Introduction to GIS Software

(A Hands-On Tutorial with ArcGIS Pro)

Introduction

This tutorial is designed to introduce you to working with ArcGIS Pro software and spatial data (or to refresh your memory if it has been awhile). To access ArcGIS Pro at Dartmouth, check out the following page: https://sites.dartmouth.edu/gis-geography/software/

Before beginning the exercise, familiarize yourself with foundational GIS concepts, including vector vs. raster data models and coordinate systems. We recommend the following learning pathway: https://sites.dartmouth.edu/gis-geography/basics-of-gis-training/

Important reminders for working with GIS software:

- **Use specific naming conventions for GIS**. Make sure that your computer folders, file, and ArcGIS project do **NOT** have spaces or special characters in their names, apart from an underscore. Computers interpret spaces and special characters as a command and will run into mysterious errors during analysis.

- **Your data are not stored in a GIS project**. Geospatial data is stored on your computer's hard drive in file folders. The GIS project only points the computer to where these are located, runs analyses on them, and displays them. Once you start a project, if you change anything about your existing file configuration (move or rename any folders or files), the software will not be able to find them. To fix this, open the dataset's properties and use "Set Data Source" to link ArcGIS back to the correct location.

- **Know where your output files are going and what they are named**. You will produce many, many files while running analysis in a GIS. If you do not specify where these files are saved when you run tools, they will be sent to a default location that you will **NOT** easily find. Similarly, make sure to specify a clear name for output files that you will remember, as default names are **NOT** intuitive.

- **Each GIS dataset is made up of multiple files**. A single GIS data layer (e.g. a shapefile) is not just a single file on your computer, but a collection of 4-8 files that computers interpret together. We recommend only moving, deleting, or renaming these files through a GIS software rather than a file explorer, and zipping up all files together to share.

- **Save and back up your project frequently**. GIS software, while useful, is known for crashing unexpectedly, often at the worst possible time. Similarly, computer issues always strike when least expected. We recommend copying your entire working folder with all associated files onto a USB flashdrive or cloud drive (Google Drive, Dropbox, Onedrive, etc.).

Outline:

In this tutorial, you will go through the basics of setting up a workspace on your computer, creating an ArcGIS Pro project, navigating the interface, adding data, joining attribute tables, calculating rates, and creating a simple map layout showing the distribution of population using nutritional assistance programs in New Hampshire and Vermont.

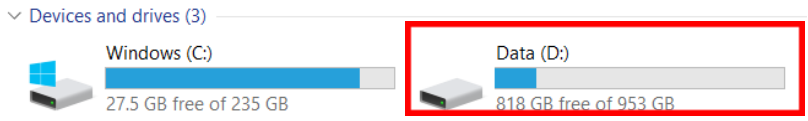
PART A: Introduction to ArcGIS Pro

1. Set up a working folder on your computer

a. Log into your computer. If using one of the Rahr Lab machines, use the public user account ("Public Cluster Machines" (or Other User → public_user if not an option), leave the password box empty and hit enter).

b. Create a new folder on the computer to store all your GIS files (there will be a lot!). We refer to this as your "working folder":

- If using a Rahr lab computer, click on the File Explorer:  , 'This PC' at the left, then double-click on the Data (D:) drive, which has more storage than the computer's main hard drive (C:). Right-click → New → Folder.



- If using the remote ArcGIS Pro application through RDS, open the virtual file explorer application, navigate to DartFS → your netID folder, and right-click → New → Folder.

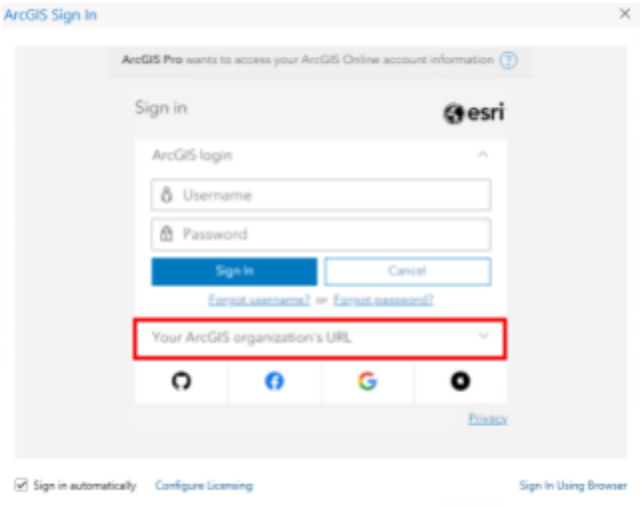
Name the folder something like *YourName_GISTutorial*. If your name is very long, you might abbreviate. Remember: there **cannot** be spaces or special characters in your folder name! Replace any spaces with an underscore.

2. Download and prepare the tutorial data

a. The data for this exercise are located on the GIS Learning Hub website in the zip file named *Intro_GIS_Software_Tutorial.zip*. This is a collection of files that have been *compressed* (zipped) together, allowing multiple files to be transferred between computers in an efficient way. You will not be able to use or edit these zipped files until they are unzipped. Unlike a Mac, you cannot just double-click on the file to unzip it – you need to manually extract it.

b. Right-click on the zip file's name in Downloads and select 'Extract All'. For the destination, click 'Browse' and navigate back through the computer to your working folder. Click once on your working folder's name, then hit 'Select Folder' and 'Extract'.

3. Create a New ArcGIS Pro Project



a. Open ArcGIS Pro. Licensing for the software has changed, so you will need to sign in with your ArcGIS Online account every time. Expand 'Your ArcGIS organization's URL', then type in *dartmouth* and check the box next to 'Remember this URL'. Click on the blue Dartmouth College box, then log in with your netID.

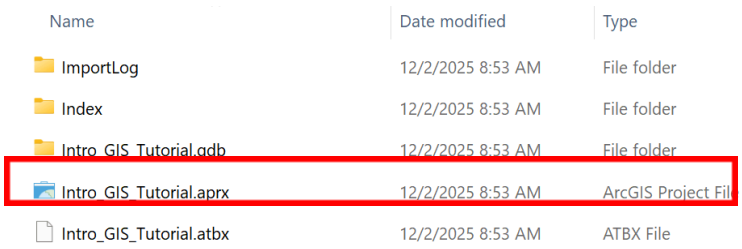
   Note: on public computers, you may become stuck in a loop of logging in as another user. If this happens, uncheck "Sign in automatically" at the bottom left, select 'Sign in Using Browser' at the bottom right, and wait for the browser to open. When prompted, open in ArcGIS Pro.

b. Under new project, select Map. Give it a reasonable name without spaces or special characters, such as *Intro_GIS_Tutorial.* For the location, click on the folder icon and manually navigate to your new working folder. You can either leave the "create new folder" option checked or unchecked.

c. A new project file should now open. An ArcGIS Pro project is made up of multiple components:

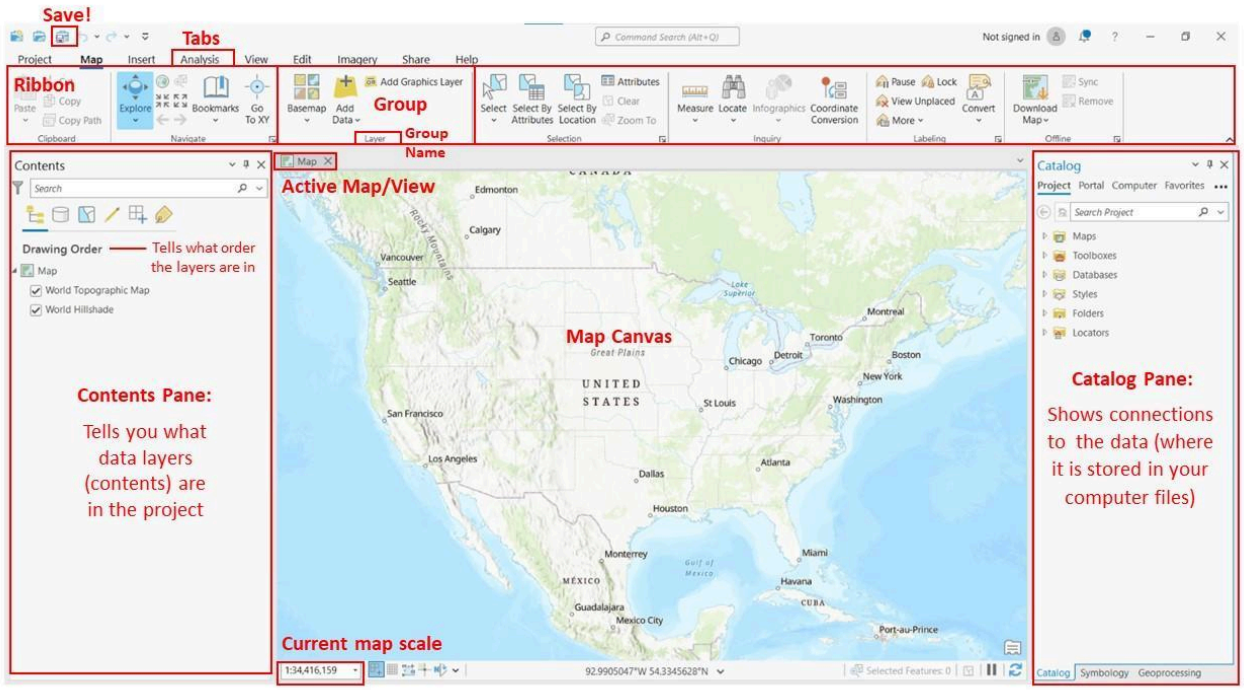
Figure 1: Esri.

The project itself is a .aprx file, or an ArcGIS Pro project file. To open the project from your file explorer, you would double-click on the following:



The other folders and files shown are created by default and necessary for the project to run. If you need to share your project, you should share all of these files together.

d. Once the ArcGIS Pro project loads, see the image below to learn/remember the interface terminology. If you are missing any of these panes, go to the View tab → Windows group → Reset panes for mapping (default).



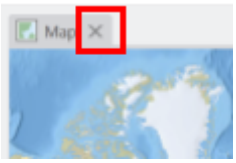
e. You may see a different basemap than shown in the screenshot. Test your knowledge: making sure you're in the Map tab of the upper ribbon, go to the Layer group, click on the Basemap button, and try changing the basemap for your map canvas.

f. The default Dartmouth basemap is called blueprint, and isn't very informative or aesthetically pleasing. You can change this by going to the Project tab → Options → Map and Scene → and changing the default basemap option to one you like.

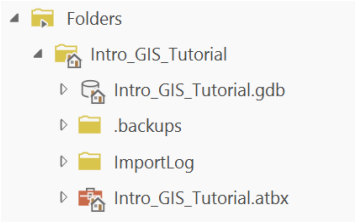
g. Take a look at other settings you can change in the options. We recommend waiting until you have a better grasp on the software before changing anything, but you can customize the software at any time to help your workflow.

4. Explore the Catalog

a. Look at the Catalog pane of your project (on the right). This is where you can access all your maps, layouts, toolboxes, and data at any time. Test out what happens if you accidentally close out of your map by hitting the x above the Canvas. Where would you look to find it? You can open it again by right-clicking on its name and selecting Open.

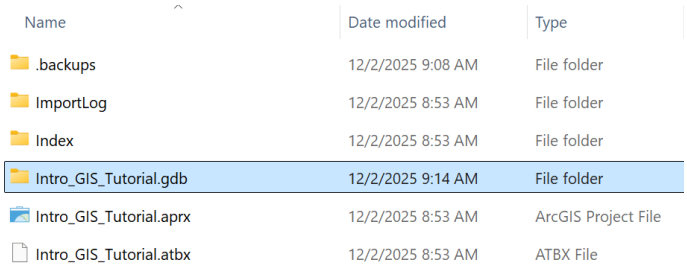


b. The Folders section allows ArcGIS to access other folders on your computer, but first you will need to manually make a connection. Expand the arrow next to Folders; you should only see a default folder with your project's name, which was created when you made a new project.



c. Expand the arrow next to the geodatabase (.gdb) to look inside. It should be empty if created properly.

d. Outside of ArcGIS in explorer, open the folder (.gdb). What do you see inside now?



Name	Date modified	Type
.backups	12/2/2025 9:08 AM	File folder
ImportLog	12/2/2025 8:53 AM	File folder
Index	12/2/2025 8:53 AM	File folder
Intro_GIS_Tutorial.gdb	12/2/2025 9:14 AM	File folder
Intro_GIS_Tutorial.aprx	12/2/2025 8:53 AM	ArcGIS Project File
Intro_GIS_Tutorial.atbx	12/2/2025 8:53 AM	ATBX File

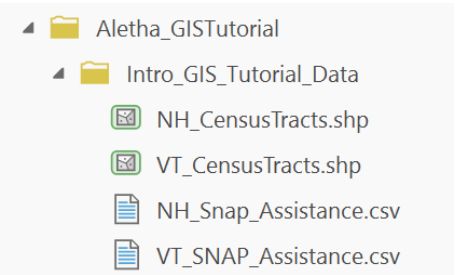
A **geodatabase** is essentially a "container" that is specially designed for storing geographic data: it keeps track of how things connect and relate to each other, and allows for faster searching and analysis. Everything you see in the folder are "behind-the-scenes" files necessary for its structure. As such, we recommend only adding things to the geodatabase or moving files around inside ArcGIS Pro to avoid accidentally deleting anything.

e. To add your data most efficiently, create a new connection to the working folder on your computer. In the ArcGIS Catalog pane, right-click on Folders and select Add Folder Connection. Browse through your computer files to your working folder. You shouldn't see any data inside, as this is only looking for **folders** to connect. Select OK, and you should see your working folder appear in the folders list. If not, right-click Folders and select Refresh.

PART B: Spatial Data and Attribute Joins

1. Add Data to the Project

a. From the Catalog, open your working folder and find the Intro_GIS_T
Expand it to see the contents.



b. The two .shp datasets (*NH_CensusTracts* and *VT_Census Tracts*) are called "Shapefiles", a specific format of spatial data used by ArcGIS. Add them to your project by either clicking and dragging into the Canvas, or right-click their name → Add to Map.

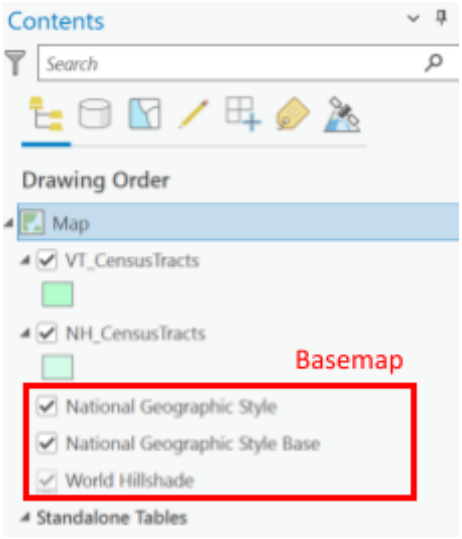
c. You should now see data for New Hampshire and Vermont added to your map. They will be a default random color, which we can update later. Are these shapefiles **vector** or **raster** data? How can you tell?

d. While each shapefile looks like an individual file within ArcGIS Pro, this is not the case on your computer's hard drive. Outside of ArcGIS, open your file explorer and browse to your working folder. Examine the contents of the *Intro_GIS_Tutorial*_Data folder. How many files actually make up each shapefile?

   Shapefiles typically have 3-8 different file components, which each serve a different purpose (e.g. .dbf stores attribute information, .prj stores coordinate system information, .shp stores geometry). **All of these files** are necessary for ArcGIS to read it as one dataset. If you need to send someone data in the future, you must share all the files together.

2. Explore the Map Contents

a. In your Contents pane at left, you should see the two shapefile names at the top. Layers are shown on the map canvas based on their drawing order, which automatically shows items at the top above items on the bottom. Do you notice any changes if you click and drag the shapefiles into a different order?



b. Towards the bottom of the Map, you should see a number of layers for your basemap. The number and name depends on which basemap you choose. Uncheck the box next to each layer to see what it does. If you ever want to hide place labels or only show labels, you can always turn these on and off.

c. Click and drag your basemap land layer to the top of the Contents pane. What happens to the data? Place it back at the bottom of Contents.

3. Examine Attribute Information

Remember that there are two components to geospatial data: spatial and attribute. You can see the spatial component on the map canvas, but you can also examine their attributes.

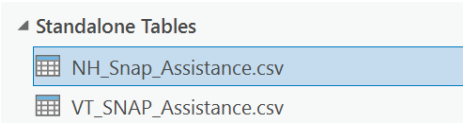
a. Right-click one of the census tract layers and select Attribute Table. In the bottom table, you can see records (rows) for each polygon displayed on the map.

b. Use the slider bar at the bottom to look through the fields (columns). What information do you see in the attribute table? Is there anything we can use to create a meaningful map?

The census tract shapefiles contain fields with ID values and random values, but no population or demographic information. To add relevant information, we will need to use the *relational database* aspect of GIS by joining the shapefile's attribute table to the two external tables. This is very common for Census data, which will often require joining many tables together.

4. Assess Data Types

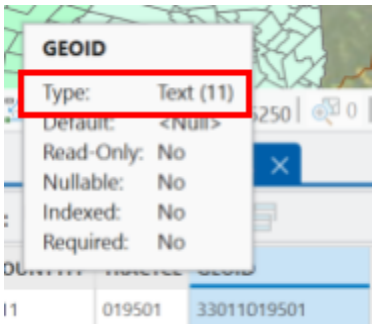
a. Make sure the two CSV tables for NH and VT are added to your project. They will not be visible on the map, as they do not have coordinates, but they should be listed in the Contents under Standalone Tables.



b. Right-click the NH CSV name and Open. In the table, you should see a field named 'GEOID', which contains the ID number of each tract polygon, along with other fields describing the total number of households in each tract, and total number of households using the Supplemental Nutrition Assistance Program (SNAP).

c. Compare the NH CSV table to the attribute table of the NH shapefile. To join them, you will need to find a field with identical values within both tables to use as the linking key. The fields can have different names, but the values should be the same. Which common field will you use as the linking key?

d. Choose one of the NH attribute tables, then hover your cursor over the linking key field until a message box pops up. What is the type (data type) listed?



e. Check the data type for the linking key in the other NH data. Are they both the same? Write down the types to remember them.

f. Do the same for the VT CSV and VT shapefile. Do the VT linking keys have the same data type, or different?

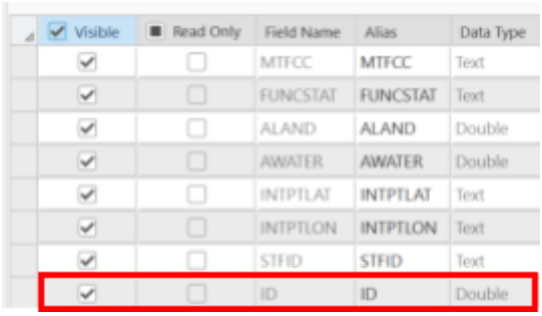
g. Test out what would happen if you joined tables together with different data types: right-click on the NH shapefile's name in Contents and go to Joins and Relates → Add Join. The input table should be the shapefile, and the join table NH_SNAP_Assistance.csv. Leave the Input and Join fields as GEOID and select OK.

h. Check the attribute table for the NH shapefile and scroll all the way to the right. You should see new fields added from the joined table. Did the join work successfully?

i. Because the linking keys had different data types, the join did not work and produced all null values. You will need to remove this join by right-clicking on the shapefile name in Contents → Join and Relates → Remove all Joins.

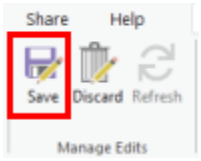
5. Update Field Data Types

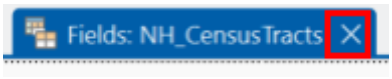
a. In order to join the datasets successfully, you will need to add a new field with the proper data type and copy GEOID into it. In the attribute table for the NH shapefile, click the Add Field button. Add a new field to the table called ID and make sure it is the data type Double (decimal).



Note: we add a new field instead of simply changing the data type of the existing GEOID field because once a field has been created and saved in ArcGIS Pro, its data type cannot be edited.

b. Click on the Save Edits button on the upper ribbon, then close the Fields window.





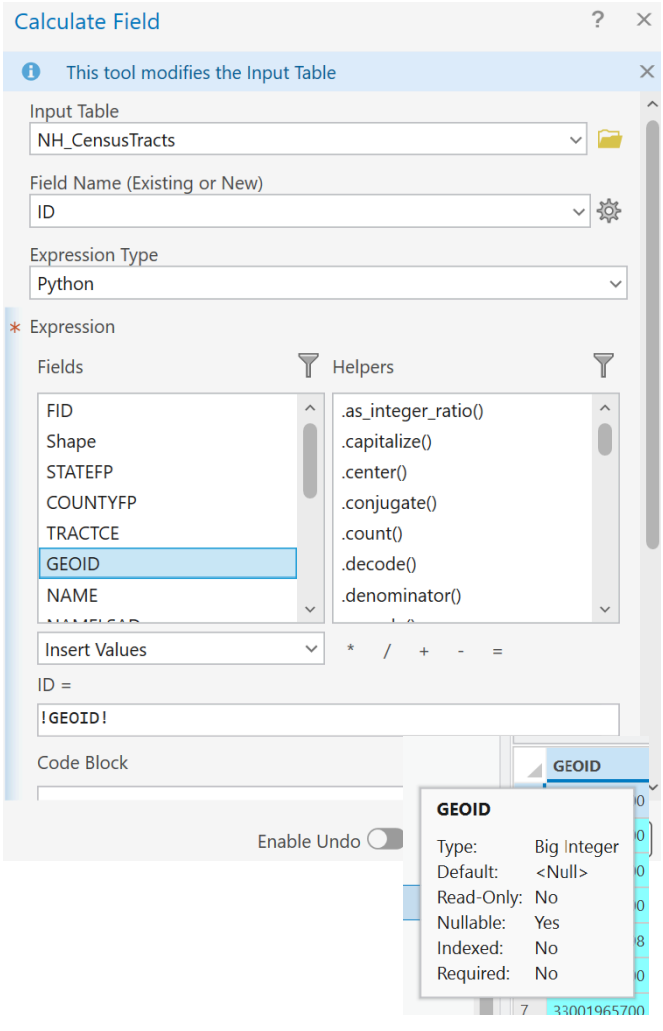
c. Scroll all the way to the right of the NH census tracts attribute table. You should see the new field at the very end, filled with 0s. Right-click on the field name and select Calculate Field.

d. This will open the Field Calculator, which calculates all values within a field simultaneously. You can use it to apply many different equations to the data, but we will simply copy values over from one field to another.

e. To copy values from another field, scroll down in the list under Fields until you see GEOID. Double-click on the name GEOID. This should cause the textbox under the menu, beneath "ID =" to be filled with !GEOID!. The exclamation points tell the computer to read this as a field name from the dataset. Click OK. This field should now be populated with values.

f. Repeat the same steps to make a new field in the VT census tract shapefile with the data type 'Double' and copy over GEOID values.

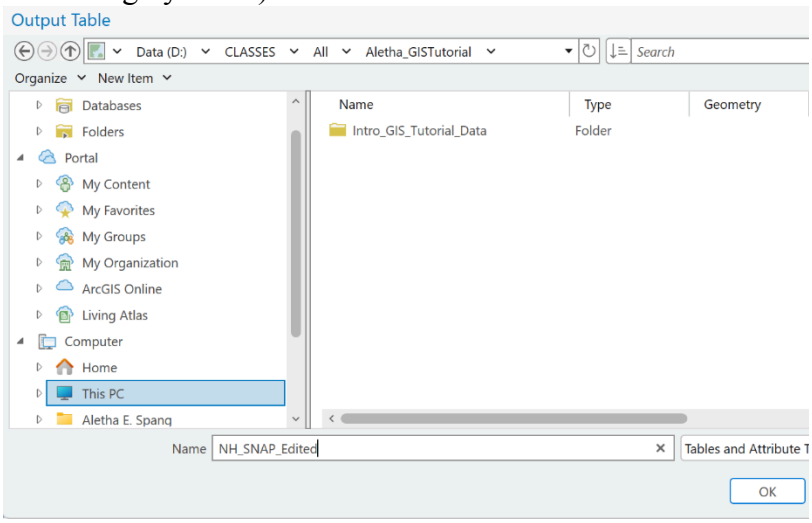
g. There is one other potential issue with joining the data. In the CSV attribute table, you may notice that the GEOID has a data type called



"Big Integer". This is a particular type of data that can store integer values that are longer than ten digits. While ArcGIS can display this, it cannot actually create or edit this amount of data.

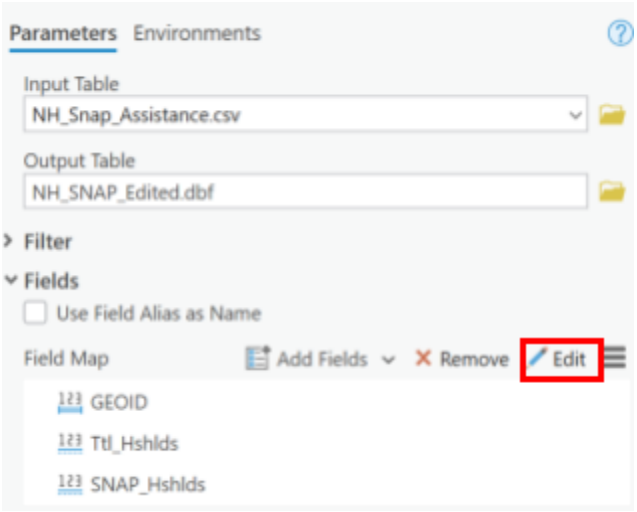
How might you fix this? Based on the last steps, you might consider adding a new field to the table and copying over the values as another data type like double. But CSVs cannot be edited in ArcGIS (note that the add field button is greyed out).

h. Instead, you can export the table into a new format, while simultaneously updating the field. Right-click on the CSV name and go to Data → Export Table. Use the folder icon to set a location on the computer to save the new table. For this tutorial, we will use your working folder, but you could also use the geodatabase.

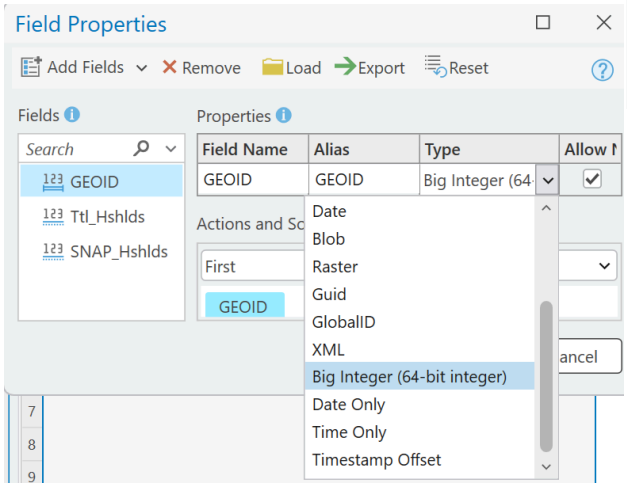


i. In the box next to Name, give it a reasonable name that will make sense to you, like *NH_SNAP_Edited*. Click OK. You should see the output table is now listed as a .dbf file, which is the native table format for ArcGIS.

j. Before running the tool, expand the arrow next to Fields and select Edit.



k. In the following window, you should see properties for the GEOID field. Use the dropdown to change the data type from Big Integer to Double.



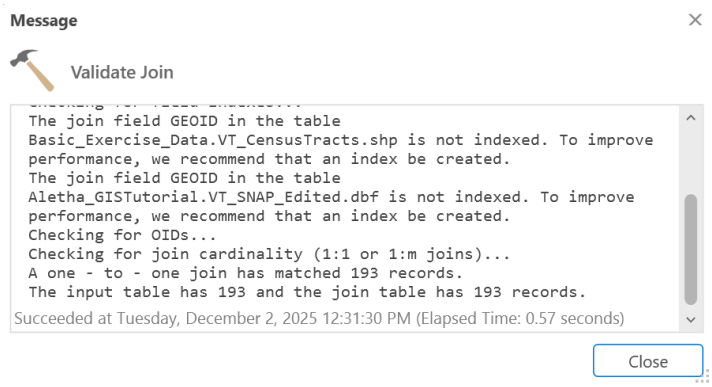
l. Do the same to update the GEOID field with Double data type for the other CSV table.

6. Join the Shapefiles and Tables

a. Once the data are ready, join the edited NH SNAP assistance table to the NH census tract shapefile. You will always want to start joins from the data you want

the final product to resemble (e.g. the shapefile, as it has polygons that can be mapped, unlike the table). Right-click the shapefile name in Contents→ Joins and Relates → Add Join). Use ID as the input field, and GEOID as the join field.

b. Ignore warnings about indexing and click the Validate Join button. If the join will work, it should say something like the screenshot at right:



c. Check the attribute table for the NH shapefile to make sure that the join succeeded. Then repeat the same process to join the edited VT table to the VT shapefile.

7. Make the Attribute Joins Permanent

Now that you have successfully joined tables to both your shapefiles, you will need to make the join permanent. ArcGIS temporarily joins the data together within its interface, but the underlying files are still separate on your computer's hard drive (the shapefile +.dbf table). If you close the program, they will become unlinked.

8. Right-click on the NH census tract shapefiles and go to Data → Export Features. Give it a name like NH_Census_Join and save it into your working folder.

9. Repeat the same process on the VT census tract shapefile. When finished, remove the original layers and tables so you are only left with the joined shapefiles (right-click the layer's name in Contents and Remove).

PART B: Coordinate Systems and Projection

If you have a keen geographic eye, you may have noticed that your VT and NH shapefiles look quite stretched and fat on the map. This is because they are currently in an unprojected geographic coordinate system, which the computer plots as X and Y cartesian coordinates. As a result, data looks quite distorted.

There are two places to look for coordinate systems in your ArcGIS project. The **map** (container that visualizes spatial data), and the **spatial data** themselves (files on your hard drive). You will need to update both categories to a projected system.

1. Update Map Coordinate System

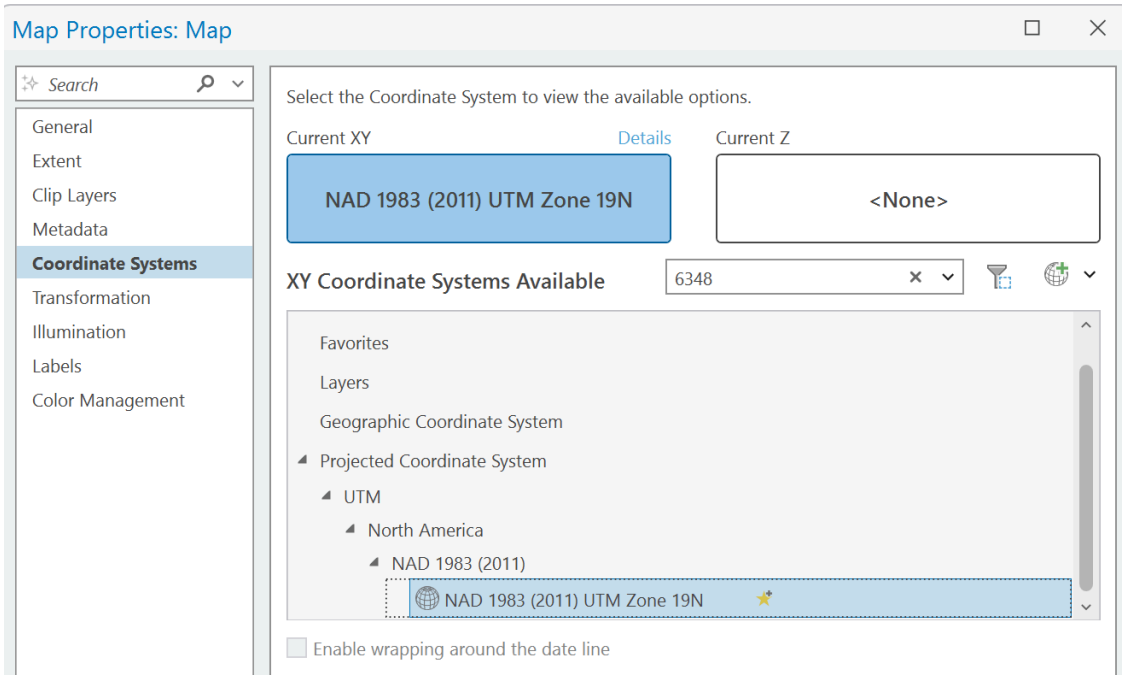
Updating the map's coordinate system is very easy, since it doesn't require the computer to write out new data files with calculated coordinates. You can do this simply in the map's properties.

a. Right-click on Map in your Contents pane and go to Properties → Coordinate Systems.
b. Under 'Current XY' you should see the map's coordinate system, which ArcGIS Pro automatically sets based on the coordinate system of the first data added to the project. What

coordinate system is the map currently in? Is this a geographic or projected coordinate system?

c. For this tutorial, you will use the projected coordinate system NAD 1983 (2011) UTM Zone 19N, which has minimal distortion of Vermont. For other locations, you might look up which projected coordinate system is commonly used by local or state governments.

You could type this whole name into the search bar, but coordinate systems also have unique ID numbers assigned by the European Petroleum Survey Group (EPSG) and adopted as a current standard. Our projection is EPSG: 6348. Type '6348' into the search bar and hit enter; you should see its name appear under Projected Coordinate System. Select the name and click OK.



d. Your map should change in shape, reducing the distortion on both states. It may also rotate slightly to keep the study area in the middle of the map. This means that our map is now projected into a two-dimensional coordinate system.

2. Exploring Projection on the Fly

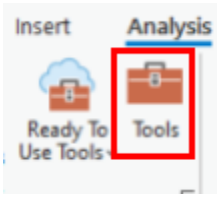
a. Open the map properties → Coordinate Systems again and expand the Layers heading. Here, ArcGIS lists the coordinate systems that your data layers are in. The basemap will always be in the Web Mercator projection, as it is a tiled image layer produced by Esri and stored in the cloud. What is the coordinate system of your shapefiles?

e. Even though your map is now in NAD 1983 UTM Zone 19N, and looks undistorted, your data files are still in NAD 1983. This is a process called **projection on the fly—** your

computer noticed a discrepancy between your map and data and performs temporary calculations to align the different coordinate systems. Note that this doesn't actually change the coordinates themselves, but makes them visually appear to be in the UTM projection.

Test your understanding: What might happen if you calculated the area of each census tract polygons while the coordinate system is NAD 1983? What would be the unit of these areas?

3. Update Coordinates into the Projected Coordinate System



To change the data layers into a projected coordinate system, you cannot just open their properties and click on the other system. You will need to actually mathematically transform the coordinates using a tool called Project.

a. Go to the Analysis tab → Tools icon. This opens the Geoprocessing pane at right, which contains all the different tools of ArcGIS. Search for "Project", a tool which will mathematically transform your coordinates from one coordinate system to another. Click once on the tool name to open it.

b. In the tool window, set the input dataset to be NH_CensusTracts_Join, or whatever you named the permanently joined layer. Save the output dataset into your folder by clicking on the folder icon and browsing to its location, then name it something like NH_CensusTracts_Projected. The output coordinate system can be set to current map, which should be UTM Zone 19N. Run the tool.

c. Check that this worked: you will not see a visible difference on the map, but if you open the map's properties and expand the Layers heading, it should now be in the correct coordinate system.

d. Repeat the same process to project the joined VT census tract shapefile. Remove the old layers so you are left with only the projected versions.

PART C: Create a Map

Now that the data layers have all necessary attribute information and are in a projected coordinate system, you can make a map visualizing utilization of nutritional assistance programs across the states.

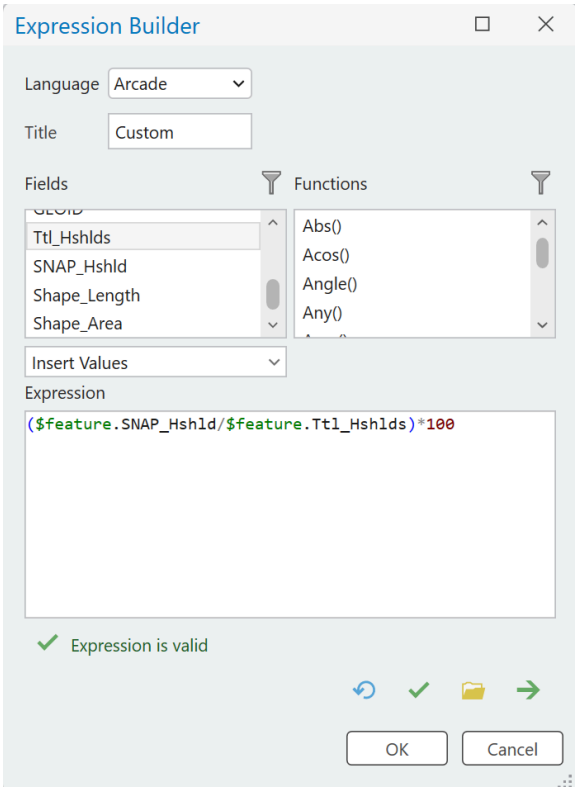
1. Update Data Symbology

a. First, you may want to change how the shapefiles are symbolized. Right-click on NH_CensusTracts_Projected and go to Symbology. The primary symbology defaults to single symbol, which will display all polygons with the same color and outline. Change this dropdown menu to say Graduated Colors, also known as a *choropleth map*. This will display values from a specified field, which we will want to be SNAP_Hshld, or the total count of households using SNAP. Change the dropdown menu next to Field accordingly.

b. Note the spatial pattern of nutritional assistance in New Hampshire— which areas have the

highest number of households on SNAP?

c. Often, a raw count of households can just show population distribution rather than a meaningful trend, as more people typically leads to more nutritional assistance. You can account for this by normalizing the data, or dividing it by the total number of households so that it becomes a rate. While you could do this by adding a new field to the attribute table and calculating it, you can also do this on-the-fly using an Arcade expression, which is ArcGIS's native programming language.

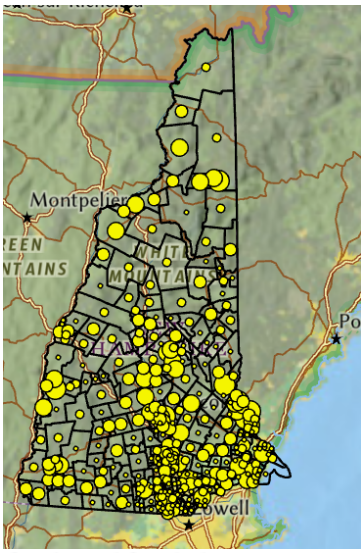


d. Click on the green x box next to Field, then type in the following expression to divide the SNAP household field by the total household field, symbolizing households using SNAP as a percentage.

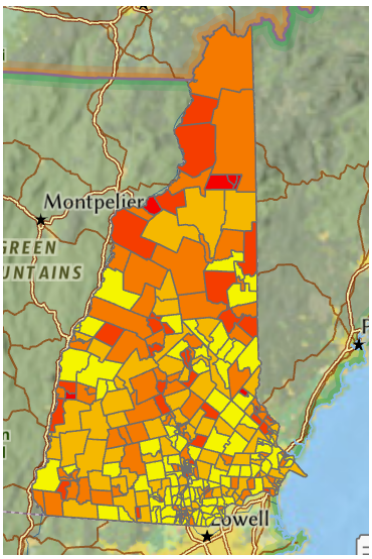
*($feature.SNAP_Hshld/$feature.Ttl_Hshlds)*100*

e. Aside from just showing population trends, what other potential issues might arise from using choropleth symbology (graduated colors) on raw counts?

Variation in the sizes of polygons can also be problematic: census tracts in rural areas tend to be larger than those in urban areas. This can influence people's perceptions of spatial trends, as it seems like the larger areas are more important, even though the smaller census tracts usually have more population. We usually show raw counts (total population, etc.) as graduated symbols (below, left) rather than graduated color (below, right).



Graduated Symbols

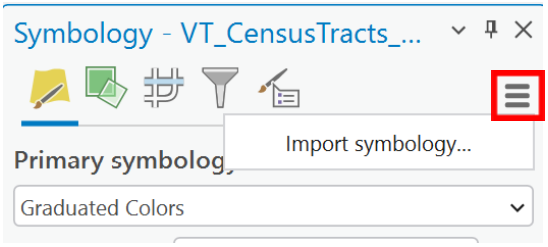


Graduated Colors (Choropleth)

f. Click on the Histogram tab at the bottom to see a distribution of values within the field. You can change how the data are classified by switching the Method from Natural Breaks to something else— read through the descriptions to see what the differences are. You can also change the number of classes to get more or less variation (usually 4-8 is a reasonable number), or switch the color scheme.

g. You can manually edit the class breaks by double-clicking into the upper value boxes under the Classes tab. You should also double-click into the label boxes and change to be percentages (e.g. type in "38 – 63%", rather than 0.38 – 0.63).

h. Once you are satisfied with the symbology for the NH layer, you should update the VT layer to match (this way, you can just use one legend that is interpreted for both states). Open the symbology for the VT layer, then click on the three lines at the upper right corner and Import symbology. Leave the input as VT, change Symbology Layer to NH, and run the tool.



2. Create a Simple Map

To showcase your findings, you will create a simple map layout. This allows you to add text for titles and legends, and to export as a PDF or image.

a. Go to the Insert tab → New Layout. Choose a paper size that seems appropriate (8.5"x11" or 11"x17" are common choices, either landscape or portrait).

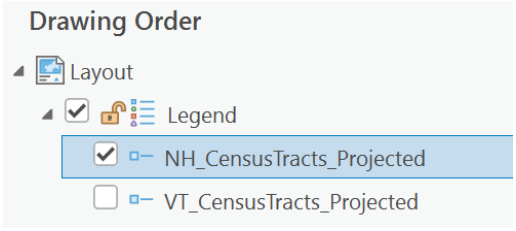
b. A layout window will open with a blank sheet of paper. Only things in the white paper space will be exported, so make sure you don't place anything beyond its boundaries.

c. In the Insert tab, click on Map Frame, then select the image of the map that matches what you just created. Click and drag to add it to your layout, like drawing a text box.

d. Add a legend by going to the Insert tab → Legend and picking any one of the options. Click and drag to draw it on your layout. It usually looks quite chaotic! We can clean it up by renaming the layers. This will not change the underlying data file, just how it is symbolized in the project.

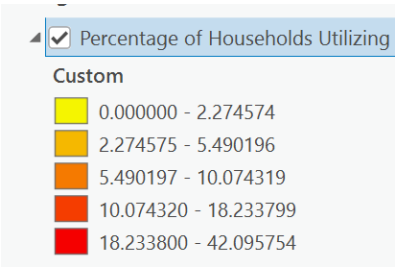
e. Leave the layout tab and go back into your project's map. In Contents, right-click on one of your NH or VT shapefiles and go to Properties → General. Change the name to something like "Percentage of Households Utilizing SNAP".

f. Go back to the Layout tab. At the top of the Contents pane, under Legend, uncheck the boxes for every layer that is not



the one you just edited so that there is only one item in the legend.

g. You can remove the "Legend" title, since it's intuitive for viewers to interpret. In the Contents pane, right-click on Legend and go to Properties. Under the map frame dropdown, uncheck the box next to Title: Show.



h. To remove extra 'custom' heading in the legend, click on the Show Properties box, and uncheck the box next to Headings (if grayed out, make sure only that one layer is selected in the legend Contents pane).

i. Add a title to the map by clicking on the Insert tab, then in the Graphics and Text group, click on A. Click and drag to draw the textbox. Type in some title that explains what this map shows and the study area (the what and where). Once placed, click on the new tab Text in the upper ribbon. Change the size to something reasonable.

You should also update the font in your map to make it look more intentional and professional. To make your life easier, you might also change the entire font settings for the project so it will update on all future maps. Save your project, then go to the Project tab → Options → Text and Graphics and change the default font name to something you like better (good choices might be Arial, Avenir, Bell MT, whatever looks easy to read and professional.). Then click the back arrow at the upper left. You may need to save, close, and reopen the project for the change to actually apply.

j. Add a scale bar by going to the Insert tab, clicking on the scale bar button and selecting an option (scale bars should not be too fancy and distracting from the rest of the map). Click and drag to place it where it won't be the center of attention. Adjust the scale bar size by clicking and dragging the diagonal corners to **make the numbers easy to read and with logical breaks** (e.g., 10 miles rather than 13.482 miles).

3. Export your Map

Finally, you can export your map as either a PDF or image. PDF is a vector format that maintains scalability, while images will be capped at a certain resolution. We recommend a minimum resolution of 300 dpi if exporting an image.

a. Go to the Share tab → Output Group → Export Layout button. Select the Vector PDF option. This should open an export window at right. Make sure the name is set to save into your overall working folder and name it something you will recognize.

Conclusion

You have now successfully completed the Introduction to GIS Software tutorial! To explore more advanced analysis sections, check out the Introduction to Vector Analysis and Introduction to Raster Analysis tutorials on the GIS Learning Hub. Feel free to reach out to aletha.e.spang@dartmouth.edu for any questions.