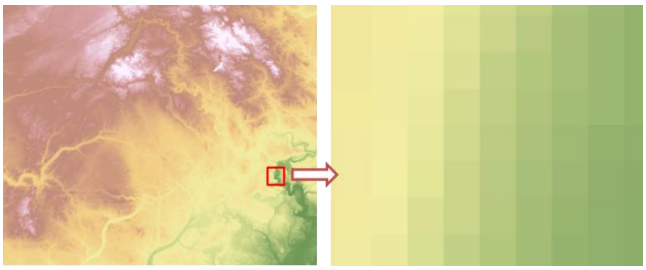
Vector data represented by points, lines, and polygons.

In mathematics, a vector is a geometric quantity having magnitude and direction. In GIS, therefore, all vectors have a **xy coordinate** value, wherein points have a single value, lines are made up of two or more values connected by lines, and polygons have three or more values that are connected by lines *and* form a closed shape. Vector data maintains a constant resolution, which means no matter how close you zoom in on a point, it will not become blurry or pixelated.

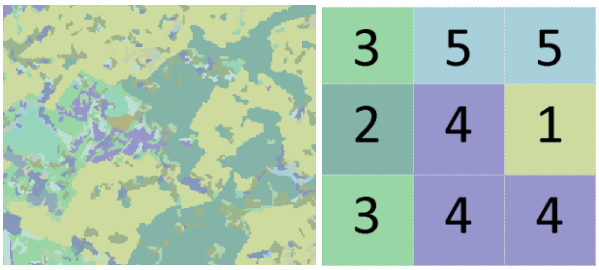
Raster data works a little differently in that it represents objects or phenomena over an uninterrupted surface. Raster data is stored as a grid of **equal-sized cells arranged in rows and columns,** where each cell has a specific value, either continuous or discrete. Exactly like a photograph, the only difference being that a raster has a scaled pixel/cell size.



Continuous values represent a continuous measurement such as elevation. Discrete values represent a specific value such as land cover.



An elevation raster (and detail) showing continuous value cells.



A land cover raster (and detail) showing discrete values.

Note that in the detail of elevation raster, each cell, or grid square, has a distinct pixel value that is consistent throughout the cell. This is important to remember because when the cells are viewed next to each other, the naked eye makes them appear as though they are changing from darker to lighter values as you move left to right. For example, on the left of the detail, the cells are yellow, but as you move toward the greenish-yellow cells in the middle, they appear to be darker (more green) on the left of each cell and lighter (more yellow) on the right. This is an optical illusion. Not only would that contradict the continuous nature of the data (yellow becomes green as you move across the image from left to right, not the other way around), but it would also negate the fact that each cell has a consistent value throughout (i.e. if the cell is $1m^2$, any given pixel within that square-meter will have the same value).

With the discrete values (land cover raster), cells also have a distinct value throughout, but because they are not a continuous measurement, the colors of each cell do not change gradually or blend; instead, they change abruptly and have a much more rigid appearance. As the detail below illustrates, each unique value constitutes a type of land cover (i.e. 3 may be marshland, 5 may be water, 2 may be forest, etc.).

Storing Data

Another important consideration when getting started with GIS is how to store your data. Both vector, raster and tabular data can be stored as a variety of file types. The file type will also determine what kind of container the data is stored in. For example, vector data stored as a **shapefile** resides in a folder, just like common files on a PC. However, if that same data is stored in a geodatabase, it is considered a **feature class.**

Shapefiles are by far the most common storage format, in part because they have been around for a long time, but also because they can be read by various types of GIS software and even some non-GIS software. However, they are somewhat limited in terms of performance and storage capacity.

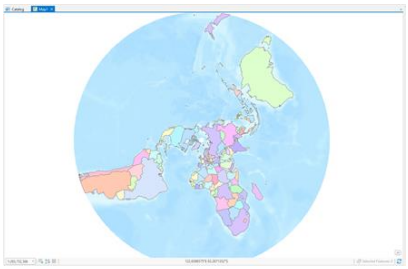
Rasters are large and take up a fair amount of drive space but this is contingent on resolution. As with photographs the sharper they are the more storage space they occupy.

Tabular data is any form of table data sorted with location information stored within. It could be txt, csv, gpx, xlsx etc. This data is very light and can be easily transformed into location data by using a GIS.

For this tutorial, we will work with shapefiles because of their ubiquitous nature. However, no matter what data format you choose, all data needs to be described. To do this, geospatial data allows you to record metadata**,** or data about data.

Projections

Projections are the basis of any spatial analysis. A projection is a way of converting spherical data into flat data so that it can be easily measured and precisely layered. Measuring anything on a sphere is mathematically intense so a GIS has many algorithms to flatten the data, hopefully with the least distortion. These algorithms take data, usually in Decimal Degrees and converts it to metres. ArcGIS will allow the user to visualize spatial data in the same spatial context but, for any analysis, all the layers must be in the same projection.



North Pole Stereographic

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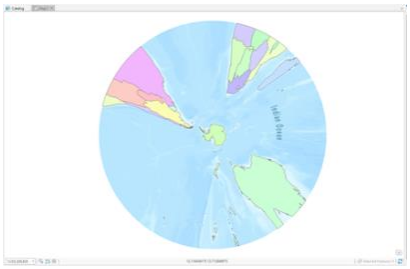


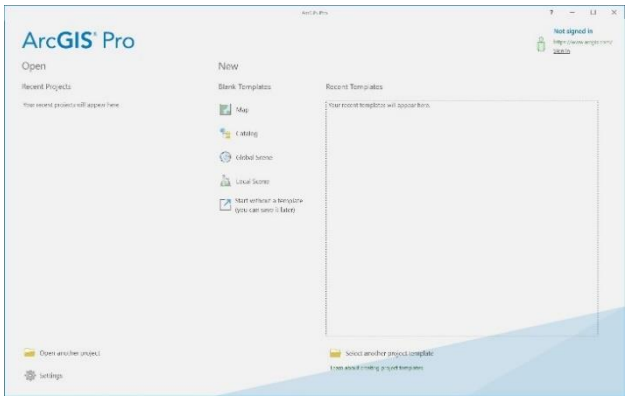
South Pole Gnomonic

Starting ArcPro

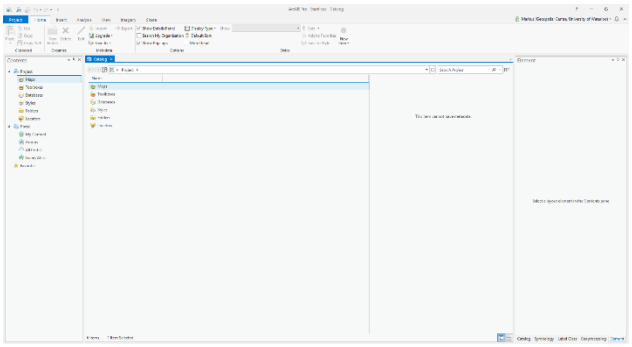
ArcPro is a suite of products that include **ArcMap** and **ArcCatalog** that were separate entities in Arc Desktop (Map)**.** These have been seamlessly blended along with an ArcGIS online connection for a very dynamic experience. We have provided the Canada Ecozones shapefile as a base layer for this tutorial and additional data will be acquired from an online geo hub.

1. From the Start menu or the desktop icon 

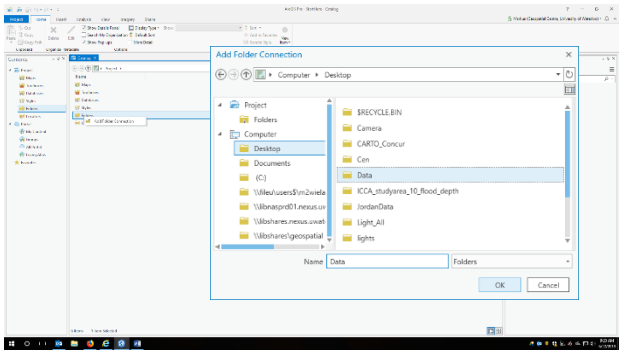
, launch ArcPro and wait for the Getting Started window to appear.



2. From this window, choose **Catalog** under New.
3. From here create a new project. For now let ArcPro create the new folder and associated Geodatabase. This can be changed later if required.

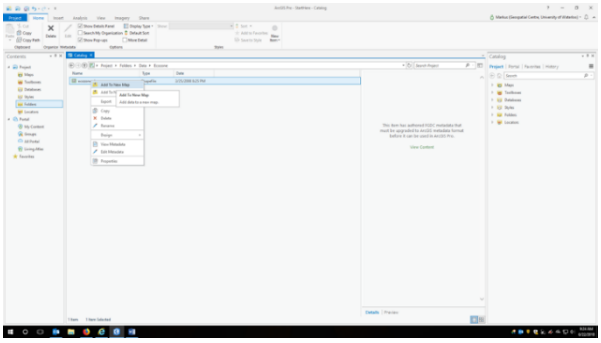


4. The ribbon has base tabs—Map, Insert, Analysis, View, Edit, Imagery, and Share—that are always present when a map view is active. Each tab has its own set of tools, organized in groups. The Catalog tab/tools are for interacting with files, folders and databases, as the Map tab has tools for interacting with the map.



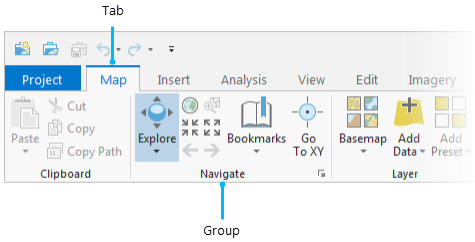
5. Create a connection to a folder that contains spatial data (this can also double as your project folder) by right clicking on **Folders** (under the Contents panel) and click through the dialog box to your desired folder. This will point ArcPro to the folder containing the spatial data. Select the (unzipped) Ecozones folder provided with this tutorial or any other folder that contains shapefiles.

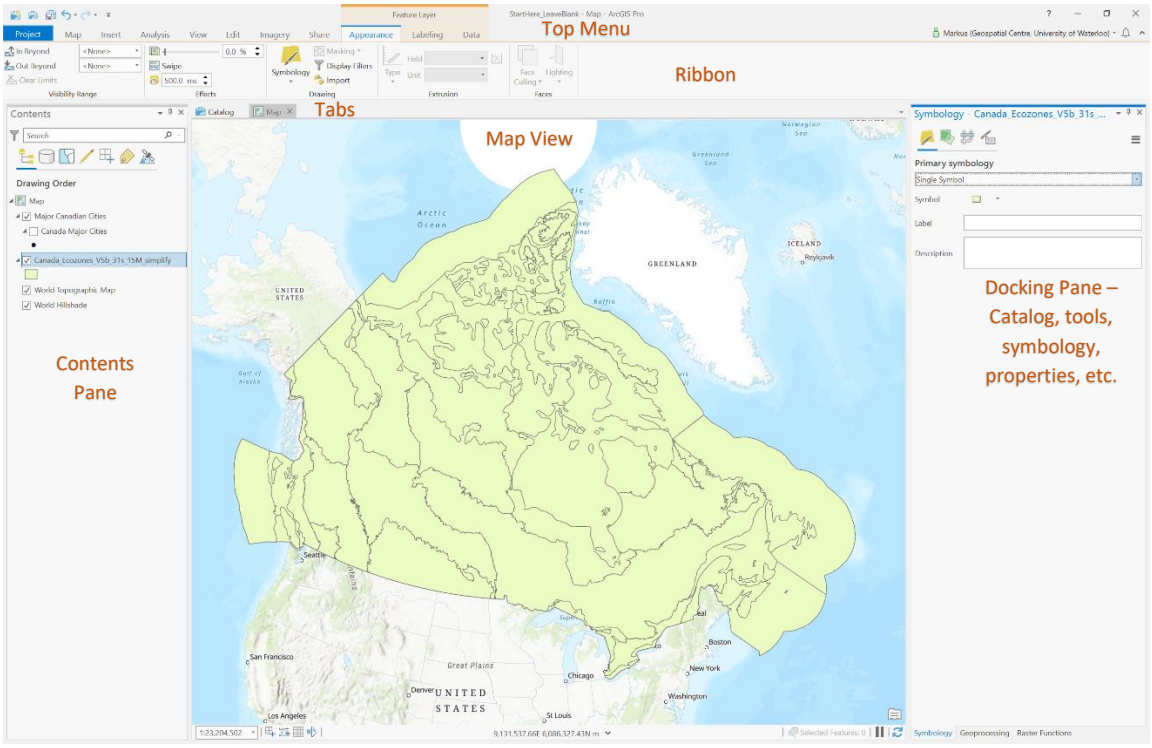
6. Either add a new map under the **Insert** tab to add a shapefile to or right click your preferred shapefile and **Add to new map**.



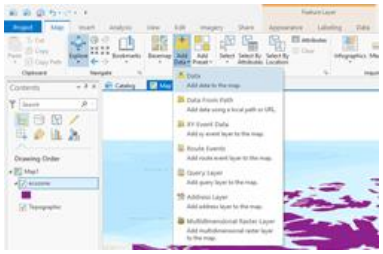
7. Add the Ecozones tutorial file (Canada_Ecozones_V5b_31s_15M_simplify.shp) to the map and ArcPro will shift tabs to the Map.

8. The Explore tool allows you to move around the map as well as to get information about map features of interest.

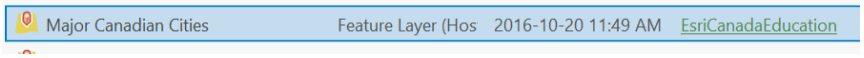


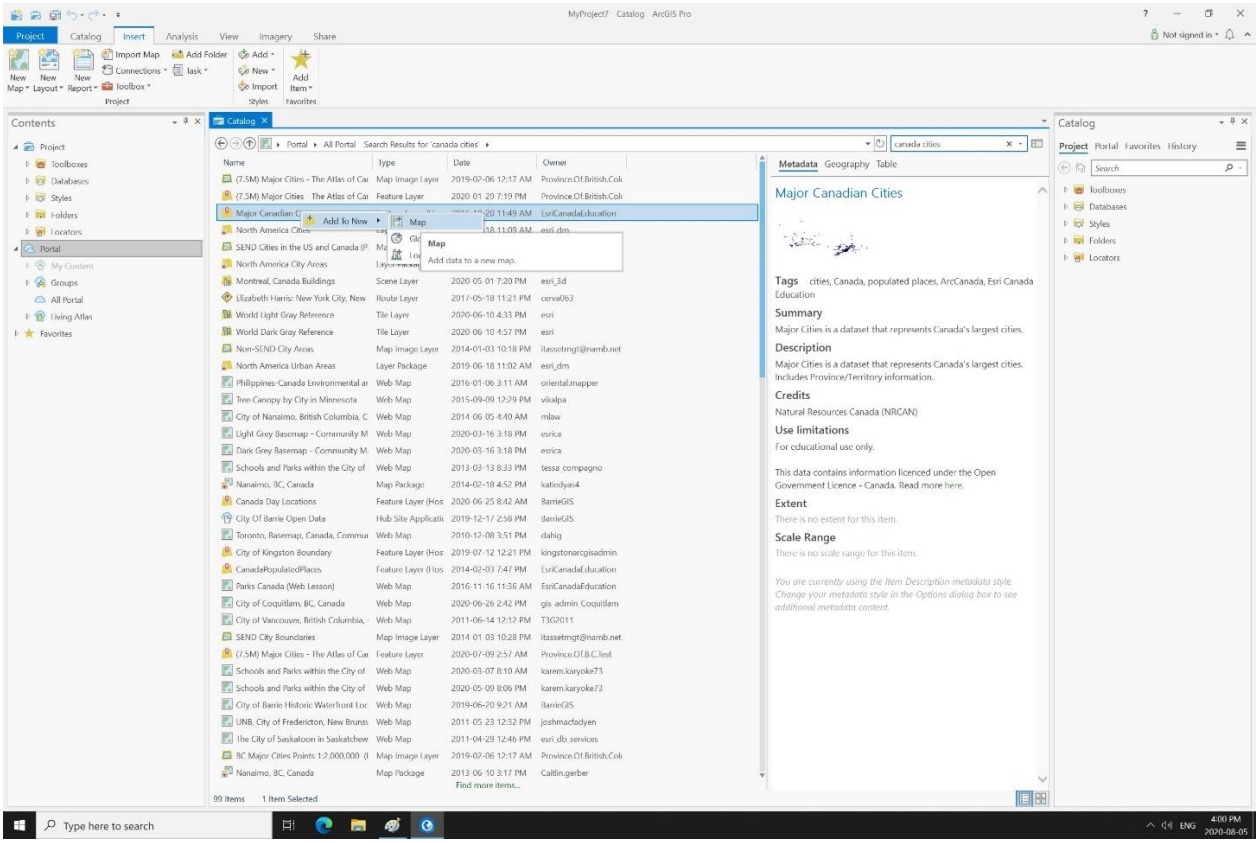
9. 

10. Additional data can be added several different ways:
    a. Map tab:
        i. Add Data in the ribbon
        ii. Drag and drop a spatial data file from a windows explorer folder



    b. Catalog tab:
        i. Get a spatial data file from a connected folder (see instruction 5)
        ii. Get spatial data from other sources connected. Eg:
            1. Portal: By selecting **All Portal** in the contents pane this connects ArcPro to various online sources of data. There are more available if one is signed-in to ArcGIS Online.
            2. On the top right of the Catalog tab there is a **Search Box**. For this example, type in “Major Canada Cities” and right click to add the “Major Canadian Cities” [Ensure this is the Feature Layer from ESRI Canada Education] to the same map as the ecozones.



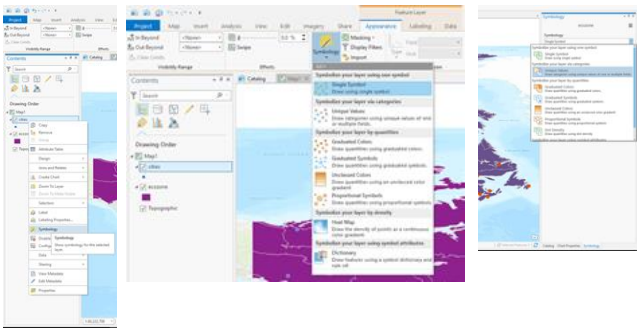


Symbology

Symbology is a way of visualizing map attributes in different lights. Since, shapefiles have attributes (a table that contains descriptors for the individual objects that make up a shapefile) symbology can be changed to highlight or delineate the differences within one column. For the Ecozones shapefile we will highlight the different ecozones with unique colours.

Changing size and colours

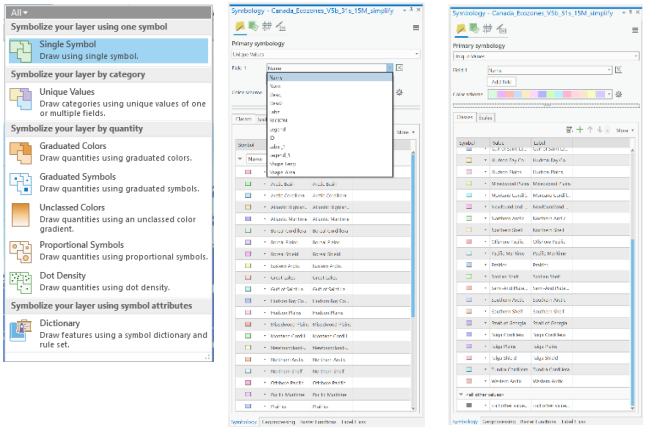
Change the colours, size and outline of spatial data as a **Single Symbol**. All choices will bring up the Symbology properties pane on the right side.



1. Right click on the Ecozones layer.
2. Selecting symbology in the ribbon under the Appearance tab.
3. Or, 2x clicking the symbol in the Contents panel.
4. Select **Unique Values**.
5. Change the Field 1 dropdown to Name.
    a. This colours each of the attribute values of Name a unique colour.

Conditional formatting

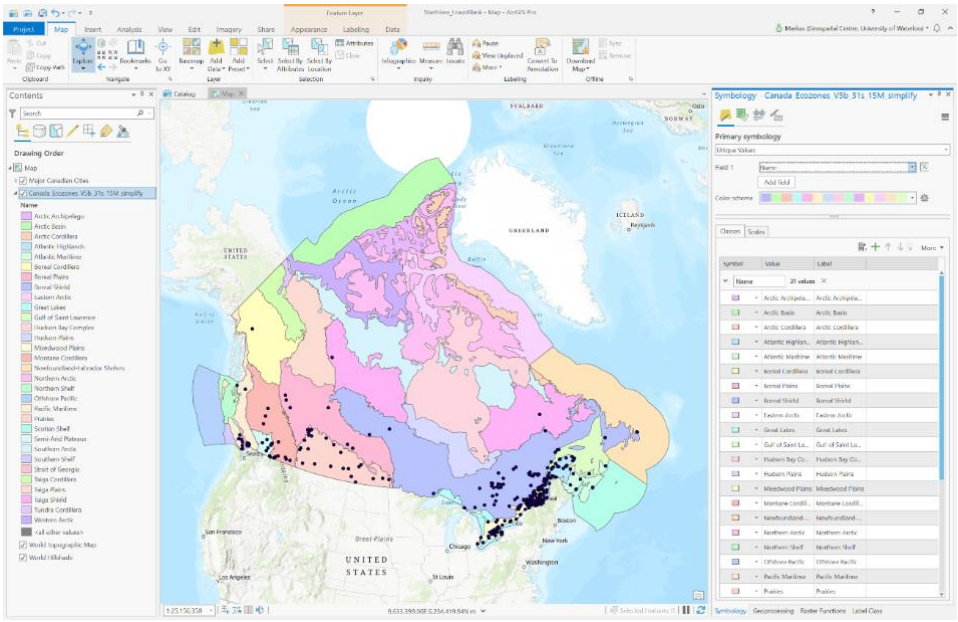
Some examples of making spatial data more dynamic using unique values or ranges:



1. Unique Values
2. Graduated Colours
3. Graduated Symbols
4. Proportional Symbols
5. Dot Density

The different forms of Conditional formatting allows one to highlight the attribute data from a shapefile by its type.

1. Unique Values – assigns a colour to each unique value
2. Graduated Colours – draws quantities using graduated colours (low to high)
3. Graduated Symbols – draws quantities using graduated symbols (based on a chosen break method)
4. Proportional Symbols - draws quantities using proportional symbols (sizes symbols according to a quantity)
5. Dot Density – draws quantities using dot density (clustering of dots)



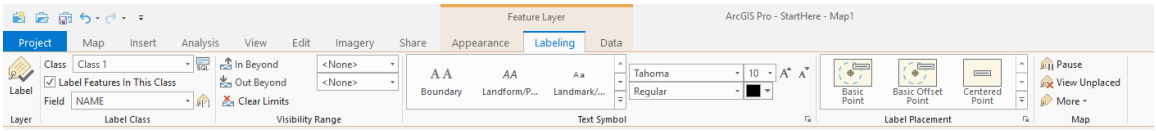
Labeling

Labeling is a way of adding more definition to your map by verbally highlighting features to attract a viewer's attention. Below are instructions on how to **label the cities layer** that was brought in from the portal.

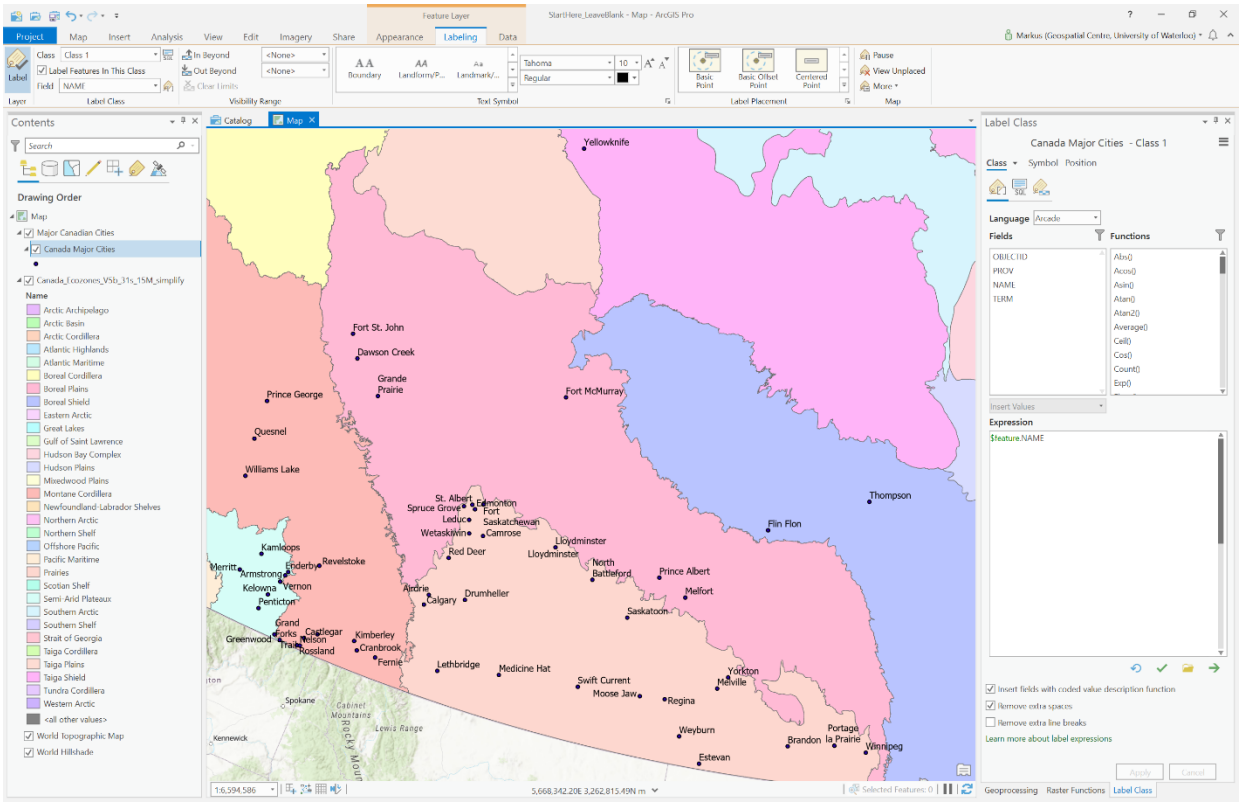
Adding labels to the map

As with Arc Map, ArcPro can automatically label the feature layer in the map based on the attributes in a selected column.

Selecting the **Labeling** tab on the top of the Ribbon will bring up all the properties for labels you can change in the Ribbon. Also, a Label Class pane on the right gives the same options as the Ribbon tab, plus some extended functions for creating attribute filters (Expressions).



Select the Major Canadian Cities layer in the Table of Contents. On the left side of the ribbon, under the Field dropdown select NAME and then click the label button. Your map should look like the one below.



At this point in the tutorial your map should like this.

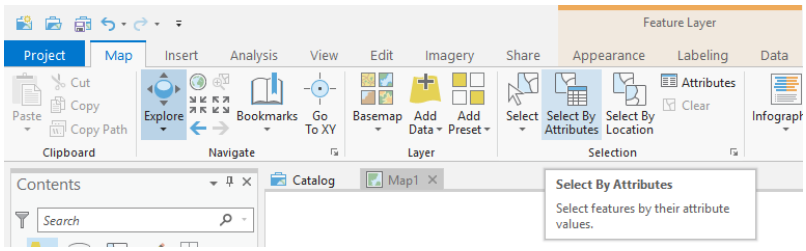
Selecting Data

GIS software allows for the organization and visualization of large amounts of data in many different formats. As mentioned previously, vector data is made up of 3 forms; points, lines, and polygons. Every one of these shapes is attached to an attribute table that describes it. E.g. a city point has name and province attributes.

Large amounts of spatial data are difficult to manually filter. GIS are designed around being able to extract specific data in two ways; **Select by Attribute** and **Select by Location**. This means a user can query the table data and query the visual data.

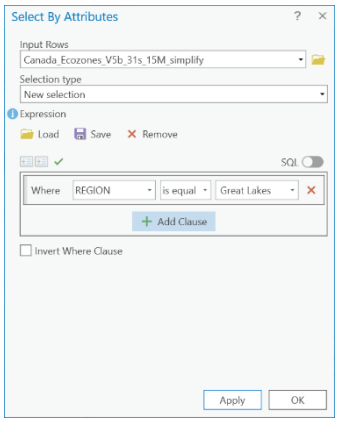
Select is a means of highlighting spatial data, it does not change any of the data. For example: If one is looking for the top 5 major cities in Canada to be ranked alphabetically, all one must do is open the attribute table (right click on the Major Cities Layer in the TOC), sort A-Z by double clicking the header of the NAME column and select the first 5 rows. This will highlight the top 5 cities in cyan on the map and in the attribute table. Select shows the connection between the table and the objects in shapefile. With this we can visualize chosen aspects of our layers.

Select by Attribute



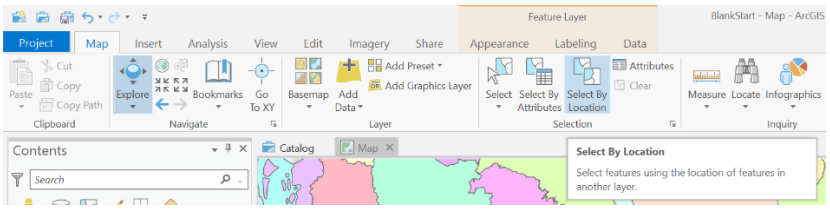
Selecting by attribute is like querying a database table. Arc Pro allows the user to create SQL statements by clicking dropdown list boxes. For this example, we are going to find all the Great Lakes Ecozones by the Name attribute.

Querying the table data:



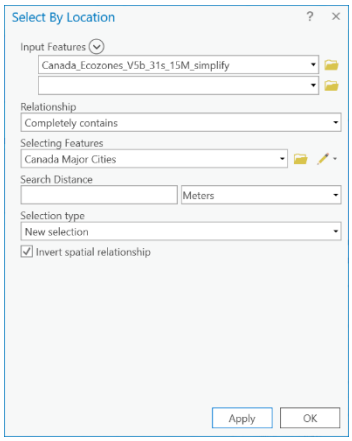
1. Right click on the Ecozones layer in the Contents panel and select Attribute Table or Ctrl-T.
2. Clicking Select by Attributes under the Map tab Ribbon opens the Geoprocessing dialogue box.
3. Choose the Ecozones layer to Query its attributes.
4. Build a SQL statement by clicking **Add Clause**.
5. Select the column in the table (Name) which is to be queried. “Where” Name …
6. Select the appropriate logical expression. “is equal” …
7. Select Great Lakes in the dropdown. “Great Lakes”
8. The full SQL will be: “Select from Ecozones Where Name is equal to Great Lakes”
9. Click Apply
10. You will see the row with Great Lakes under the Name column in the table and the Ecozone around the Great Lakes on the map highlighted in Cyan.

Select by Location



Selecting by location is a way to spatially compare two different layers. In a GIS one can find all the points within a search distance of a line (E.g.: Find all the Osprey nests within 200m of roads), find lines that intersect polygons (E.g.: Find all the roads that cross flood plains), and find which polygons contain points. For this Select by Location example we will find which Ecozones don't have Major Canadian Cities.

Querying the location data:



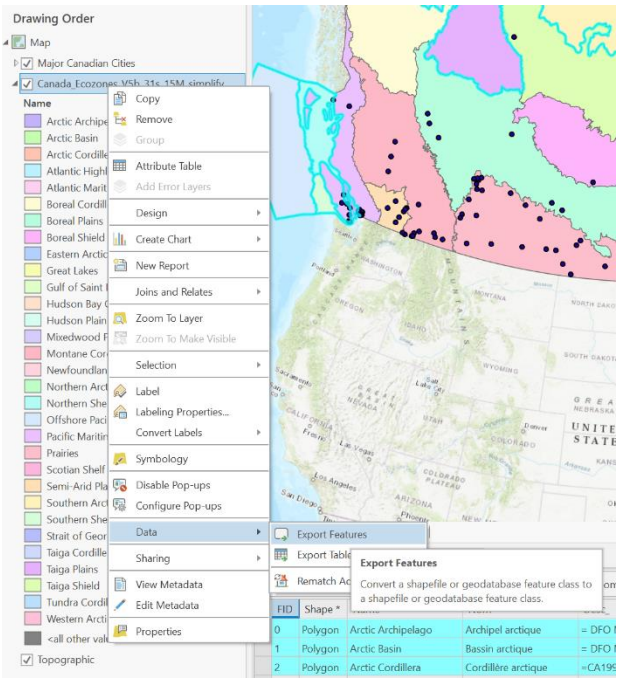
1. Clicking Select by Location under the Map tab Ribbon opens the Select by Location dialogue box.
2. Choose the Ecozones layer as the top Input Feature.
3. Select the Completely contains Relationship.
4. Then set your Selecting Features as Canada Major Cities.

Since we are trying to find where the Major Cities are NOT in the Ecozones we need to invert the spatial relationship.

5. Check the Invert Spatial Relationship check box.
6. Click Apply
7. You will see the Ecozones that do not contain any City points outlined in cyan on the map. Also, if you have the Ecozones attribute table you will see some of the rows highlighted in cyan and at the bottom of the table it should say 18 of 31 selected.

As mentioned previously these two methods of selection only highlight your choices and do not change the base data. From here you can export the data to create a new shapefile containing only the selected data.

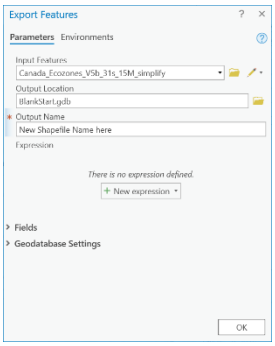
Right click the Ecozones layer in the TOC, click Data, and click Export Features.



Select an Output Location.

Give your new shapefile a useful name describing the data created under Output Name. E.g.: “Ecozones_no_Cities”.

And click OK to save.



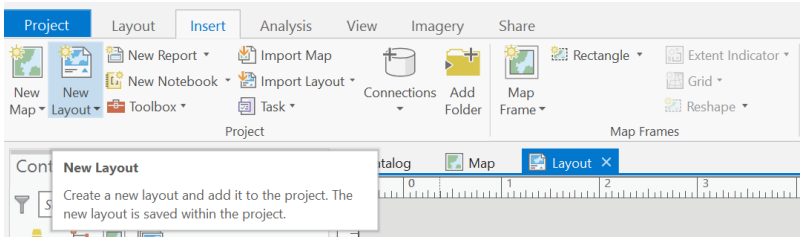
When finished with your selections or wish to create new ones be sure to click the Clear selection button in the ribbon. This removes all your selections and the cyan highlights from the map and table.

Creating a Layout for Export or Print

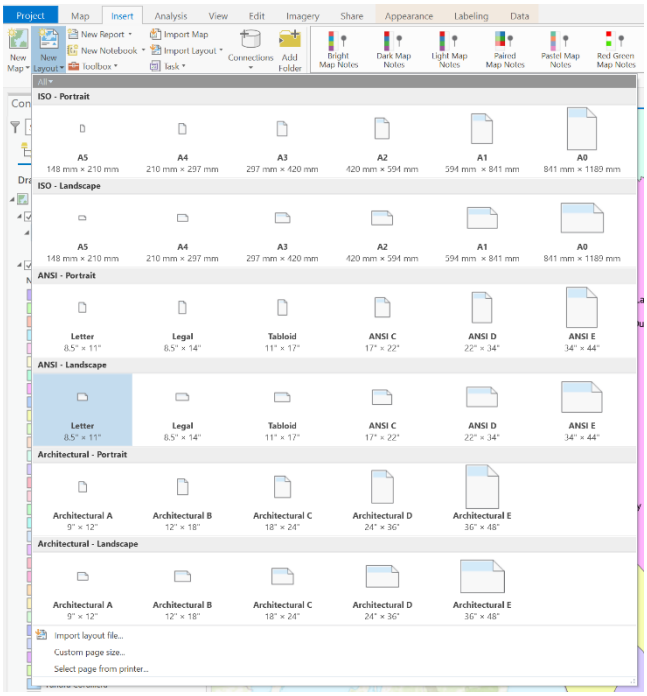
To finalize your map or figure you will need to create a layout. This is the best way to put together your map’s symbology and labeling in a cohesive manner for your research. This section shows one how to size, title, add legends, direction, etc. to their map. One of the layout choices is where the map is currently zoomed to, in this case we will zoom in to Southern Ontario.

Layout

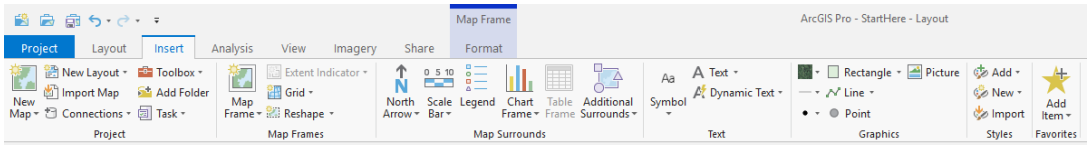
Select New Layout under the Insert tab in the ribbon.



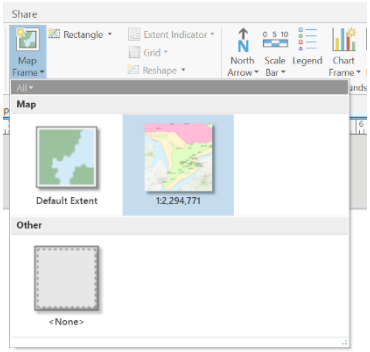
Once you have a paper size, ANSI letter (8.5X11 inches, a normal sheet of paper). This will give you an idea of how large your map will be.



Once a paper size is selected a new Layout tab will open and change the context of the Map and Insert ribbon tabs.

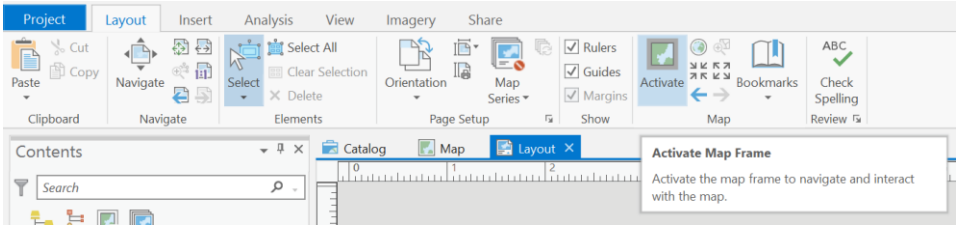


1. Insert a Map Frame – Select one of the two choices:
    a. Default Extent: is the full map extent including the base map.
    b. Representative Fraction Scale: is the scale of the zoomed in data frame. In this case Southern Ontario



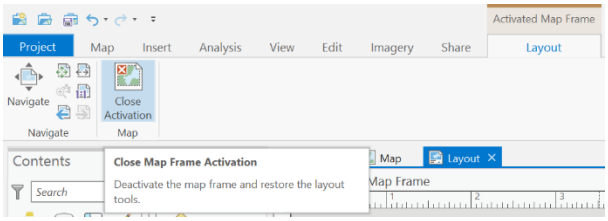
2. Select the Representative Fraction.
3. Click and drag out the size of rectangle you want the map to take up on the layout sheet. The Map Frame can be resized later.

4. To move the map around in the Map Frame:
    a. Select the Layout tab
    b. Click the activate button

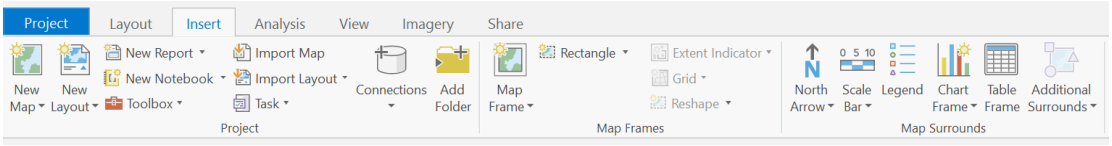


    c. This allows one to move and zoom the map within the Map Frame.

    d. When the Map Frame is all set-up the select the Layout tab and click close activation.

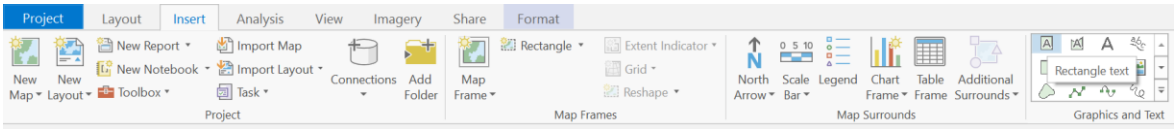


5. To add the rest of the pertinent information to your layout like North Arrow, Scale Bar, Legend and Title go back to the Layout tab. These additions are dynamic so they will change as the map information changes.

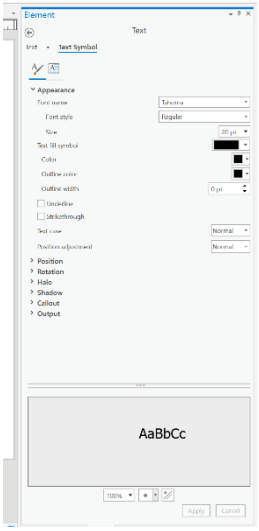


    a. North Arrow – if required, click on North Arrow button, select a North Arrow that suits your map and draw the rectangle size that you need. The arrow will adjust its angle to the maps North.
    b. Scale Bar – click on the Scale Bar button, select a North Arrow that suits your map and draw a rectangle anywhere on your layout. Since these are dynamic, adjust the length of the Scale Bar box to have the scale be an easily recognizable number (0 - 200 kilometers). The properties for the scale bar can be changed in the properties panel that shows up on the right side.
    c. Legend - click on the Legend button and draw a rectangle anywhere on your layout. This legend will show all the visible layers on the map. Legend properties can be changed in the panel to the right.

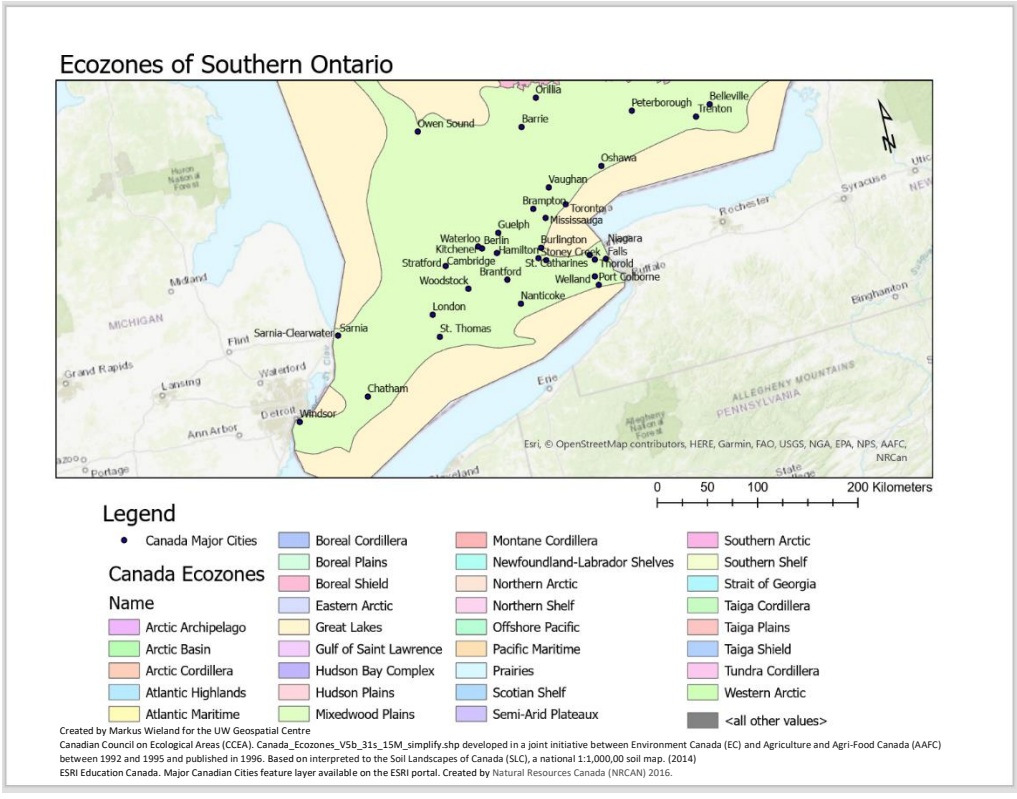
d. Adding Text – select the first A (Rectangle text) in the Graphics and Text area of the Insert ribbon.



i. Draw a rectangle for your text box on your sheet in the layout view where you want your title to be (Ecozones of Southern Ontario).
ii. To change the Text Symbology – Size, Colour, Bold, Font etc. select Text Symbol in the Elements panel on the right side. Here you can change the font size to 20 pt.
iii. After making changes to the text click Apply at the bottom of the panel.
iv. Also, remember to properly cite your map data.



6. Move around and resize the layout components and your map layout should look like this.



7. As mentioned previously the map elements are dynamic and can be changed from the Data view. For example, rename the Canada_Ecozones_V5b_31s_15M_simplify in the table of contents to Canada Ecozones. This will change the Ecozone title in the Legend to a more understandable value title. This re-naming does not change the original file name, it only changes the layer name in the TOC and correspondingly the title in the Legend.

Printing and Exporting

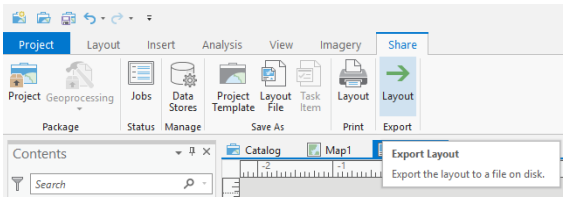
To Print or Export select the Share tab:

Print

Click the printer icon and follow the choices and instructions in the Print Layout panel on the right.

Export

Click the arrow icon, choose the image file type and the resolution in the Export Layout panel on the right.



This tutorial covered the basics of GIS and getting started with ArcPro. If you have any questions on learning more about ArcGIS and how to incorporate it into research, please contact us.

Contact Us

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Ecozones Shapefile:
Canada_Ecozones_V5b_31s_15M_simplify.shp
Obtained from the Canadian Council on Ecological Areas (CCEA)
https://www.ccea.org/ecozones-downloads/

Created by Markus Wieland for the University of Waterloo Geospatial Centre (2020)