

Introduction to ArcGIS

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Goals of the Exercise

This exercise introduces you to ArcGIS Pro. You use these applications to create a map of pan evaporation stations in Texas, and to draw a graph of monthly pan evaporation data measured at these stations. You link the spatial location of the observation sites, with the time variation of the water observations data at those sites, and prepare a layout containing the map and chart. You will also upload your results as a web map of evaporation data so that it can be publicly viewed.

Computer and Data Requirements

To carry out this exercise, you need to have a computer which runs ArcGIS Pro version 2.2. You will also need an ArcGIS Organizational Account to enable you to login to ArcGIS Online.

In the first part of this exercise using ArcGIS Pro, you will be working with the following spatial datasets:

1. A polygon shapefile of the counties of Texas, called **Counties**
2. A point shapefile of pan evaporation stations, called **Evap**
3. A polygon shapefile of the state of Texas, called **Texas**

These shapefiles consist of several files (e.g. **evap.dbf**, **evap.shp**, **evap.shx**). You can get them from this zip file: <http://www.cae.utexas.edu/prof/maidment/giswr2018/Ex1/Ex1Data.zip>

You need to establish a working folder for the exercise. This can be in any convenient location on the computer you are working on (e.g. C:\giswr2018\Ex1).

After you have downloaded the zip file **Ex1Data.zip** double click on the file and you should see Winzip or other zip utility to open the file on your computer (if it doesn't open you'll have to unzip this file on a computer that has a zip utility installed). Extract all files from the zip file to the working folder that you've set up to do this exercise. You should end up with a file list that looks something like this. You may see these data within a sequence of folder names, and if so, click on each folder down through the sequence until you locate the required files.

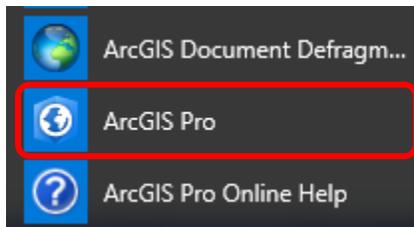
Name	Date modified	Type	Size
Counties.dbf	9/5/2012 11:41 AM	DBF File	47 KB
Counties	9/5/2012 11:41 AM	PRJ File	1 KB
Counties.sbn	9/5/2012 11:41 AM	SBN File	3 KB
Counties.sbx	9/5/2012 11:41 AM	SBX File	1 KB
Counties.shp	9/5/2012 11:41 AM	SHP File	8,450 KB
Counties.shp	9/5/2012 11:41 AM	XML Document	22 KB
Counties.shx	9/5/2012 11:41 AM	SHX File	3 KB
Evap.dbf	9/5/2012 11:33 AM	DBF File	30 KB
Evap	9/5/2012 11:33 AM	PRJ File	1 KB
Evap.sbn	9/5/2012 11:33 AM	SBN File	1 KB
Evap.sbx	9/5/2012 11:33 AM	SBX File	1 KB
Evap.shp	9/5/2012 11:33 AM	SHP File	2 KB
Evap.shx	9/5/2012 11:33 AM	SHX File	1 KB
Texas.dbf	9/5/2012 11:44 AM	DBF File	1 KB
Texas	9/5/2012 11:44 AM	PRJ File	1 KB
Texas.sbn	9/5/2012 11:44 AM	SBN File	1 KB
Texas.sbx	9/5/2012 11:44 AM	SBX File	1 KB
Texas.shp	9/5/2012 11:44 AM	SHP File	1,058 KB
Texas.shp	9/5/2012 11:44 AM	XML Document	20 KB
Texas.shx	9/5/2012 11:44 AM	SHX File	1 KB

Procedure

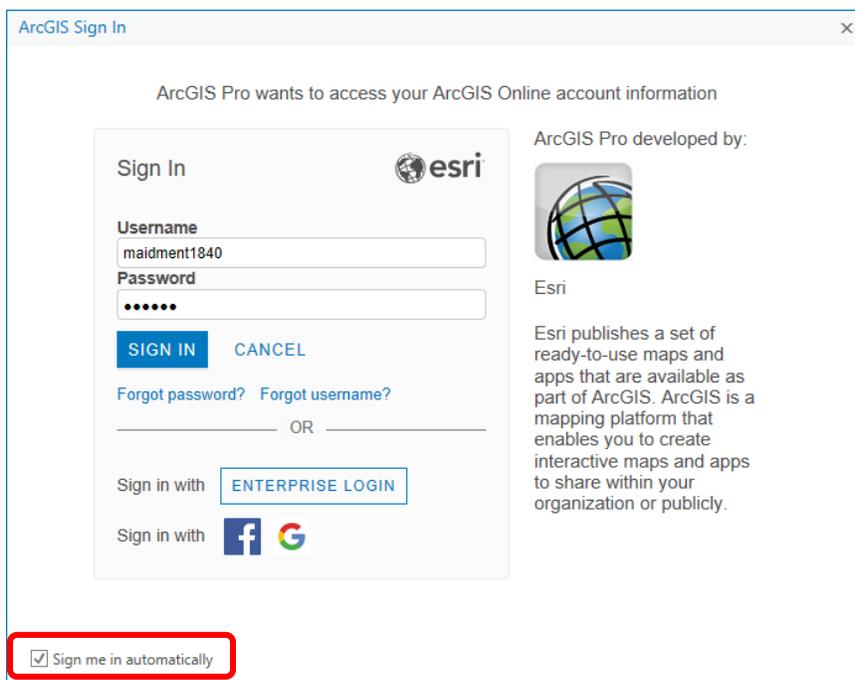
Please note that the following procedure is a detailed outline, which can be followed to complete this lesson. However, you are encouraged to experiment with the program and to be creative.

1. Visualizing Geospatial Data in ArcGIS Pro

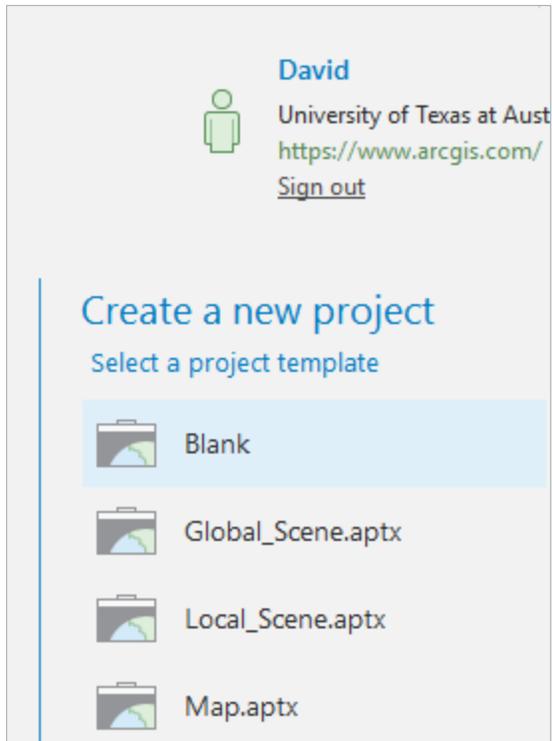
Open **ArcGIS Pro** on the Windows Desktop within the folder labeled **ArcGIS**



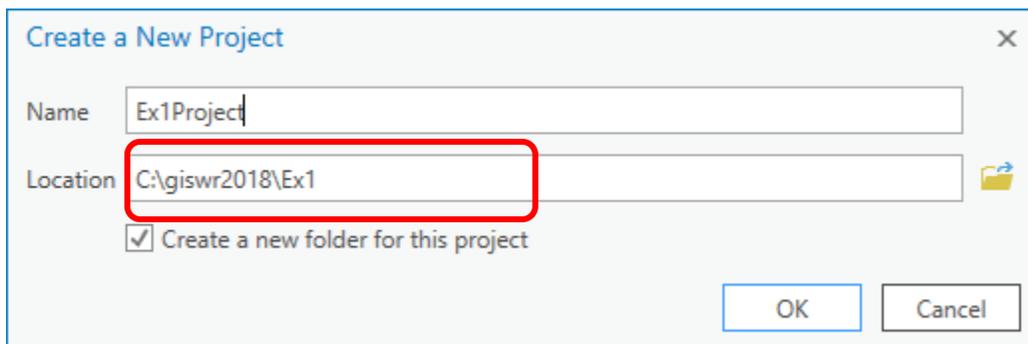
The first time you open ArcGIS Pro, you will need to sign in using your ArcGIS Online account. For convenience, you may want to leave the **Sign me in automatically** checkbox selected. Once in ArcGIS Pro, you can check whether you are logged in or not in the upper right-hand corner.



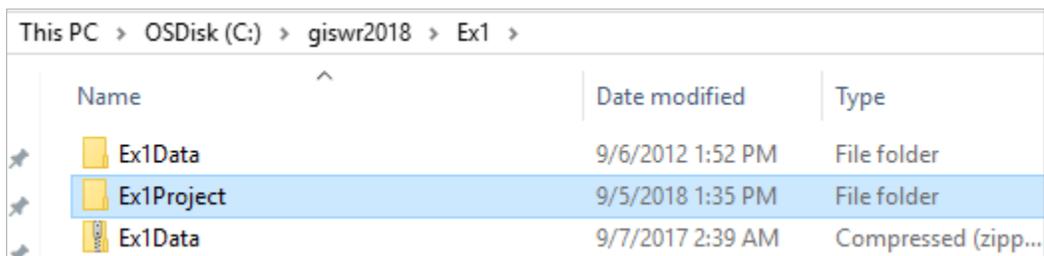
Once you are in ArcGIS Pro, you will want to start with a **Blank** template.



Set the location to the folder where you want the data associated with this project to be saved



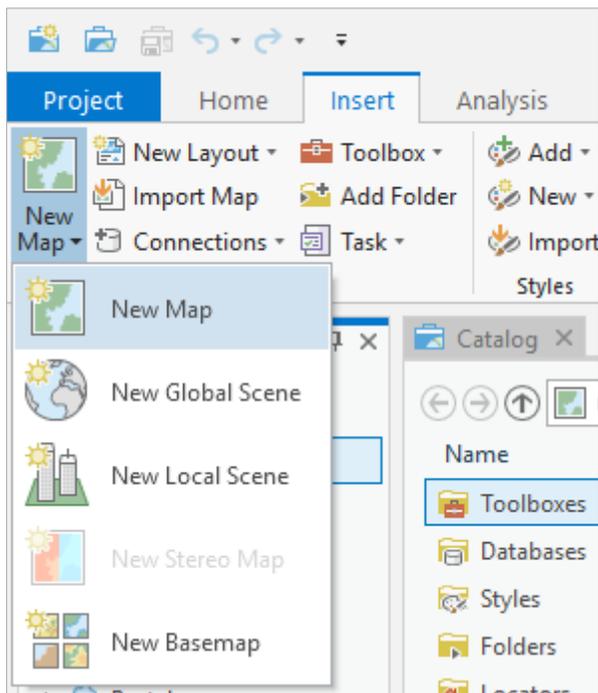
You will see that a new folder **Ex1Project** is created in your folder



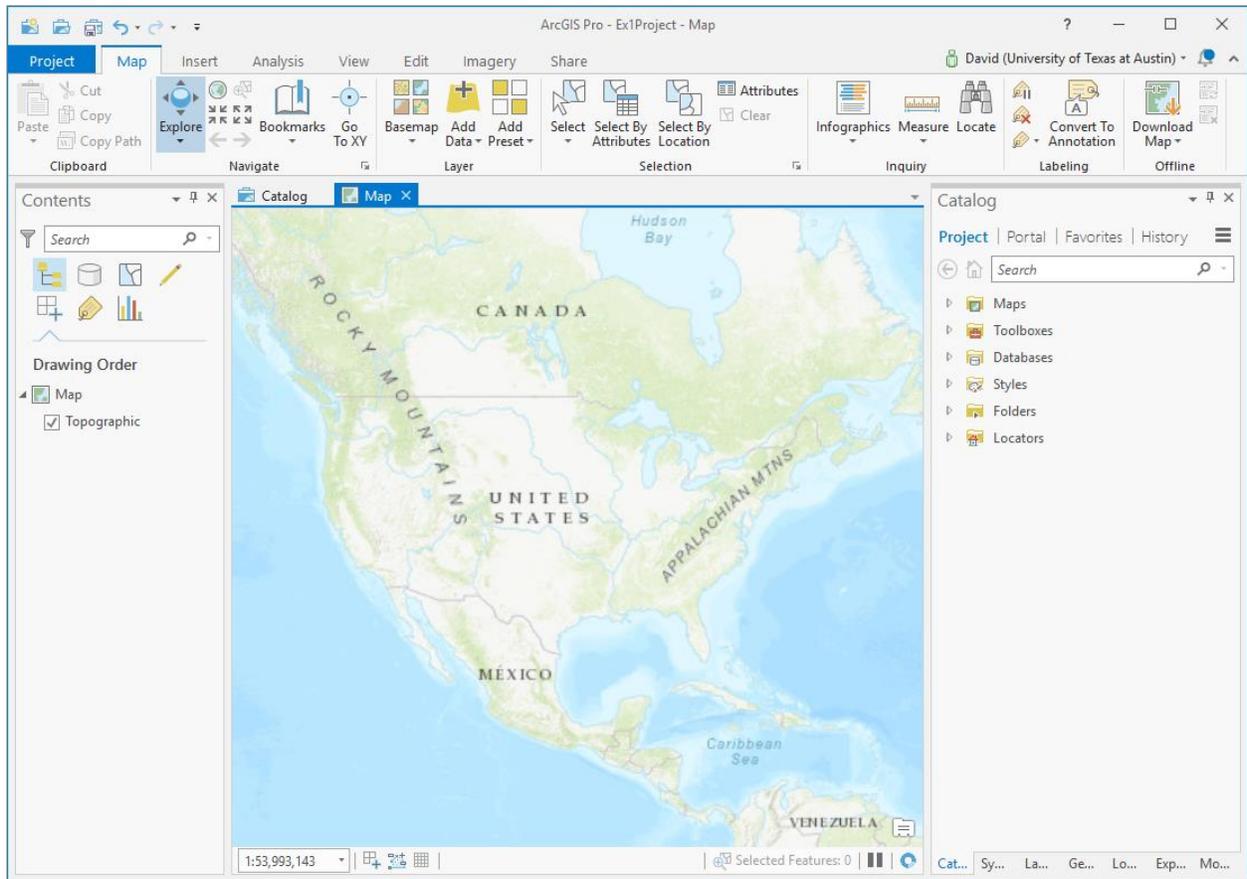
And if you look inside this folder, you'll see a project template containing **Ex1Project.gdb**, which is the geodatabase for this project, and **Ex1Project file**, which stores the map layout for the project, and **Ex1Project toolbox** that contains any special tools created for this project.

 Ex1Project.gdb	9/5/2018 1:35 PM	File folder
 Ex1Project	9/5/2018 1:35 PM	ArcGIS Project File
 Ex1Project	9/5/2018 1:35 PM	ArcGIS Toolbox

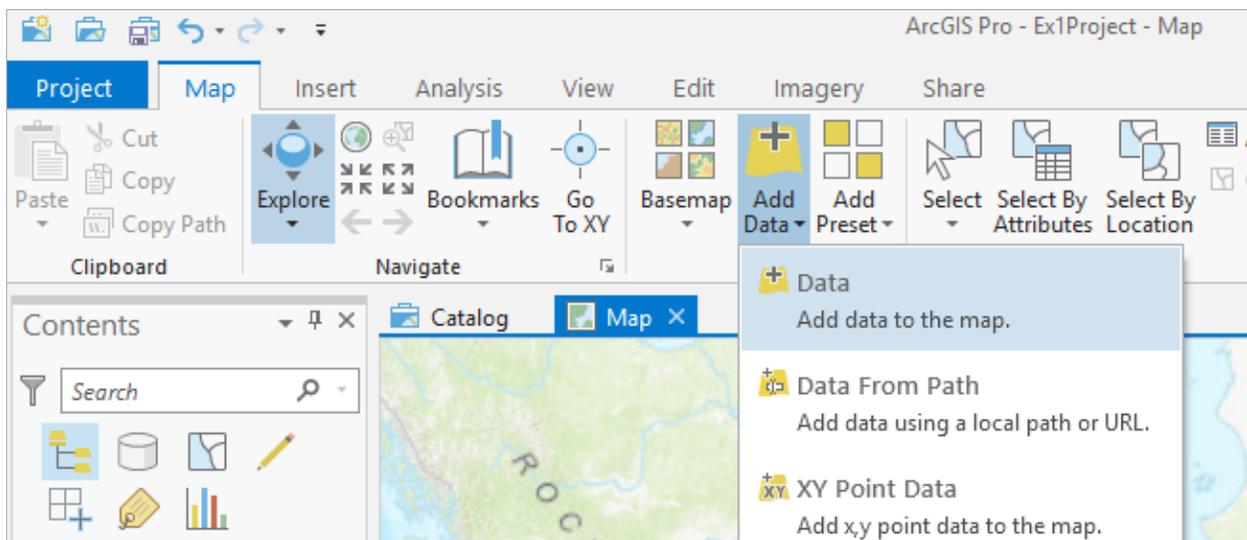
Click on the *Insert* tab in ArcGIS Pro, then click on the **New Map** button to create a map.



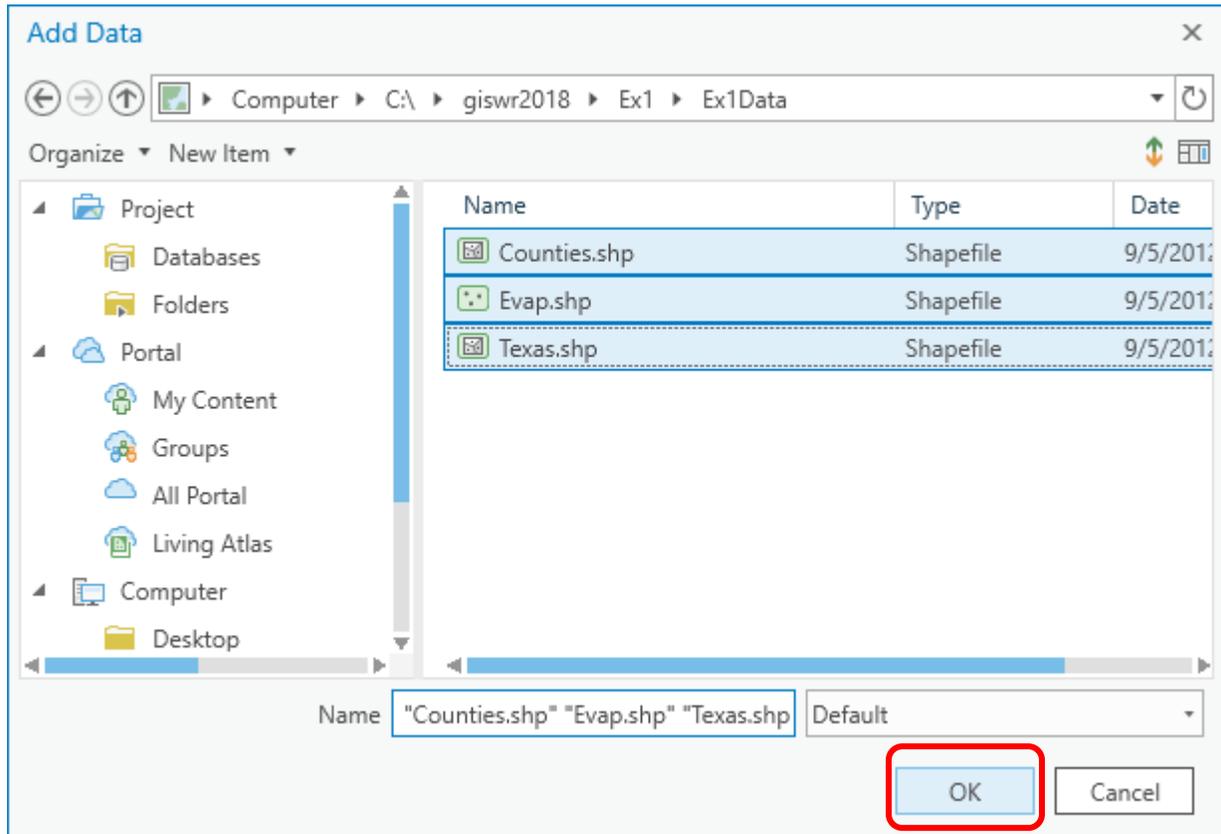
and you'll see a map display open with a nice map of the United States. Pretty cool!



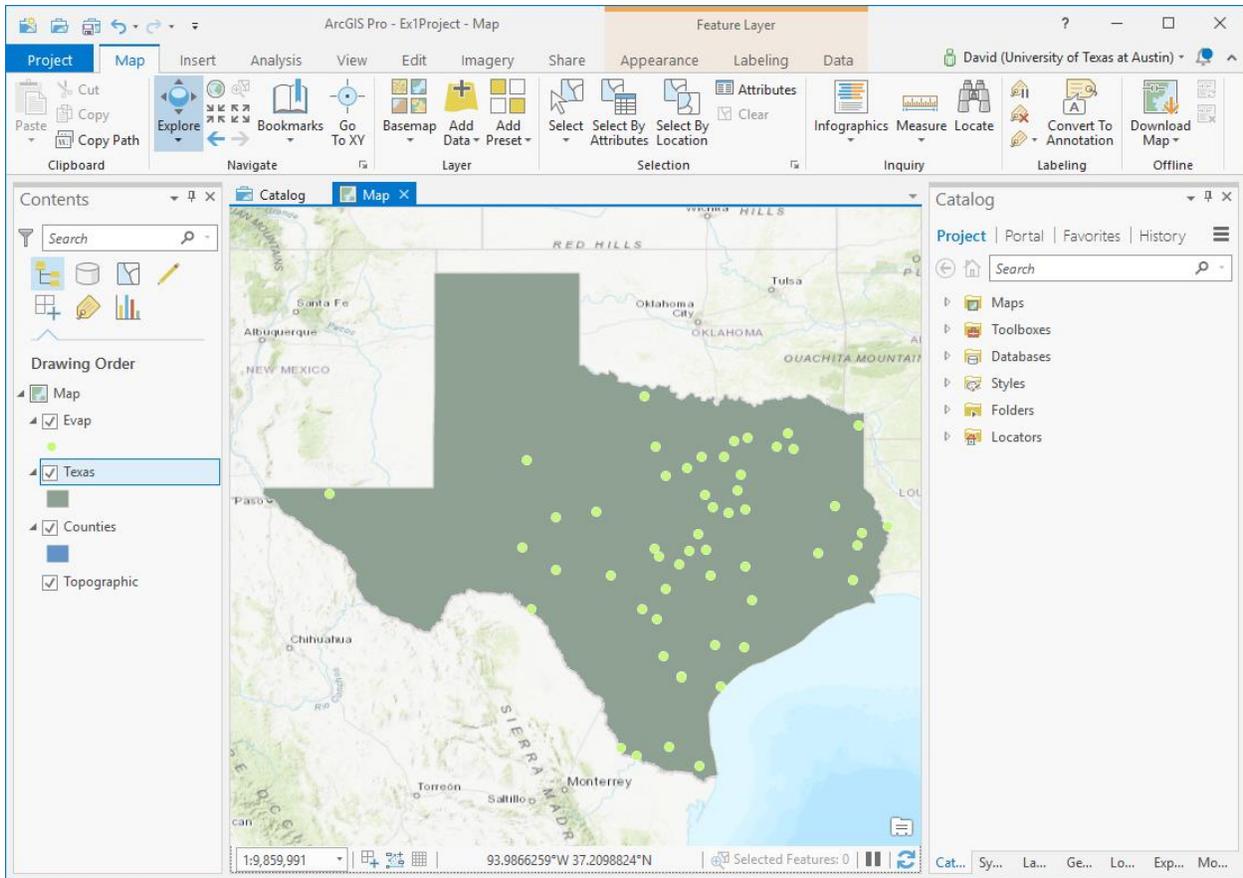
In the *Map* tab, use the **Add Data** button to add the data for this exercise to the map display.



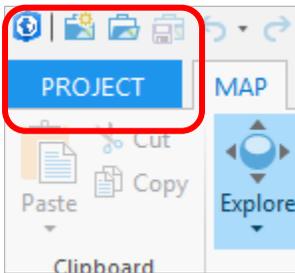
Navigate to the folder containing the exercise data and select all three shape files at once by using the shift key. Click the **OK** button to add the data to your ArcMap display.

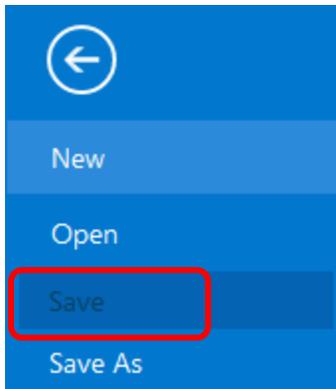


The display should look something like the following (the colors for each data layer are chosen automatically by ArcGIS Pro).

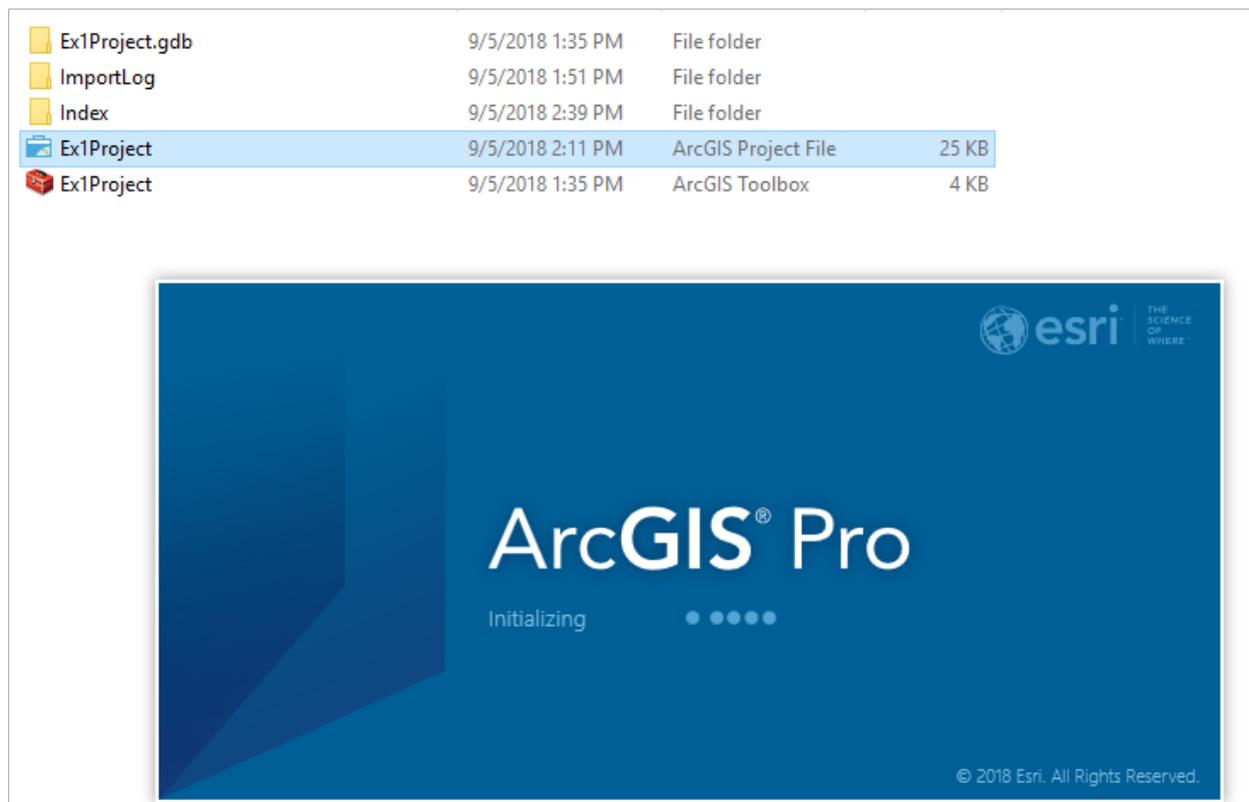


Let's make sure that we can retrieve the results of these actions if we inadvertently make a mistake and close the application. Use **Project/Save** to save the contents of the current project.



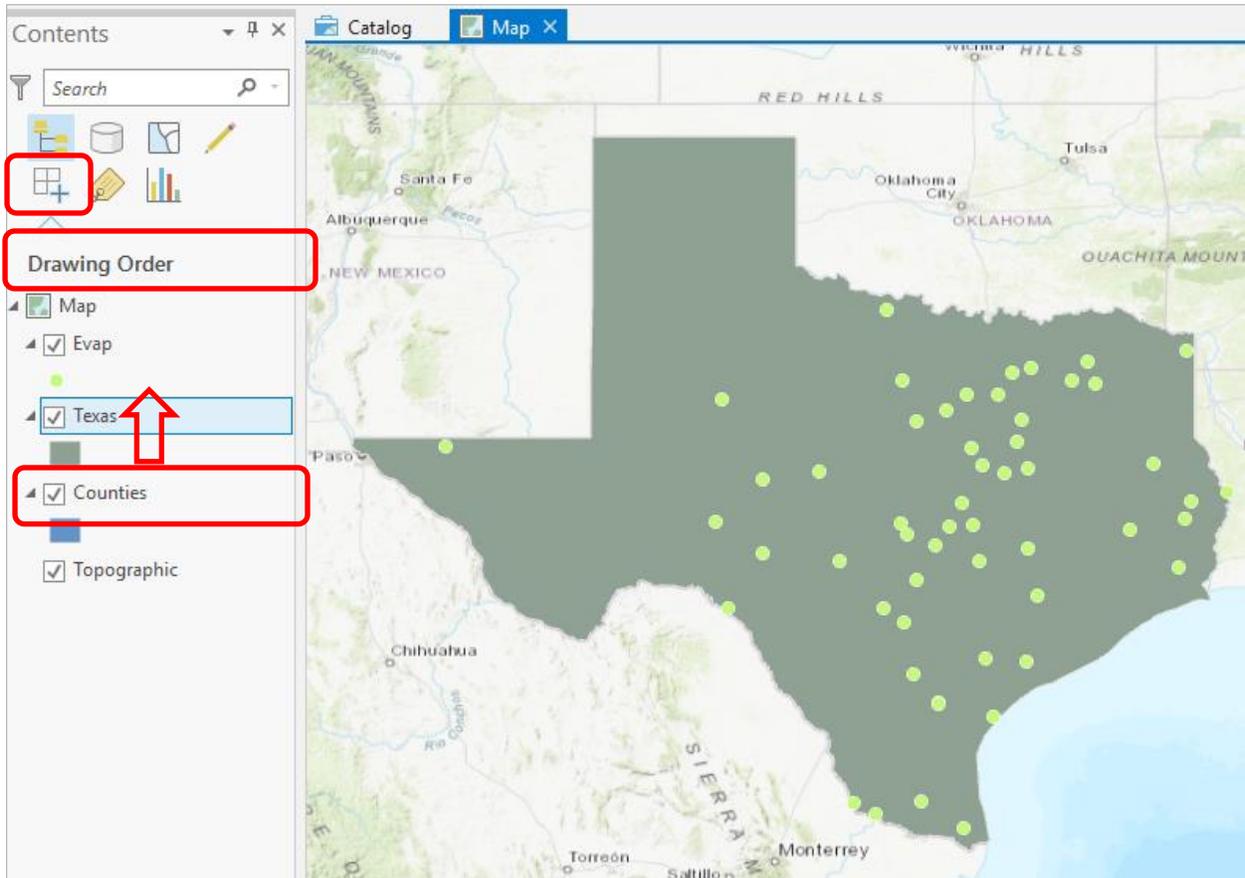


The project will save in the initial destination provided when you created the project (**Ex1Project** for this example). There is an **Ex1Project.aprx** file within the project folder that contains the table of contents and symbology information for your map. You can shut down ArcGIS Pro and reload the same map display by clicking on **Ex1Project.aprx**. Sometimes, ArcGIS Pro fails for some unexplained reason and you get the “Blue Screen of Death” on your computer. In this case, you have to wait until the computer recovers and you can login and restart applications. If this happens, restart ArcGIS Pro as shown below and you can pick up where you left off when you last saved the project. *Make sure you save your project often!*

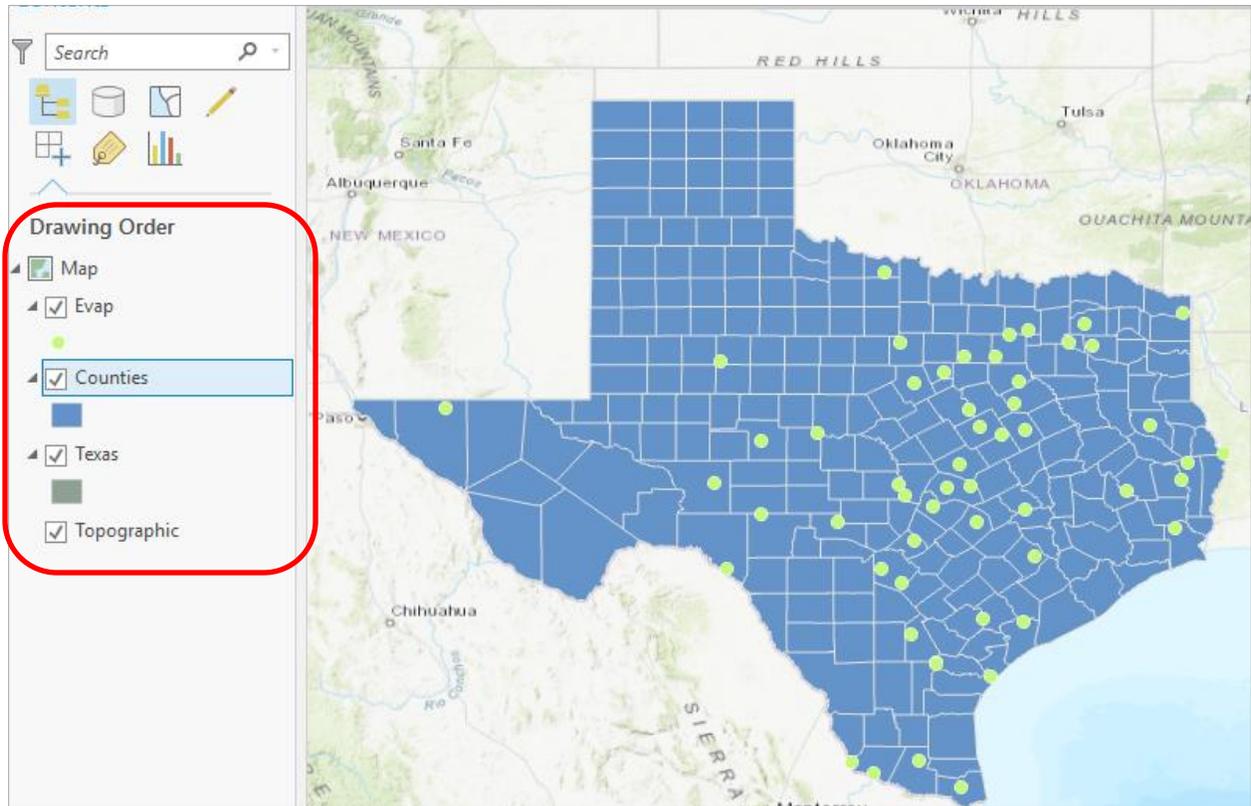


Note that the .aprx file that is saved does not contain the map data, rather it contains references to the data. This means that if you move the data files and then try and load the map document, ArcGIS Pro may not be able to find the data. We'll deal with how to fix this later.

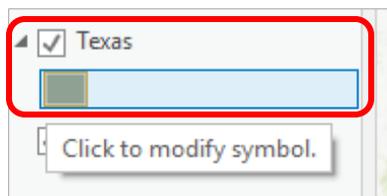
Depending on the order in which themes were added the **Texas** theme may lie above the **Counties** theme so you cannot see the **Counties** theme.



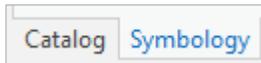
Click on the **Counties** theme and drag it up so that it is located above the **Texas** theme. You'll then get a display showing the counties. If the layer does not respond to being dragged check that you have the drawing order tab in the Contents pane (the pane on the left) active. There are options to switch into other panes that provide other functionality and give other information about the layers in your map. You could explore these if interested.



To change the appearance of a map display, you can access the **Symbology** menu by selecting the Symbol displayed in the ArcGIS Pro table of contents and the **Symbology** information will open on the right side of the screen. Alternately, you may right-click on the layer name (ie. “Texas”) and select **Symbology**.

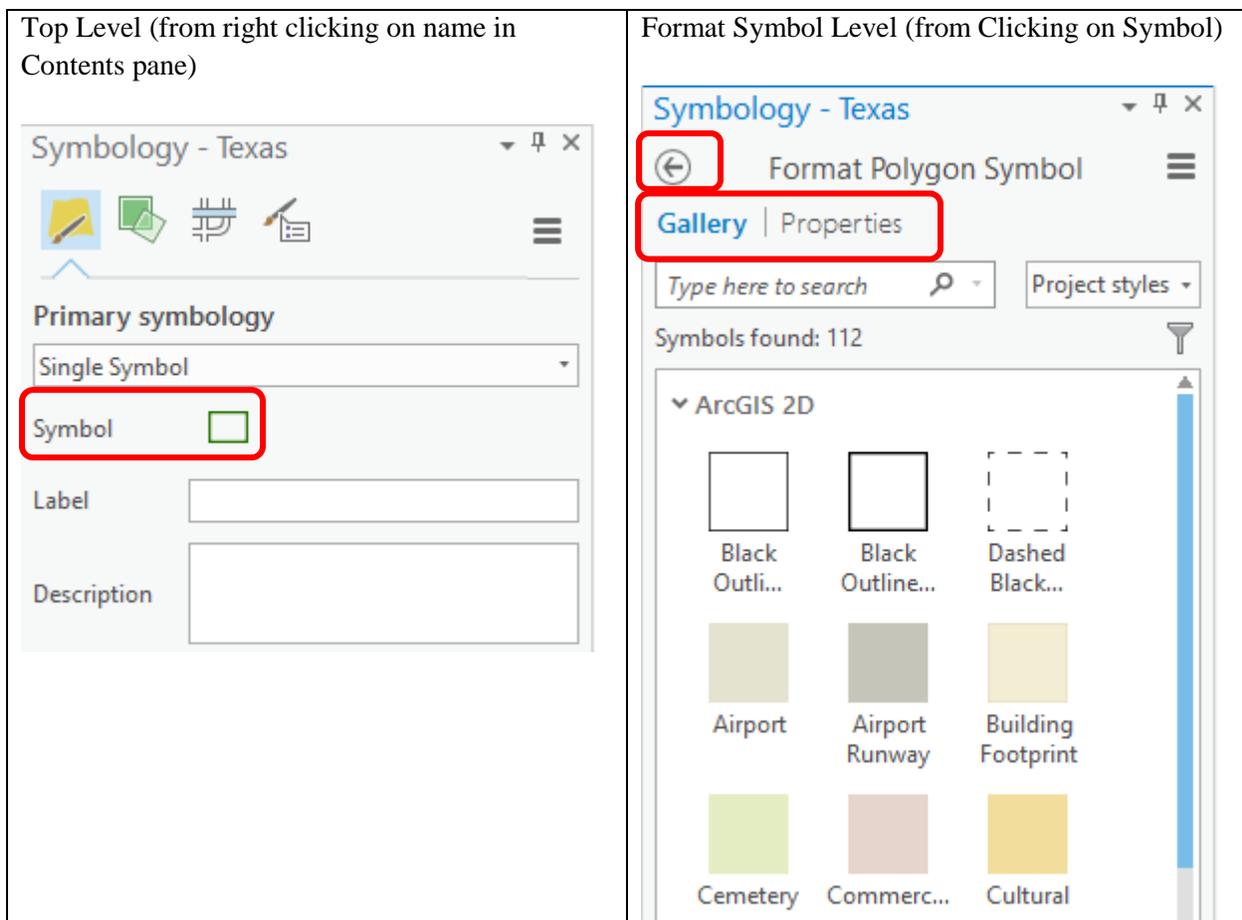


You’ll see a new Symbology window open in the right hand side of your screen, denoted by the Symbology tab at the bottom of the window.



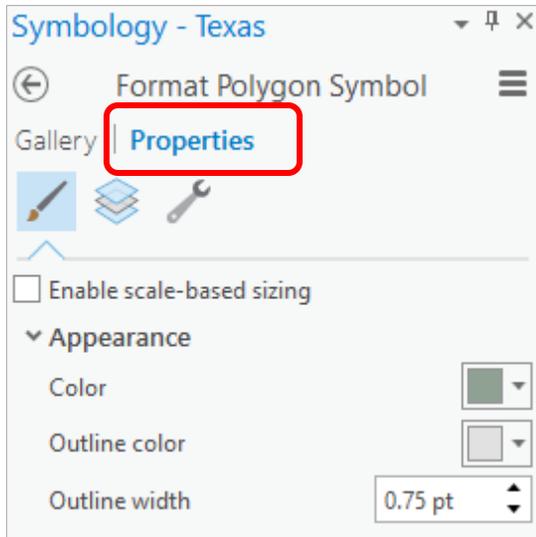
You’ll notice in working with ArcGIS Pro that new windows open up on the right hand side for different functions such as Symbology, Geoprocessing, Catalog, etc as you go through different tasks in the exercise.

Note that depending on whether you open Symbology through the layer or through the symbol you get into symbology at the top level or at the Format Symbol Level

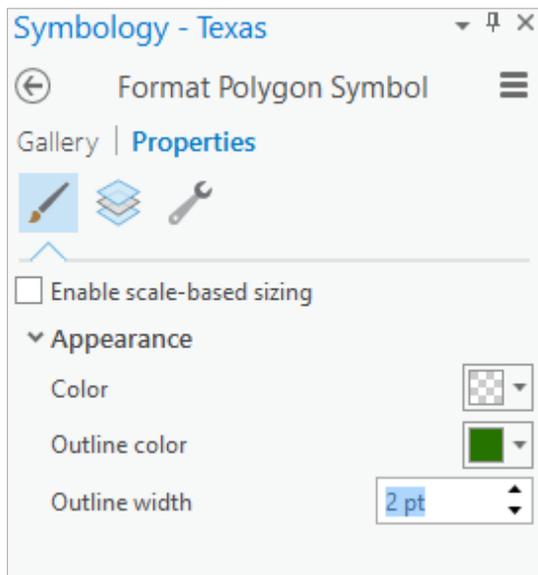
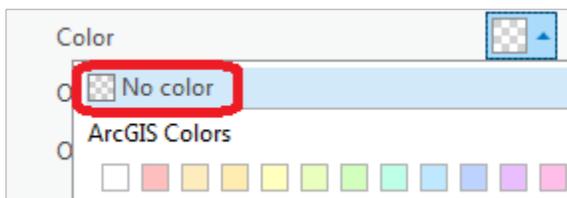


Clicking on the left arrow and Symbol toggles back and forth between these. You'll see at the top of the Format Polygon Symbol panel there are two headings: **Gallery** and **Properties**. Gallery gives you a menu of choices as to what Symbology you can use, and **Properties** shows properties of the currently selected Symbology. You can also Toggle between Gallery and Properties to control the ways symbology can be adjusted. Experiment a bit with the options to get a feel for how you can change colors and outlines, or use preset symbology definitions.

Select **Properties** in the Format Polygon Symbol panel. You'll see three important items in this panel, the **Color** that refers to the color used for filling the interior of the polygon of Texas, **Outline Color** that refers to the color of the line defining the border of Texas, and **Outline Width** that defines how thick the Outline will be. As you work with ArcGIS Pro, you'll spend a lot of time modifying these to make visually interesting and attractive maps.



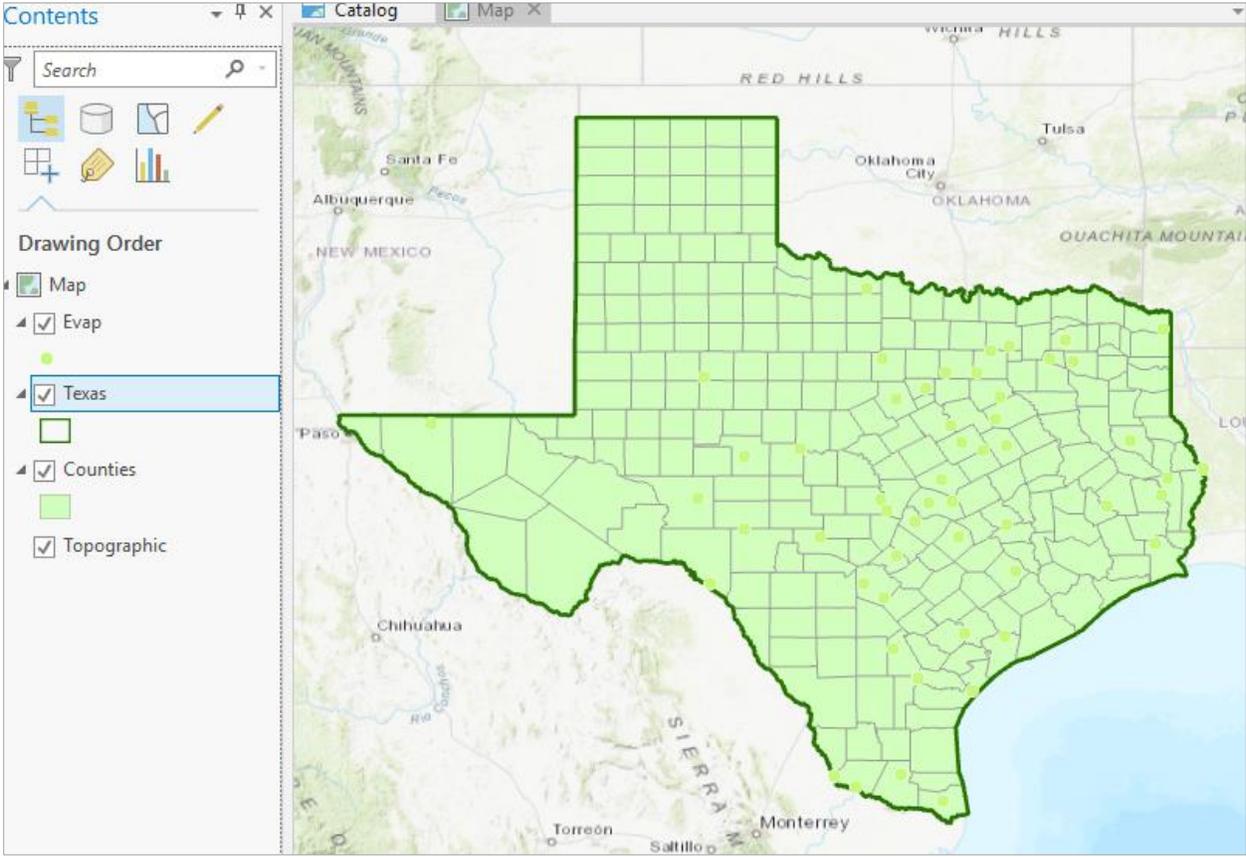
Now make your selections for the **Color**, **Outline Color**, and **Outline Width**. You can show the outline of the State of Texas more distinctly by using the **No Color** symbology for the Fill Color and then changing the Outline Color to Green and the **Outline Width** to 2.



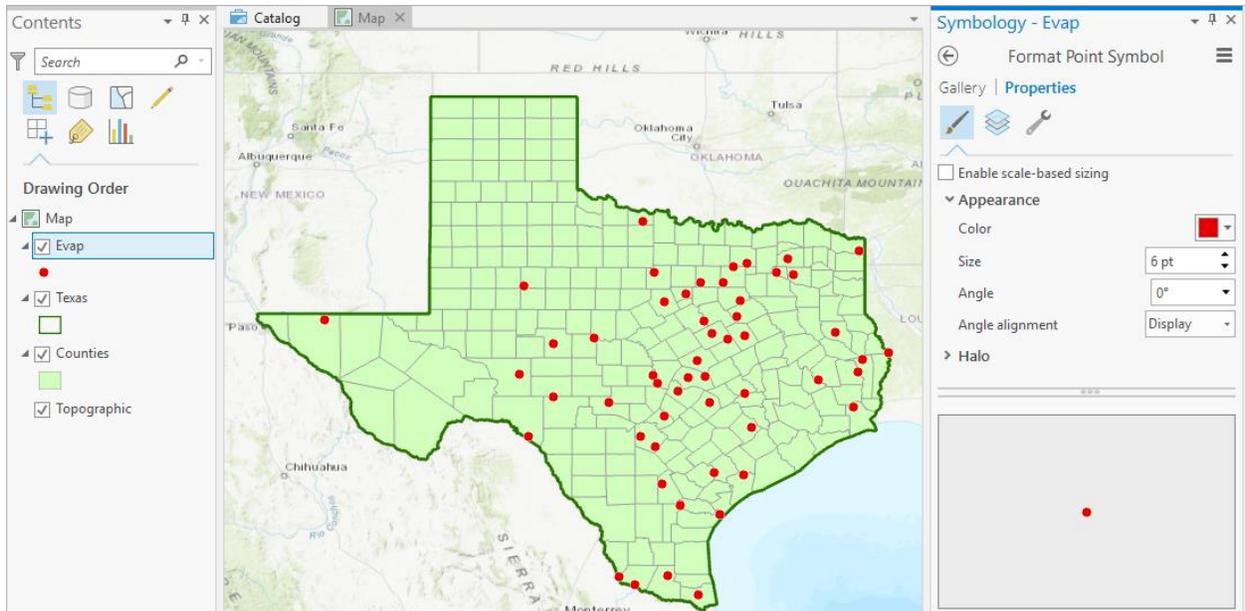
And click **Apply** at the bottom of the panel to cause these Symbology changes to be made.

Apply

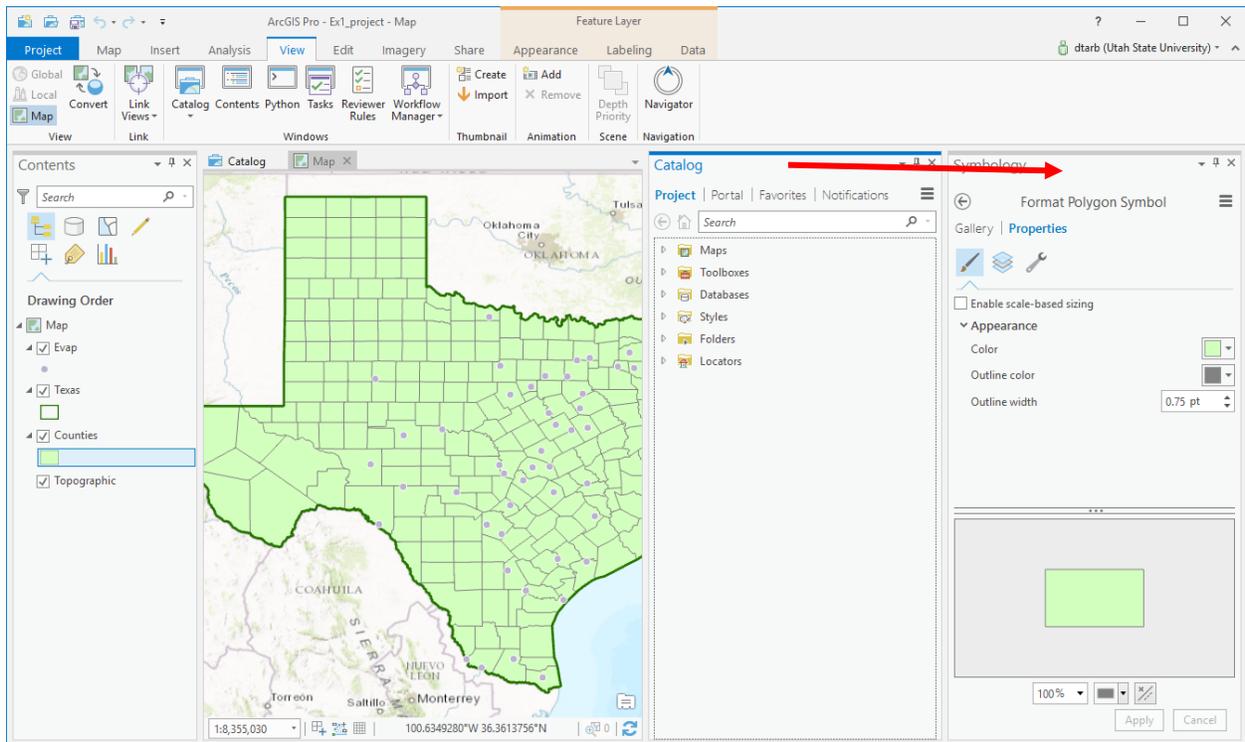
Drag the **Texas** layer above the **Counties** layer, and you'll see that the Counties are not obscured as they were before, and the State of Texas is highlighted with a nice Green outline! We are green in Texas! If you have another color for your Counties, then click on the Counties symbol in the Legend and in the **Symbol Selector** window that appears select a nice green color and hit Ok to recolor your counties and choose a dark grey color for the outline so you can still see the boundaries of the counties.

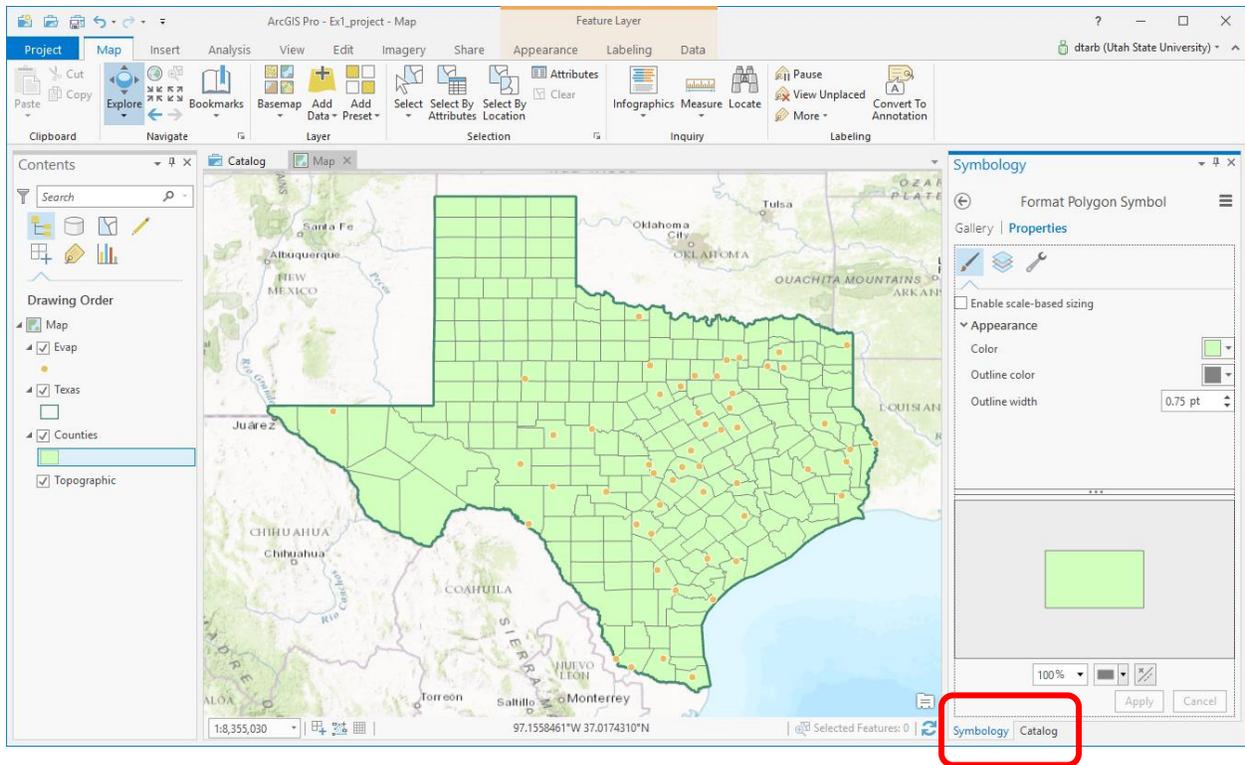


You can see that the Pan Evaporation stations, originally colored green, have been obscured as we changed the colors of the Texas and Counties themes. Let's color them in red so that they show up clearly. Follow the same procedure for the Evap theme as for the Texas and Counties themes to open the Symbology panel and change the color of the point symbols to red.



Note that your display may contain multiple tabs and panes. You can move these around and dock them to suite your preferences and what you are doing. Here I docked the catalog pane and symbology pane together to simplify what I am working with.

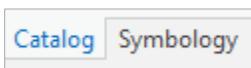




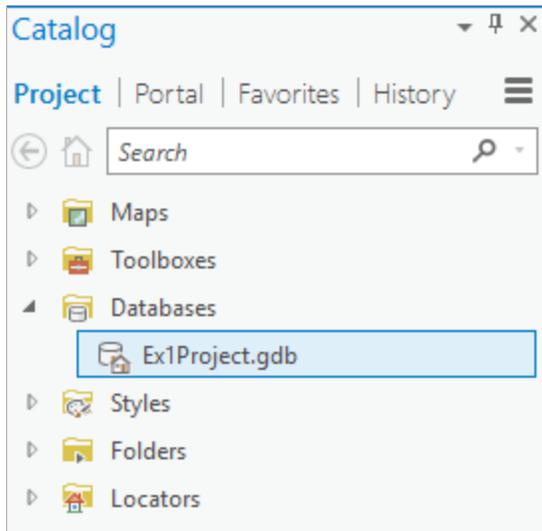
2. Storing Data in the Project Geodatabase

The data files we have now are still in the form of shape files that we downloaded from the web link. It's good in ArcGIS Pro projects to copy the data over into the Project geodatabase so that you have all your information in one nice tidy package.

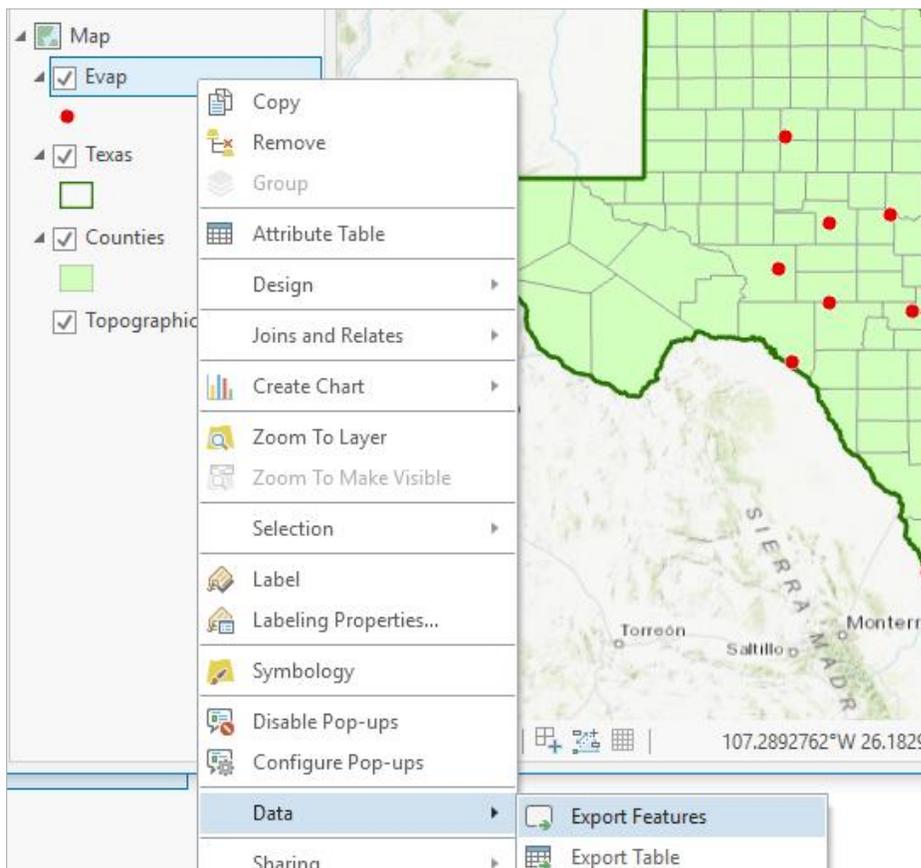
If you click on the Catalog tab at the bottom of the right hand side panel



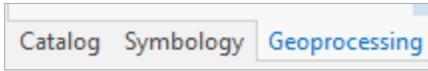
You'll open up a panel that shows the project components. If you click on Databases, you'll see your **Ex1Project.gdb** database that is presently empty.



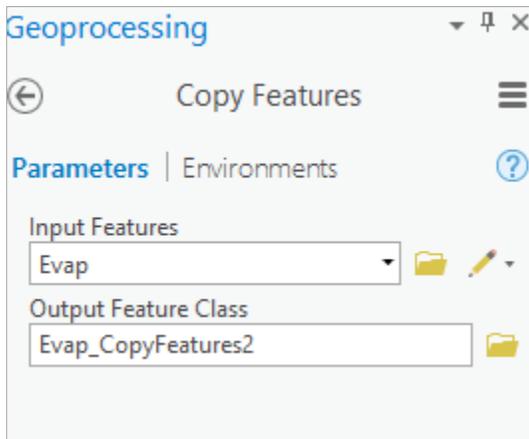
Let's put the Evaporation stations in the geodatabase first. Right click on the **Evap** theme and select **Data/Export Features**.



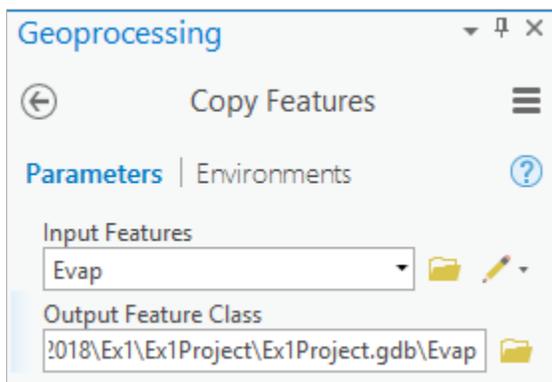
You'll notice that a new Geoprocessing tab and panel opens up for a function called Copy Features.



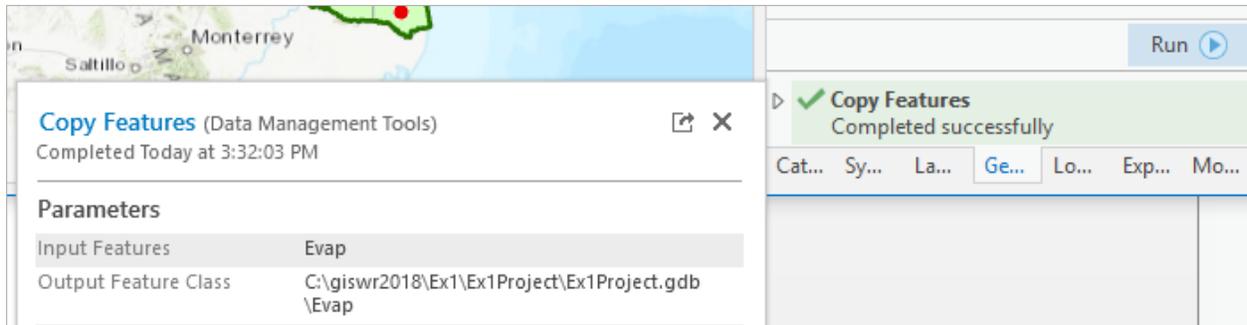
Say “hello” to Geoprocessing, because you’ll see a lot of this panel throughout the course. All the ArcGIS processing functions are accessed this way. In this case the Copy Features function takes as Input Features the shape file **Evap** and there is a proposed name for the Output Features of **Evap_CopyFeatures2**, which seems rather complicated.



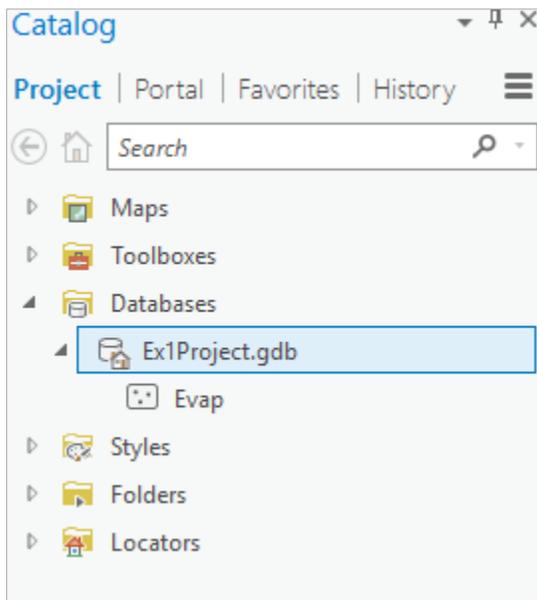
Let’s click on the Output Feature Class box and change the name to Evap. Notice that by default your outputs are being directed to the Ex1Project geodatabase. This is a really nice feature of ArcGIS Pro.



Hit **Run** at the bottom of the Geoprocessing panel to execute this function. *You always have to hit **Run** at the end of setting up a Geoprocessing function.* It’s easy to forget this and then go back and find that nothing has happened. You’ll get a message at the bottom that Copy Features has run successfully.

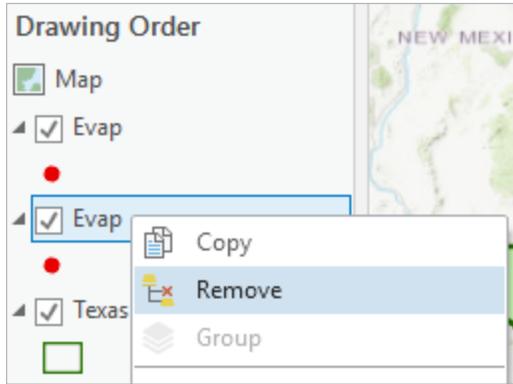


Now if you click on the Catalog tab at the bottom of the right hand window and look at your Ex1Project geodatabase, you'll see that the Evap theme has been added there.



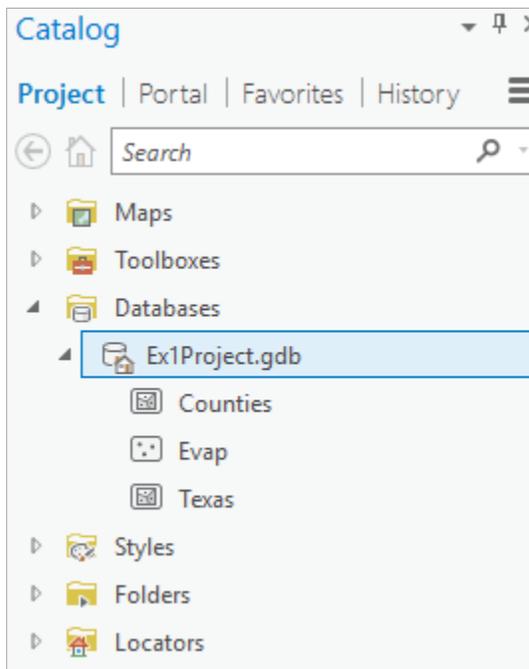
And if you look in your legend bar on the left hand side, you'll see that you've now got two copies of the Evap theme, the one on top that you just created in the geodatabase, and the one below that which is the original one created from the shape file. Notice that the Symbology of the new Evap theme is retained as the copy is made.

Right click on the lower one of these two and **Remove** it from the map display.

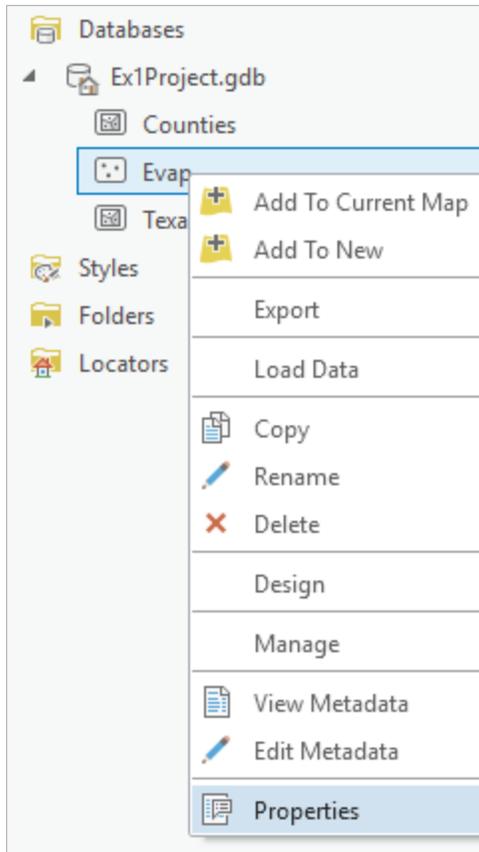


Repeat these steps for copying the **Texas** and **Counties** themes in the Ex1Project geodatabase and you'll see if you look at the Catalog panel that your Ex1Project geodatabase now has all the geospatial information in it that we'll use for this exercise. In later exercises in the class, you'll do more Geoprocessing to create new layers in the project geodatabase but in this exercise, we'll work just with these three layers.

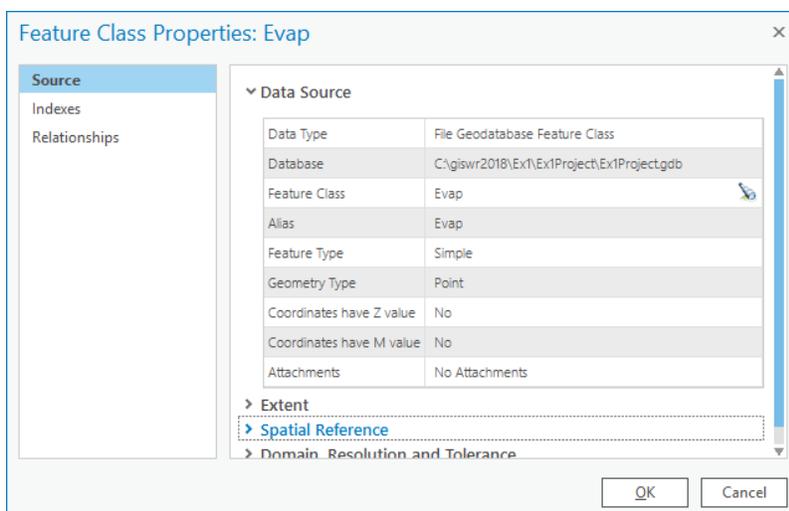
In ArcGIS Pro, use **Project/Save** to save this new version of your Ex1Project file.



Let's check out some of the Properties of the Evap data. In the Catalog panel right click on the Evap theme and select the **Properties** option.



You can read under Data Source, the location of the database, and that this is a **Simple** feature class of **Point** features. This means that these points just have (x,y) coordinates. Under the **Source** tab, select the **Spatial Reference** option



And you'll see that the location of the points is given in the **North American Geographic Coordinate System of 1983**, which means that each point has a latitude and longitude coordinate. We'll learn more about geodesy, map projections and coordinate systems shortly in the class.

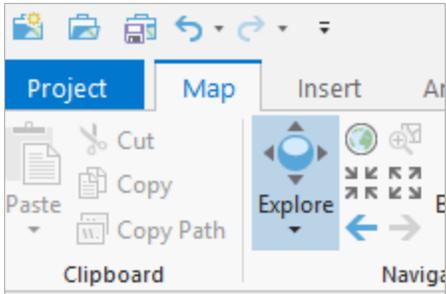
Spatial Reference	
Geographic coordinate system	GCS North American 1983
WKID	4269
Authority	EPSG
Angular Unit	Degree (0.0174532925199433)
Prime Meridian	Greenwich (0.0)
Datum	D North American 1983
Spheroid	GRS 1980
Semimajor Axis	6378137.0
Semiminor Axis	6356752.314140356
Inverse Flattening	298.257222101

Repeat this query for the **Spatial Reference** of the **Texas**, and **Counties** layers and you'll see that they are same as for the Evap layer. Hence, all our data use the same geospatial coordinate system.

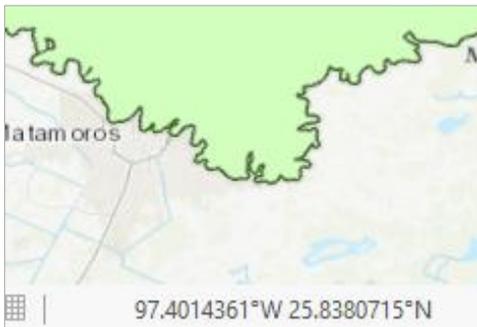
If you go to the map display and move the cursor around, you'll see the Latitude and Longitude of the cursor location changes in the bottom of the map display



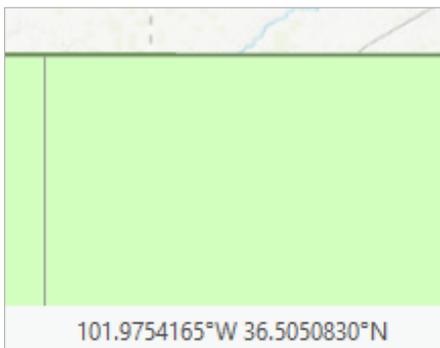
In the *Map* tab in ArcGIS Pro, you can use the **Explore** button to Pan around the map display, and use Shift and clicking and dragging a box to center on a particular location within a map. Alternatively, you can use the **Zoom in** and **Zoom out** arrows  to get closer or farther views of your map.



If you zoom in to far south of Texas you can find the coordinates of the Southernmost part of the state as approximately 97.40 °W in Longitude and 25.83 °N in Latitude. Notice that these coordinates are listed in Longitude, Latitude order, equivalent to (x, y) if we were thinking of this as a normal scientific coordinate system. These units are called **Decimal Degrees**, and this is how geographic coordinates of Latitude and Longitude are stored inside the GIS, and not as in units of Degrees, Minutes and Seconds as you might be more used to.



Similarly if you go to the top of Texas and run your cursor along the state line, you'll see that this follows the latitude parallel of 36.50 °N. Hence we can say that Texas extends from 25.83 °N to 36.50 °N from South to North or $36.50 - 25.83 = 10.67^\circ$ in north-south extent.

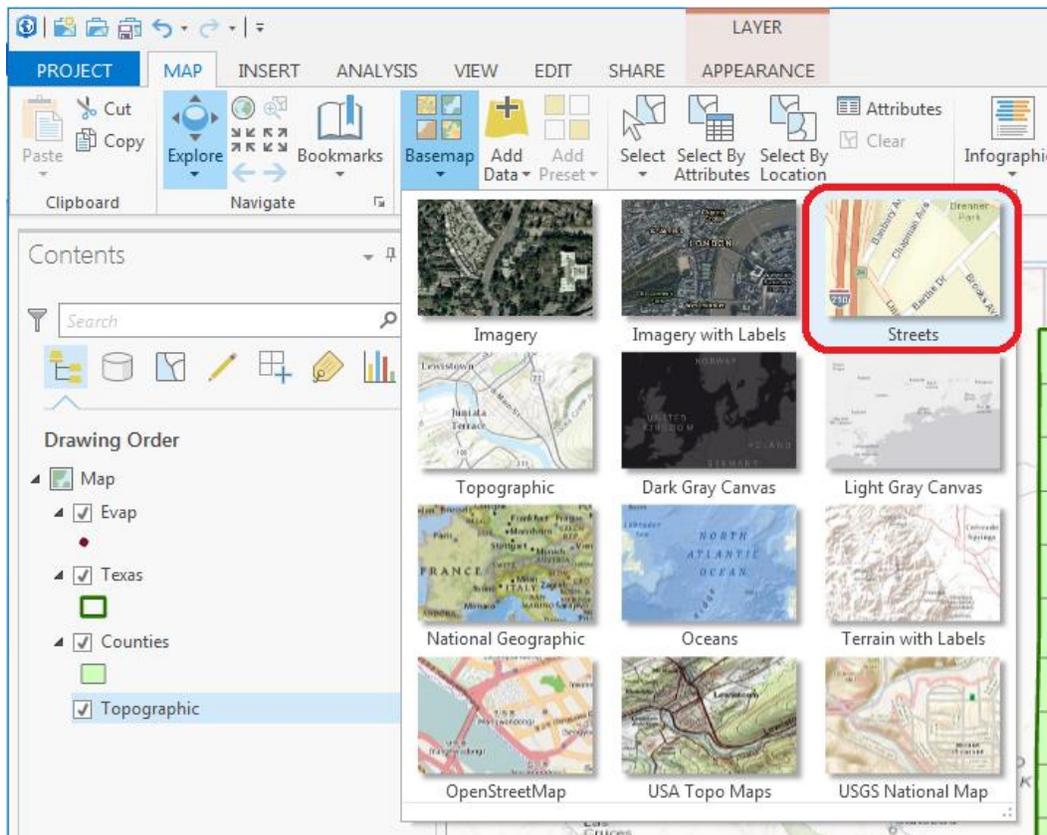


To be turned in: Find the Latitude of the most Northern and Southern locations in Texas and the Longitude of the most Western and Eastern locations in Texas. What is the North-South extent in degrees

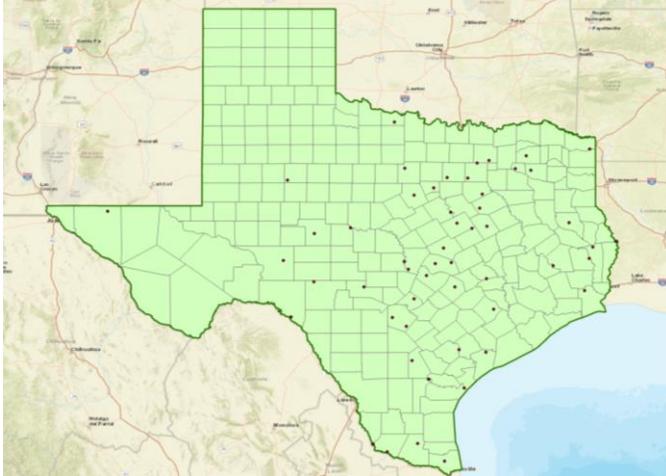
of Latitude? What is the East-West extent in degrees of Longitude? Measured in Decimal Degrees, is Texas wider than it is taller or the other way around?

3. Using Base Maps from ArcGIS Online

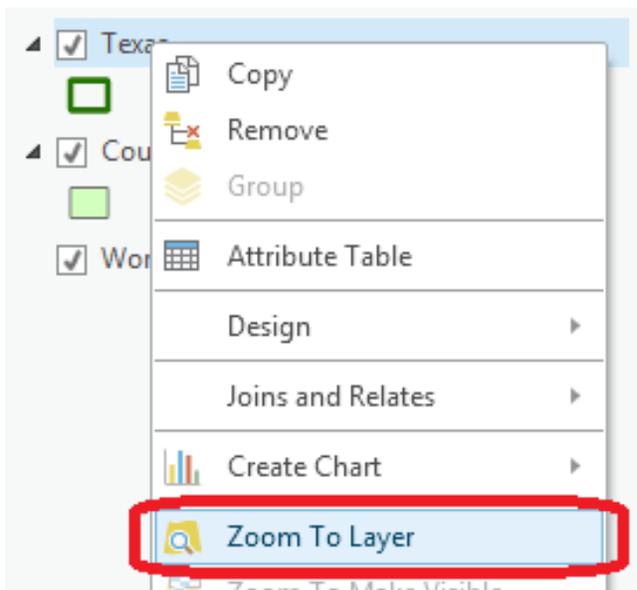
You may have noticed the topographic map that automatically loaded on start-up. This topographic map is an example of an ArcGIS Online basemap, which supplements the local GIS data we have been adding up to this point. The **Topographic** base map is the default basemap used in ArcGIS Pro.



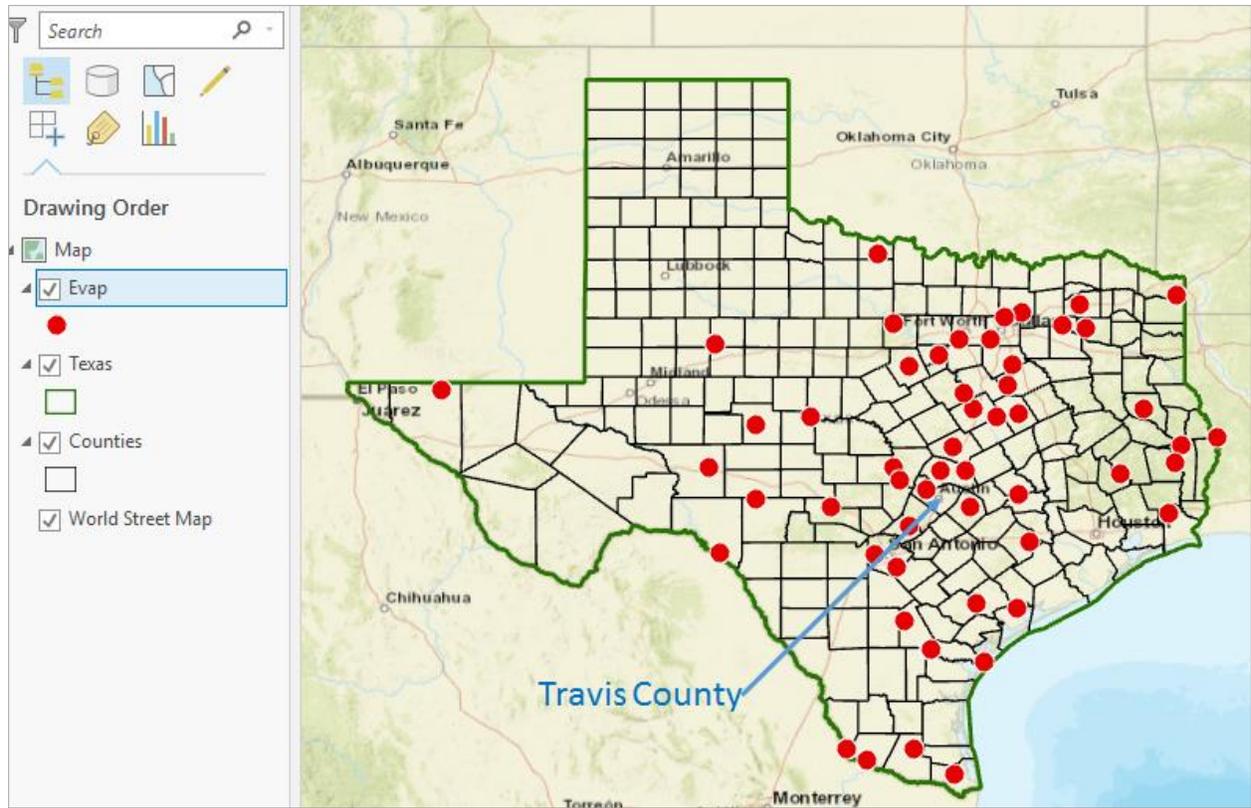
Click on **Basemap** then **Streets** to switch to the **Streets** basemap, and you should see a background map change from the default topography basemap to a display like that shown below. Pretty cool!



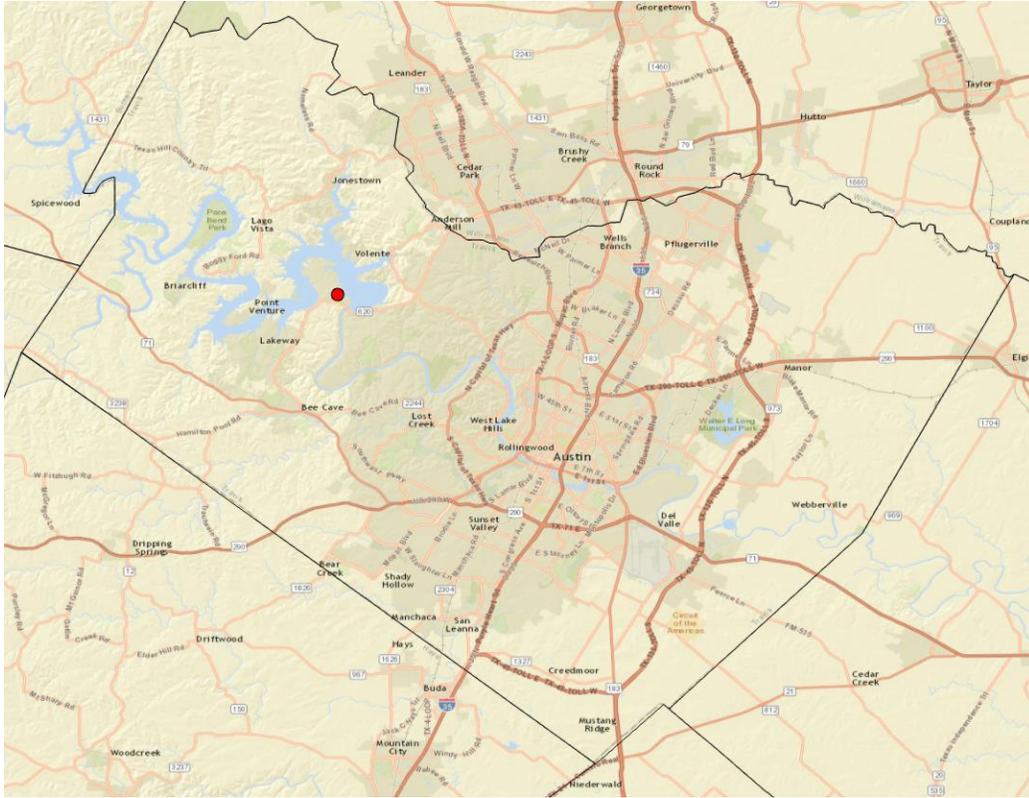
To quickly get the map to center on Texas, right click on the Texas layer and select **Zoom to Layer**



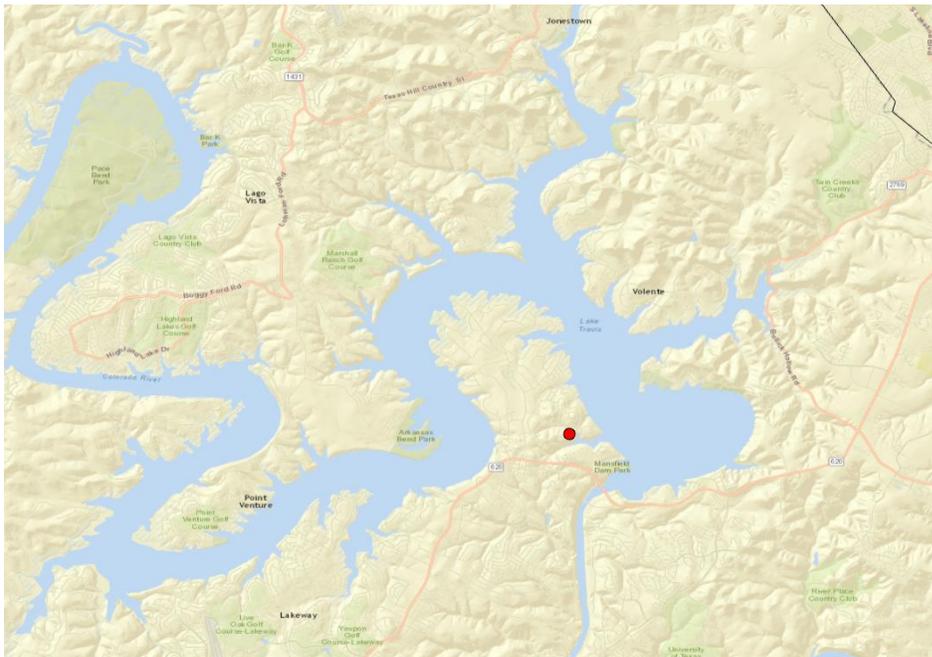
Click on the **Counties** theme and use the Symbol Selector to change the Fill Color to “No Color” so we can see through it to the background map, change the border color to black, and change the border thickness to 1. Click on the symbol for the Evap points and use the Symbol Selector to change the size of the points to 10. Let’s examine Travis County.



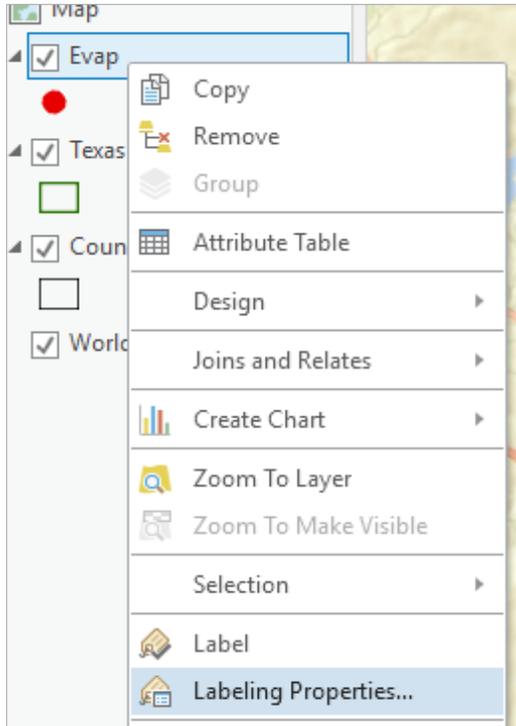
Zoom in to Travis County using the *scroll wheel* or *right-click and pan* (up zooms in, down zooms out).



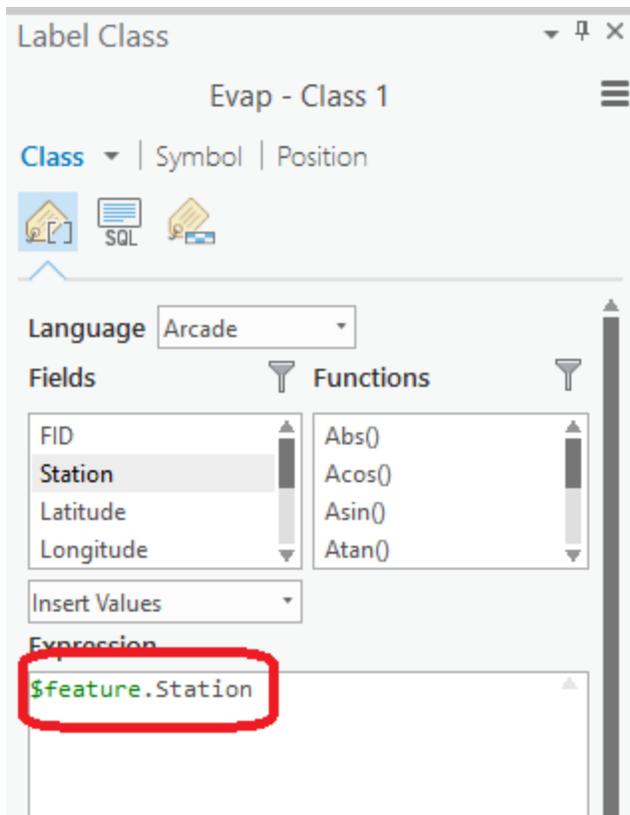
Zoom in to Travis County by Austin in the center of Texas, and let's examine the evaporation site by Lake Travis to the Northwest of the city. Notice how more detailed information appears as you zoom in.



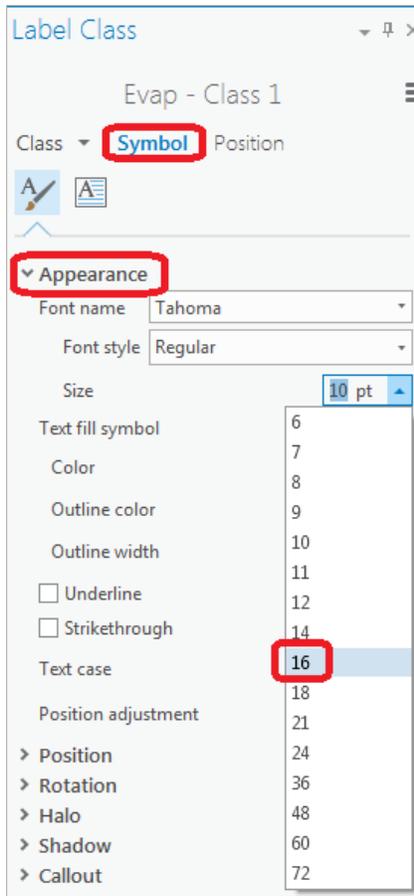
Let's label the sites with their names. To create a label, right click on Evap and select **Labeling Properties** from the menu to open the **Label Class** options on the right side of the screen.



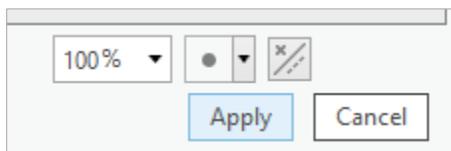
Verify that **Station** is selected (`$feature.Station` in the Expression box).



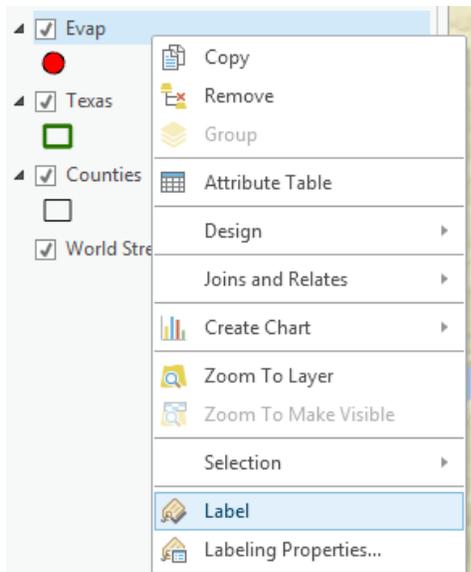
At the top of the **Label Class**, select **Symbol** and **Appearance**, then select **16** point as the type size. Hit Apply at the bottom of the screen to accept changes.



Hit **Apply** to confirm these selections



Now, to display the label, right click on the **Evap** theme and select **Label** from the menu.



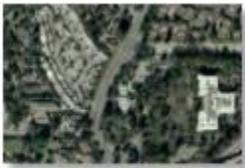
Now we've got a nice map that shows the location of our observation site labeled with its name.



If you zoom in a bit closer, you can see just where the site is located near Lake Travis. You can even see the access roads you'd use to go to this site.



Now, let's look at some imagery for this location. Proceeding as you did before to get the Street map, use the **BaseMap** button to add data for **Imagery**.



Imagery

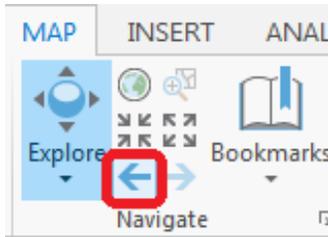
And now you'll see the same information displayed against a background map of orthoimagery, and let's zoom in a bit to see more detail. For the **Evap** theme, I have used the **Properties/Label** to change the color of my site labels from black to blue to make them easier to see against the image background. This is really cool stuff! You can really get a sense of context about where this observation site is located.



Use **File/Save** to save this map display as **Ex1Project.aprx** so that you can get it back later.

4. Accessing and Querying Attribute Data

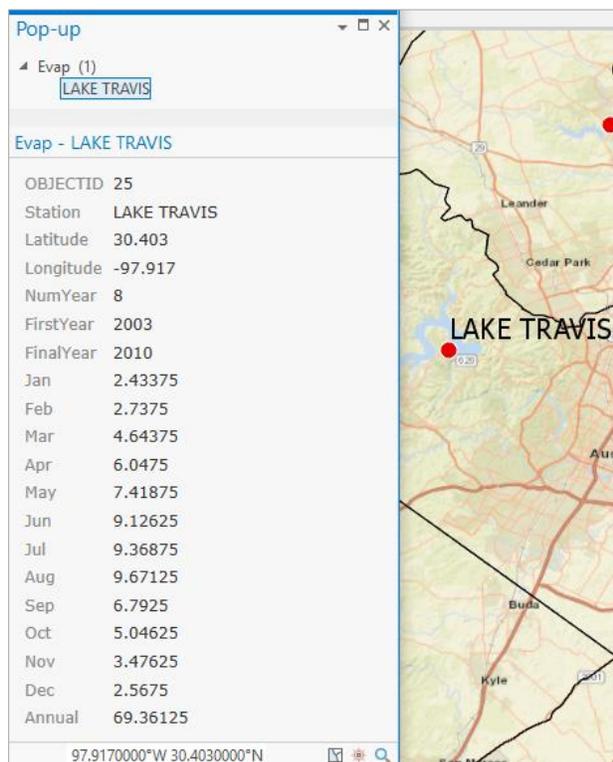
Let's go back to the view we had earlier of Travis County. Use the Go Back to Previous Extent arrow



to step back through the views we have just been working on, and switch back to the **Streets** basemap again. Change the Label color for the **Evap** sites back to Black.

Numerical and text information stored in the fields of the shapefile tables are called **attributes**. To access attribute data of the feature at a specific location, simply click on the feature in the map you are interested in. In this case, click on the Lake Travis evaporation site symbology (the red point).

In the window that pops up you'll see the attributes of that particular feature. In this instance, what you see is that the data for Lake Travis cover the range from 2003 to 2010, the latitude and longitude are 30.403 and -97.917, and the values from Jan through Dec are the mean monthly evaporation recorded at this location whose annual total is 69.36 inches. Notice also that the Longitude and Latitude of the point you clicked on are shown at the bottom of the popup window they correspond to the attribute values recorded for this feature, as they should.

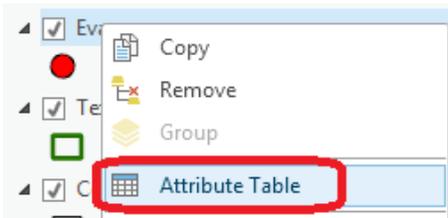


These are pan evaporation data recorded using an instrument like that shown below. The evaporation data were obtained from the Texas Water Development Board. Only data from 2001 onwards is used since the TWDB has quality control checked that information. Monthly evaporation is found by averaging the daily values of evaporation read from the pan, and multiplying by the number of days in the month. If a month has fewer than 20 daily values recorded, it is excluded from the dataset. Only years with valid monthly data for all 12 months are used in computing the mean monthly and mean annual pan evaporation data shown in the attribute table.



Viewing an Attribute Table

To access attribute data of an entire layer in ArcGIS Pro: right click on the **Evap** layer name in the table of contents, and select **Attribute Table**:



If you scroll down the resulting **Table** and click on the box to the left of **ObjectID 25**, you'll see the record that contains the attributes of the Lake Travis station that you identified earlier. You may have noticed that once you selected the row, the corresponding point was selected in the map – this is a key idea of GIS – map features are described by records in attribute tables.

The screenshot shows a GIS interface with a map of the Austin area. The 'Evap' feature class is selected in the Drawing Order panel. The attribute table below the map shows the following data:

OBJECTID	Shape	Station	Latitude	Longitude	NumYear	FirstYear	FinalYear	Jan	Feb	Mar
24	Point	LAKE TAWAKONI	32.85	-95.88	4	2005	2011	2.6125	2.92	5.0
25	Point	LAKE TRAVIS	30.403	-97.917	8	2003	2010	2.43375	2.7375	4.64
26	Point	LAVON DAM	33.034333	-96.485	3	2003	2008	3.983333	3.876667	5.476
27	Point	MATHIS 4 SSW	28.036778	-97.872	9	2001	2011	3.541111	4.081111	6.268

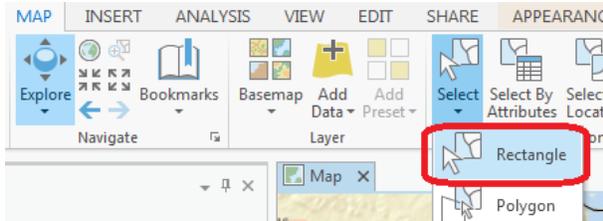
To Clear a Selected feature and select a new one, click on **Clear** at the top of the **Attribute Table**.

The screenshot shows the same attribute table as above, but with the 'Clear' button in the Selection toolbar highlighted in a red box. The 'Clear' button is located between the 'Switch' and 'Delete' buttons.

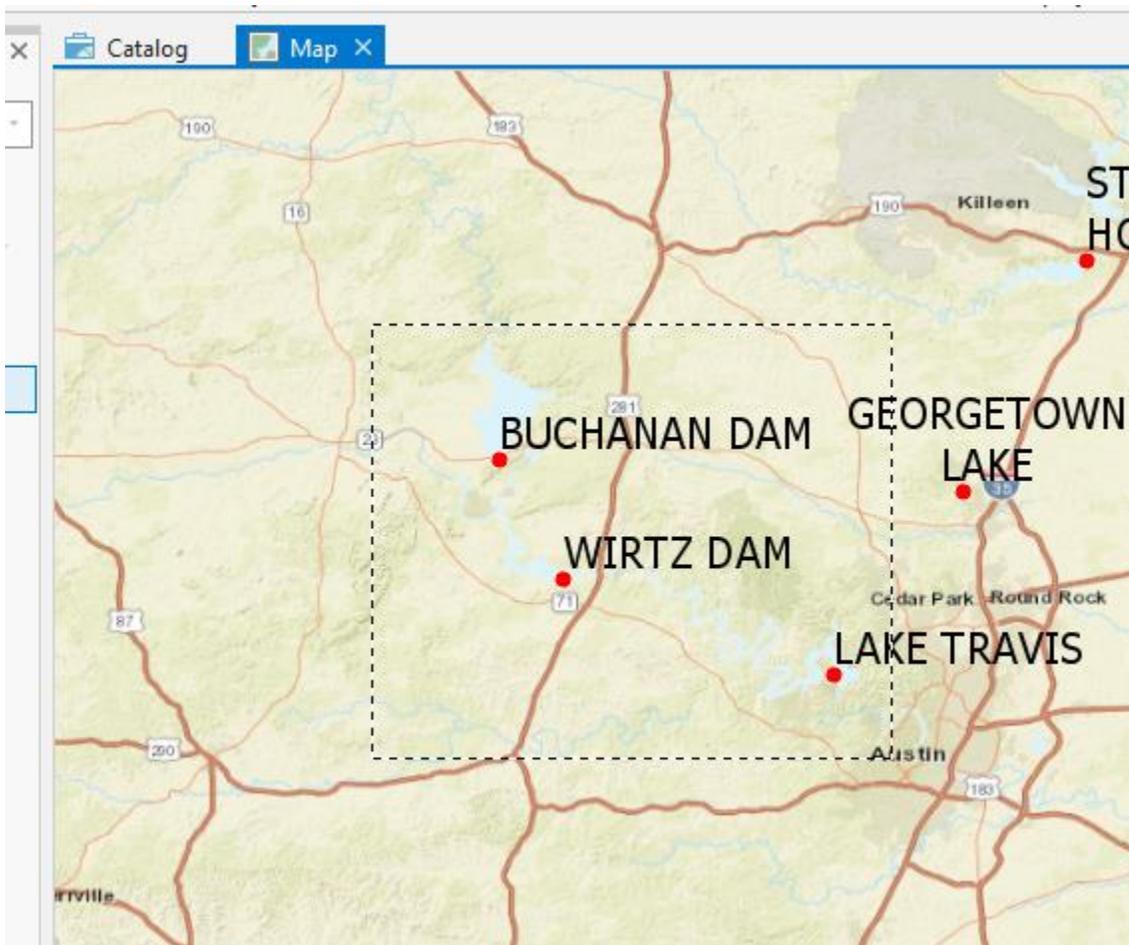
5. Selecting features from a feature class

Selecting features from a feature class involves choosing a subset of all the features in the class for a specific purpose. Feature selection can be made from a map by identifying the geometric shape or from an

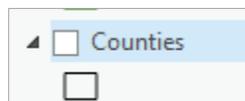
attribute table by identifying the record. Regardless of how you select an object, both the shape in the map and the record in the attribute table will be selected. Zoom out to where you can see several evaporation stations. Click on the **Select/Select Features by Rectangle** tool in the *Map* tab.



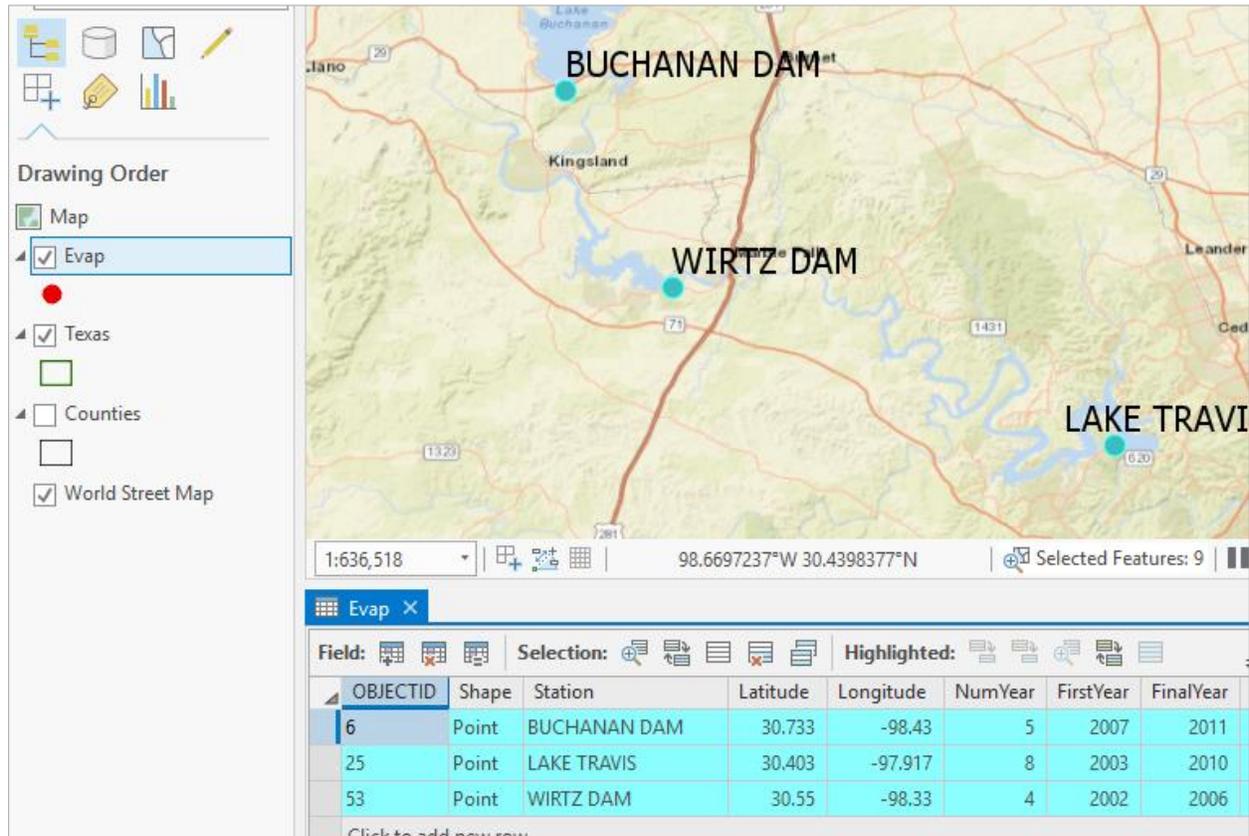
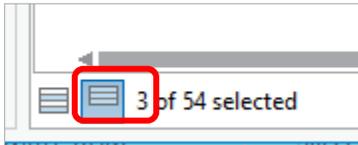
Drag a box over a rectangle covering the three evaporation sites in the Highland Lakes reservoir system shown



You'll see records highlighted both on the map and in the attribute table. I've turned off the Counties layer (click off the check box in the map Legend)



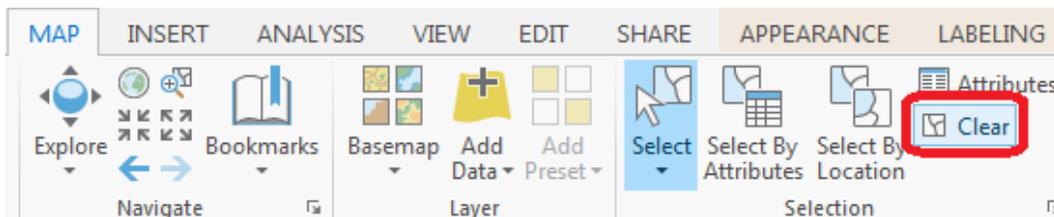
and used **Show selected records** at the bottom of the Attribute Table to just show the three highlighted stations.



The attribute table shows the following data:

OBJECTID	Shape	Station	Latitude	Longitude	NumYear	FirstYear	FinalYear
6	Point	BUCHANAN DAM	30.733	-98.43	5	2007	2011
25	Point	LAKE TRAVIS	30.403	-97.917	8	2003	2010
53	Point	WIRTZ DAM	30.55	-98.33	4	2002	2006

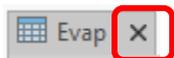
To clear your selection, choose **Clear**.



Clicking on **Show all records**, then displays all the records in the attribute table again.

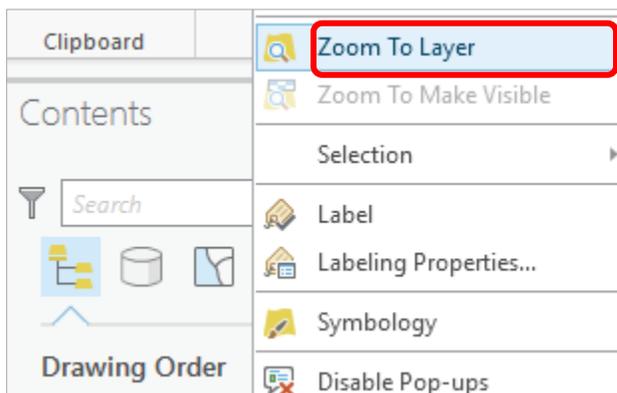
FID	Shape	Station	Latitude	Longitude	NumYear	FirstYear	FinalYear	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0	Point	AMISTAD DAM	29.46	-101.02	8	2001	2010	4.305	4.98875	7.73875	9.7475	11.7075	14.37375	13.5475	13.73625	9.43	7.4575	5.77375	4.705	107.5662
1	Point	BARDWELL DAM	32.263	-96.637	5	2001	2008	4.076	3.47	5.64	7.034	8.266	9.904	10.472	10.422	7.876	7.178	4.704	3.75	82.84
2	Point	BEAUMONT RESEAR...	30.0668	-94.2866	5	2001	2011	2.8	2.938	4.848	6.398	8.058	7.656	7.172	7.766	5.978	5.172	3.53	2.76	65.13
3	Point	BENBROOK DAM	32.647	-97.443	6	2002	2008	3.783333	3.743333	5.96	6.953333	7.78	8.95	9.971667	9.688333	7.633333	5.573333	4.658333	3.725	78.4
4	Point	BRAUNIG LAKE	29.25	-98.38	7	2001	2010	2.83	2.962857	4.674286	6.254286	8.442857	9.384286	9.308571	9.47	7.424286	5.417143	4.051429	2.834286	73.09285
5	Point	BUCHANAN DAM	30.733	-98.43	5	2007	2011	2.682	3.51	5.774	7.234	7.976	10.372	9.668	10.216	7.434	5.884	3.82	2.658	77.2
6	Point	CANYON DAM	29.87	-98.196	9	2001	2011	3.192222	3.353333	5.173333	6.75	8.347778	10.312222	9.074444	10.16	7.285556	5.811111	3.977778	2.952222	76.44777
7	Point	CHOKE CANYON DA...	28.467	-98.252	10	2001	2011	3.269	3.989	6.158	7.735	9.724	11.043	10.586	11.272	7.793	6.685	4.503	3.137	85.95
8	Point	COLETO CREEK RESE...	28.715	-97.174	8	2004	2011	2.4475	2.49875	3.83625	4.50375	5.26875	5.84875	5.39125	5.79	4.6075	4.12625	3.0775	2.29125	49.7
9	Point	DELL CITY 5 SSW	31.88	-105.226667	6	2001	2009	4.026667	5.638333	10.501667	12.705	14.768333	15.976667	13.218333	10.49	8.68	6.895	4.973333	3.72	111.6
10	Point	EAGLE LAKE	29.633	-96.38	7	2001	2011	2.912857	3.205714	4.98	6.898571	7.977143	8.924286	8.541429	8.845714	6.747143	5.377143	3.845714	2.768571	71.06714
11	Point	FALCON DAM	26.558	-99.137	6	2004	2011	3.876667	4.673333	7.6	9.671667	11.588333	13.47	13.111667	13.765	8.69	7.318333	5.686667	3.655	103.16666
12	Point	GEORGETOWN LAKE	30.683	-97.7168	5	2001	2009	2.878	2.85	4.022	5.63	7.4	8.868	8.16	9.39	5.59	4.4	2.964	2.34	64.54
13	Point	GRANGER DAM	30.7	-97.349	5	2001	2008	3.714	4.064	5.216	7.254	8.912	9.874	9.898	10.59	7.694	5.154	4.094	3.266	79.78
14	Point	INGRAM	30.15	-99.35	8	2002	2011	3.13	4.175	6.41875	7.96375	9.41875	11.1075	10.63375	10.69625	7.8175	6.0425	4.5375	3.23125	85.18
15	Point	IOWA PARK	33.916	-98.65	5	2002	2009	3.624	4.626	7.136	8.888	9.396	11.8	13.194	12.416	8.522	6.566	4.602	3.788	94.57
16	Point	JOE POOL LAKE	32.635333	-96.968667	3	2005	2008	3.29	3.68	5.936667	7.32	8.23	10.77	11.36	10.276667	8.226667	6.866667	5.113333	3.053333	84.17666
17	Point	LAKE BASTROP	30.15	-97.26	4	2001	2004	2.7875	2.7525	4.005	6.07	7.7675	8.68	8.06	9.8975	6.63	5.165	3.6825	2.56	68.082

Close the Attribute Table by clicking on the X next to the Evap tab in the table panel.

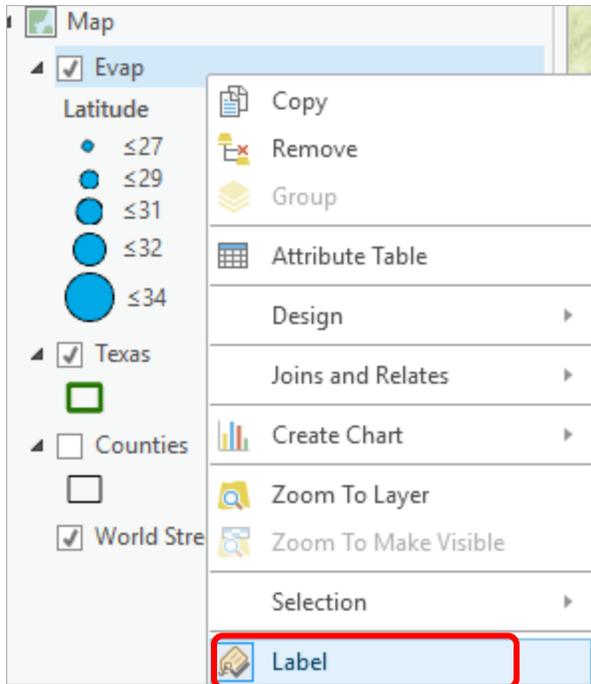


6. Mapping Annual Evaporation

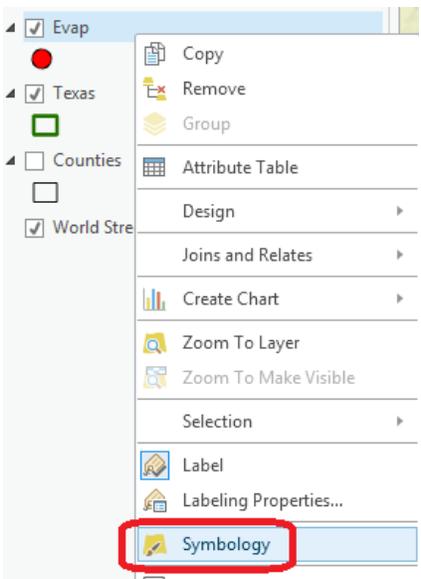
Let's suppose we want to map the values of annual evaporation recorded at the stations, rather than just placing a symbol at their location. Let's zoom out to the state of Texas again. Right click on the **Texas** feature class and select **Zoom to Layer**



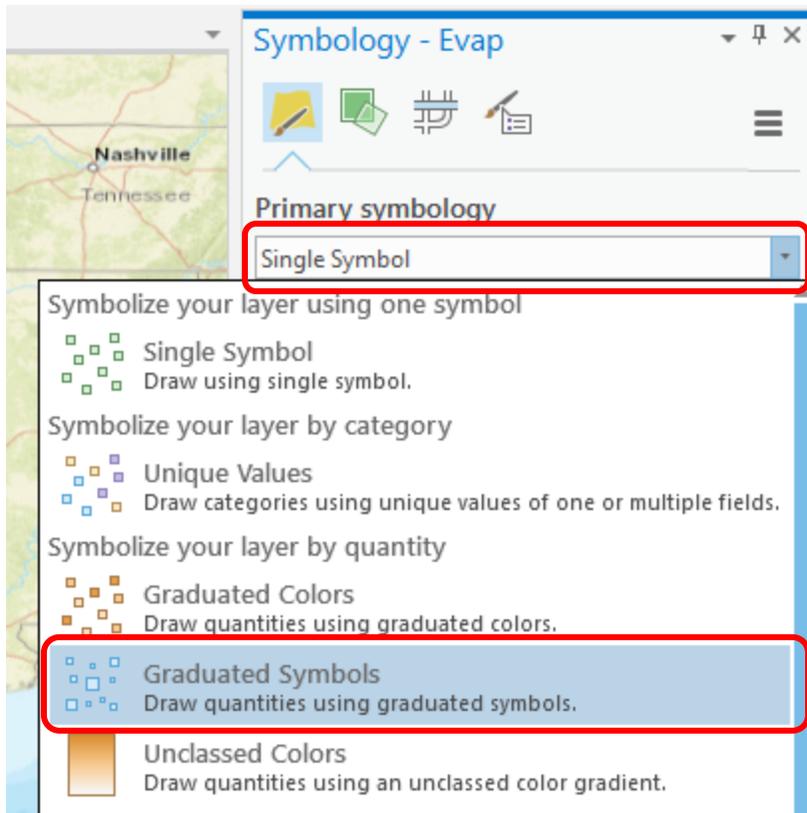
You'll see that there are a lot of labels showing up large in your new map. Get rid of these by right clicking on the Evap layer and toggling the Label entry so that the Labels are turned off.



Right click on the **Evap** layer and select **Symbology**.



In the Symbology section on the right-hand side, click on “Single Symbol” and change to “Graduated Symbols”.



Change **Field** to “Annual” and make the **Template** color blue.

Symbology

Evap

Symbology

Field

Normalization

Method

Classes

Graduated Symbol

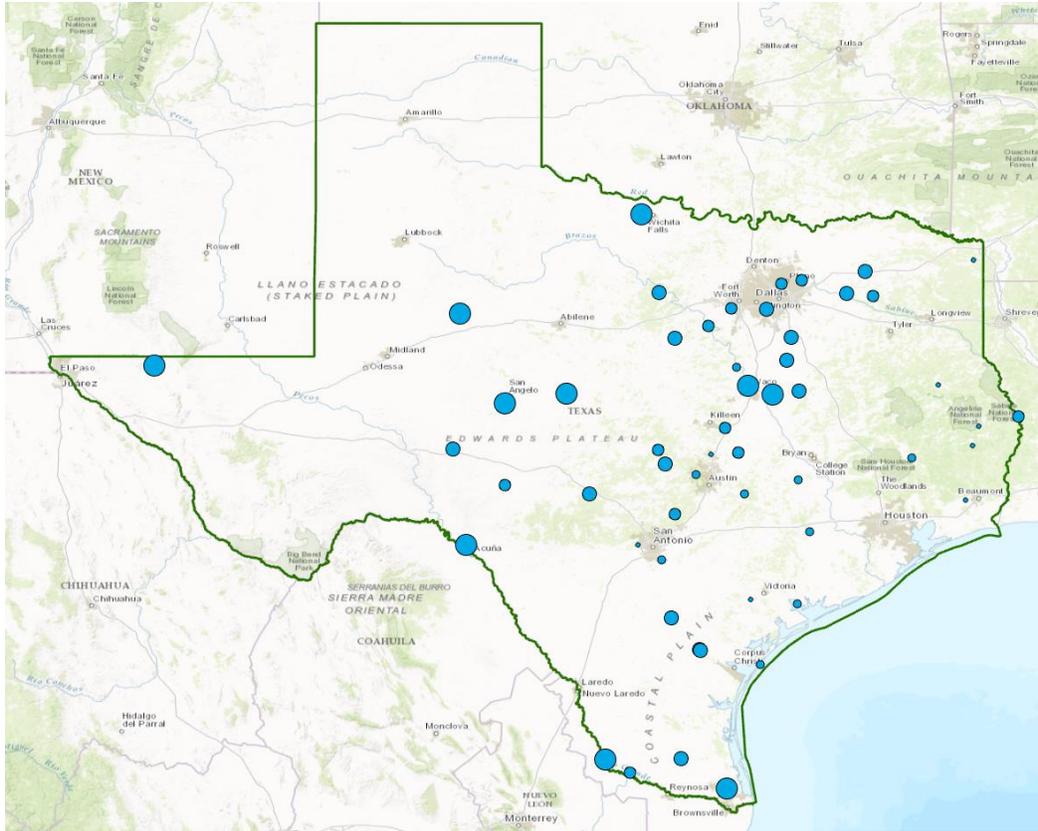
Minimum size Maximum size

Template

More

Symbol	Upper value	Label
•	≤ 65.296667	≤65
•	≤ 74.33	≤74
•	≤ 81.94	≤82
•	≤ 90.3525	≤90
•	≤ 111.65	≤112

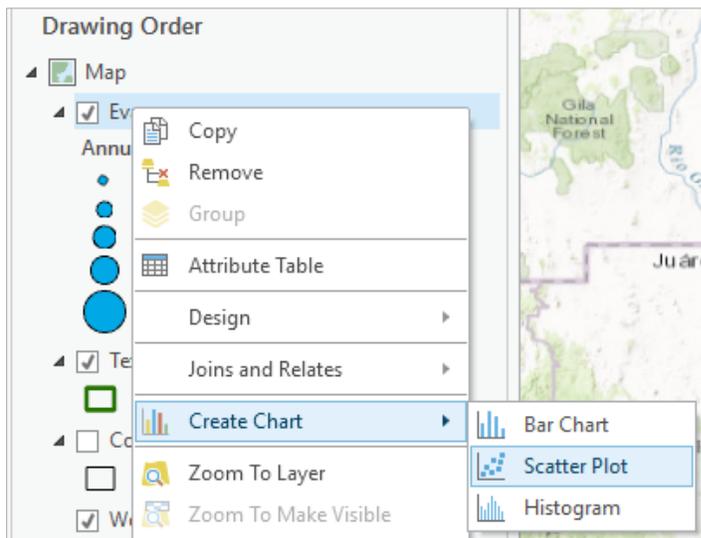
I have turned off all the other layers and added the **Topographic** base map to get the image below. Very cool!



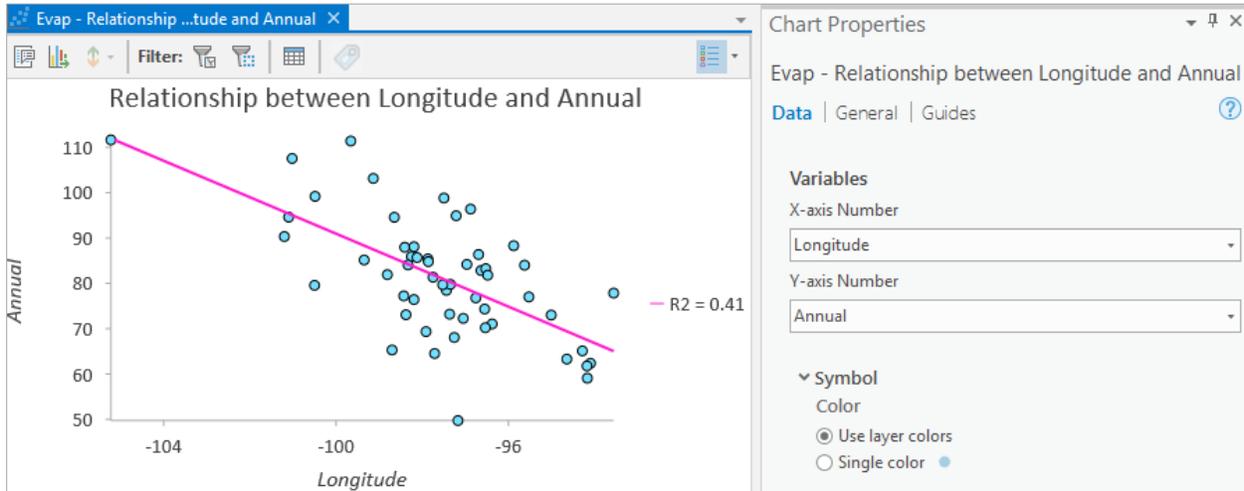
Use **Project/Save** to save your **Ex1Project** file.

7. Making a Chart

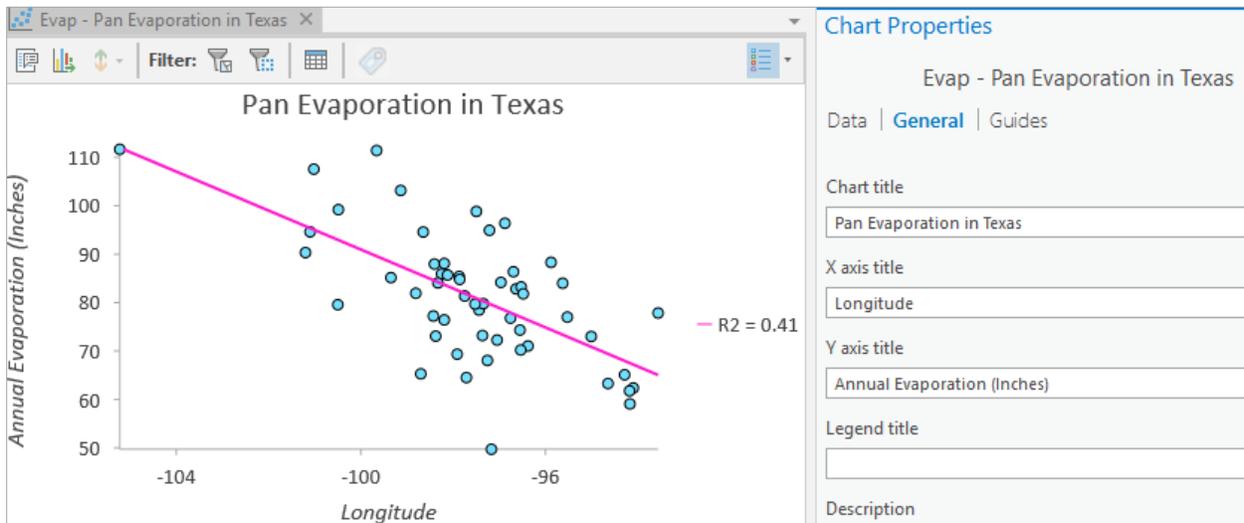
You can see from the map that there is some tendency for lower evaporation values near the coast and to the East and higher values to the West. Charts are useful because they allow you to visualize trends in data. Right-click on **Evap**, hover over **Create Chart**, and select **Scatter Plot**.



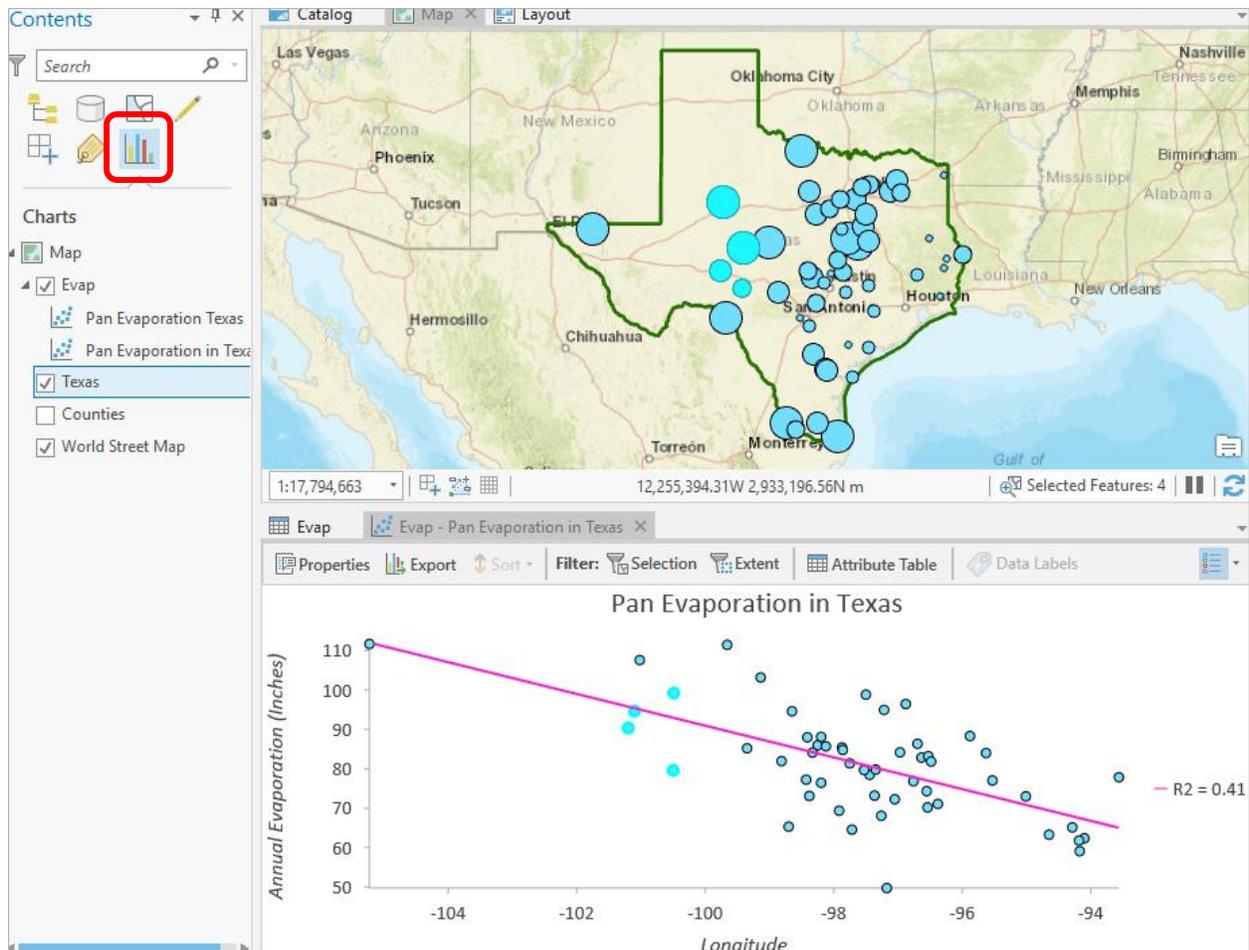
In the panel on the right select X-Axis Number as **Longitude** and Y-Axis Number as **Annual**. The results is a graph of the Annual Evaporation (**Annual**) of all the stations plotted against the **Longitude** of the station. You can see that there is a general trend of the evaporation increasing as you go from East to West in Texas. The color of the chart points is blue, the same as the map points.



Select the **General** option in the pane on the right and edit the chart properties to make them more descriptive. Change the title to **Pan Evaporation in Texas** and relabel the vertical axis **Annual Evaporation (Inches)**.



If you close your chart and later want to reopen it, you can click on the chart symbol in the Legend bar and a list of your charts will appear in the legend, along with the feature classes in your map. If you select points on the map they will also be selected as points on the chart, and vice versa. This is called "Painting" between applications. It's a nice capability to be able to relate charted data to the corresponding map locations.



If you switch back to the **Data** option in the Chart tab on the right hand panel, you'll see under Statistics, the equation of the trend line of the data is given.

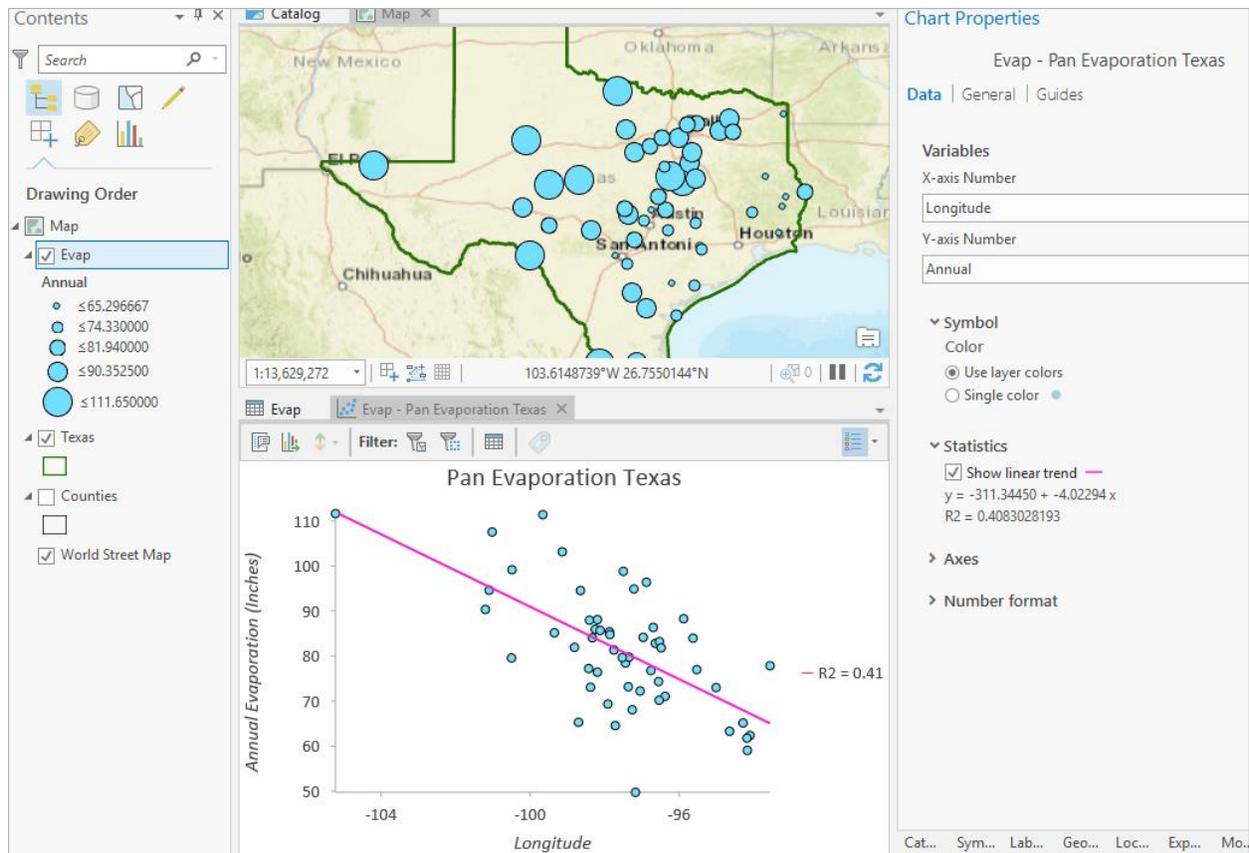
▼ **Statistics**

Show linear trend —

$y = -311.34450 + -4.02294 x$

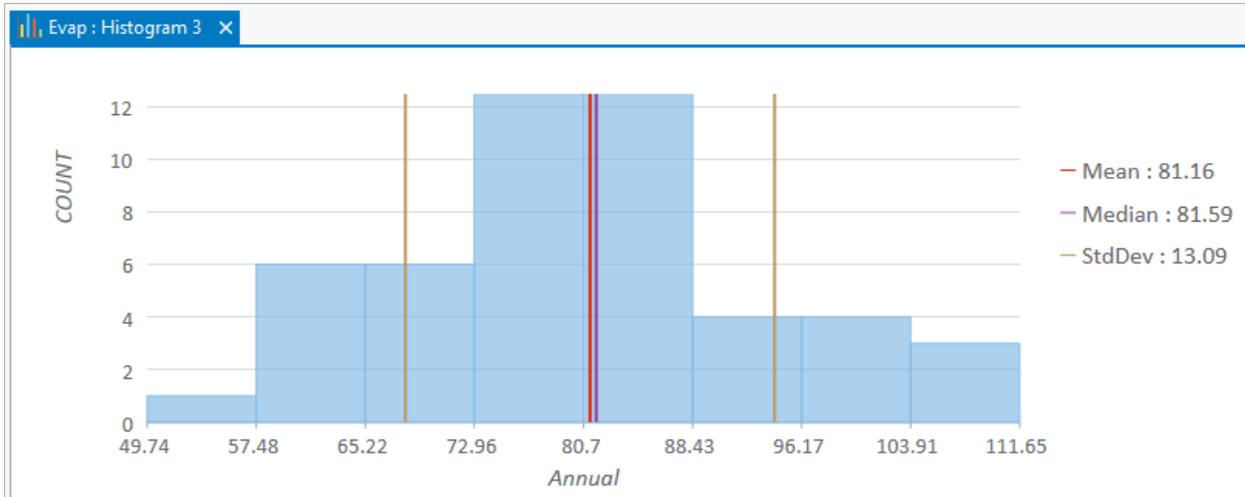
$R^2 = 0.4083028193$

In this case, the y value is the Annual Pan Evaporation in Inches, and the x value is the Longitude in Decimal Degrees. For example, for Austin, which is at approximately 98 °W, the pan evaporation estimate is computed as $Evaporation = -311.34 - 4.02294 * (-98) = 82.90$ inches. Notice that we have to use the fact that West Longitude is negative in this equation to get the right answer.

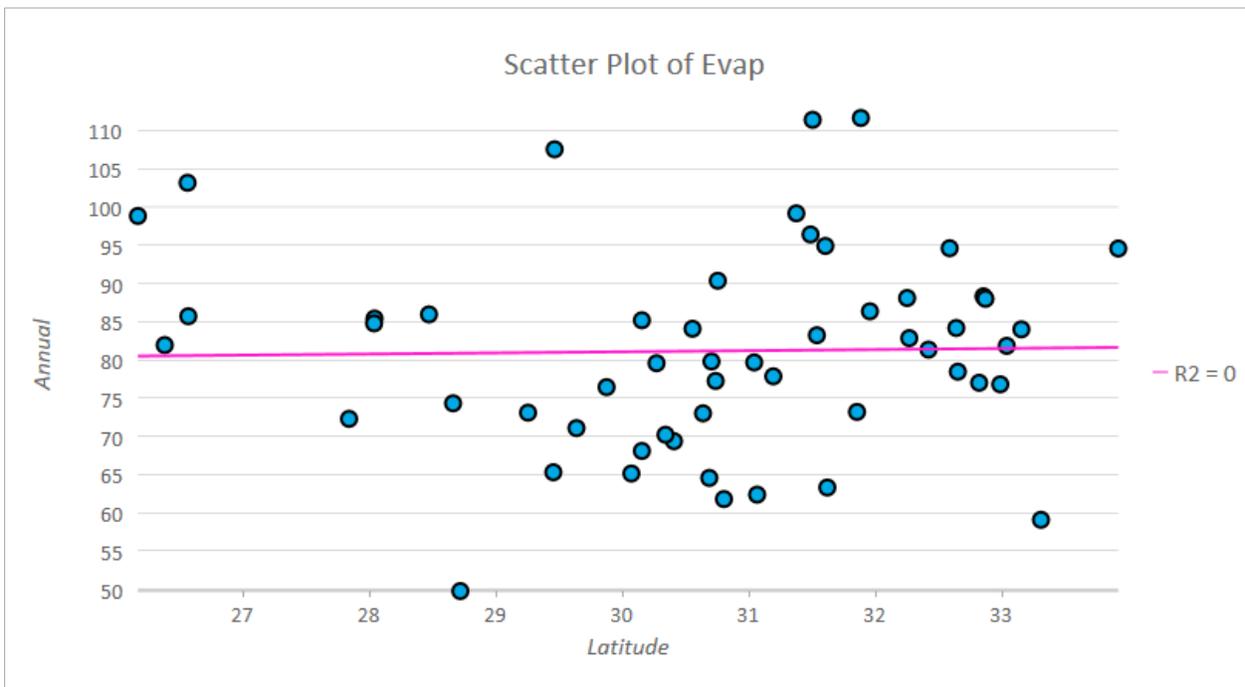


To be turned in: Use the values for Longitude of the most Western and most Eastern locations in Texas to make an estimate of Pan Evaporation at those locations. By how much does the expected pan evaporation increase as you go from East to West in Texas? Why is this so?

Try some different kinds of charts, such as Bar Charts and Histograms (using different options from the right click menu Create Chart in the table of contents layer in the left window). Note that ArcGIS Pro automatically sorts bar charts from highest to lowest from left to right. See <http://pro.arcgis.com/en/pro-app/help/analysis/geoprocessing/charts/bar-chart.htm> for more details. Here is a pretty cool histogram of the pan evaporation data, with statistical properties of the data as well.



If you create the same kind of graph for Evaporation and Latitude, you can see that there isn't a tendency for evaporation to vary with latitude in Texas, as there is for variation of evaporation with longitude.

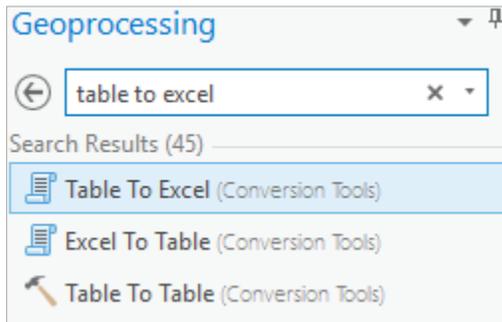


Notice how with some very simple charting steps, we've been able to get some interesting insight into the character of pan evaporation in Texas.

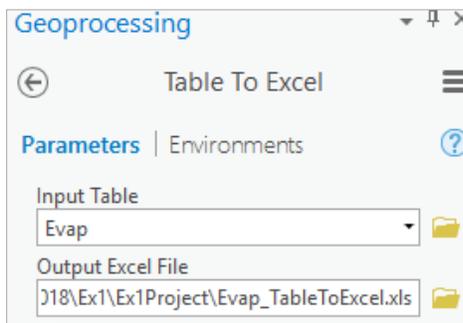
Use **Project/Save** to save your ArcGIS Pro document **Ex1Project** so that you can retain this display.

Graphing in Excel

Another option for charting is to do it in Excel. To do this we need to use Geoprocessing function called Table to Excel to create an Excel spreadsheet that from the Attribute table of the Evap feature class. Click **Geoprocessing** tab at the bottom of the right hand side panel, and type in the phrase “Table to Excel” in the Find tools box.

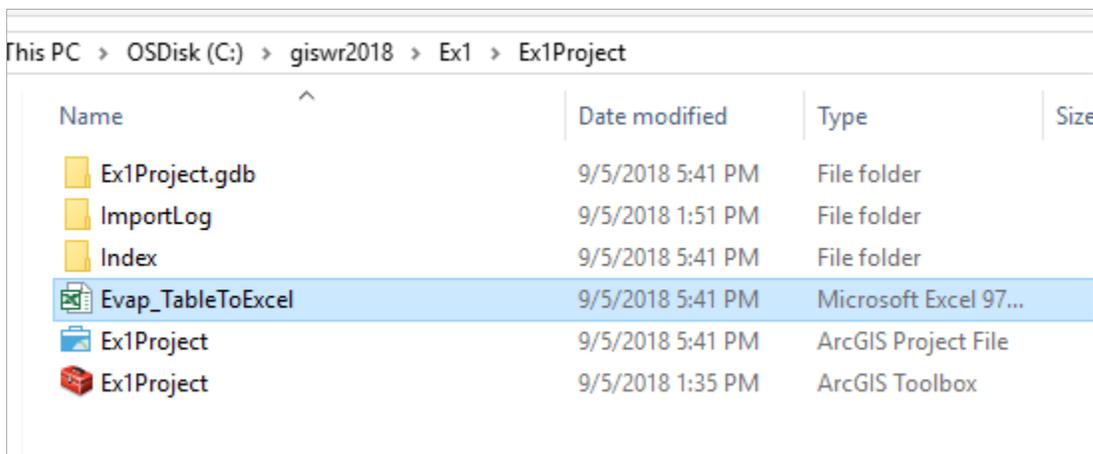


You will see a corresponding function appear as part of “Conversion Tools”. Select this function and choose the Evap table as the Input Table and just accept the default Output Excel File option.



Click Run.

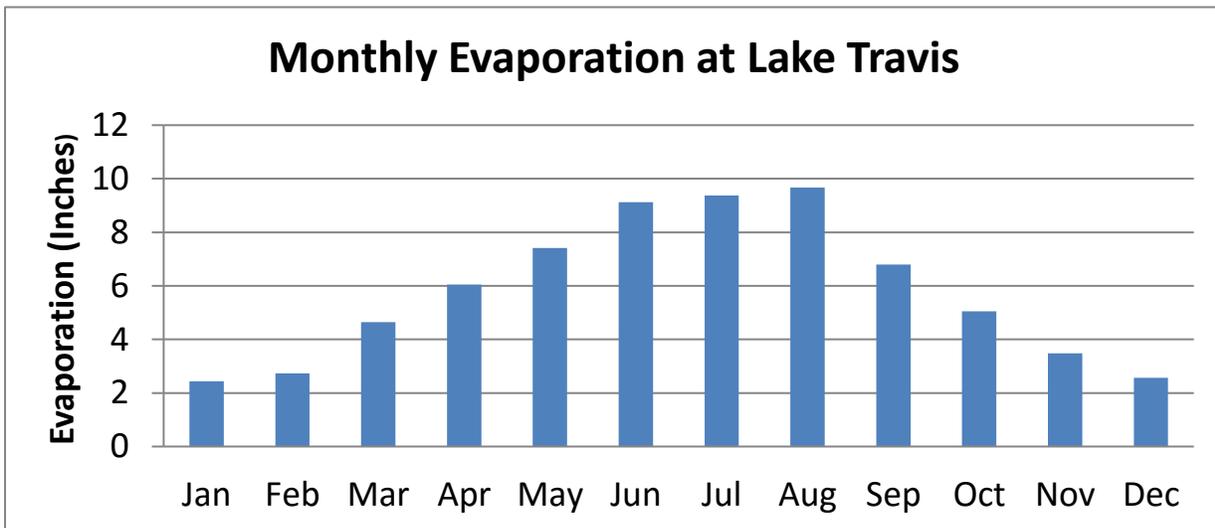
If you now go to the Ex1Project folder using Windows Explorer, you’ll see that the new Excel file is displayed along with your other project information.



Now the data are in the familiar Excel format and you can make whatever charts you want.

OBJECTID	Station	Latitude	Longitude	NumYear	FirstYear	FinalYear	Jan	Feb	Mar	Apr
1	1 AMISTAD DAM	29.46	-101.02	8	2001	2010	4.305	4.98875	7.73875	9.74
2	2 BARDWELL DAM	32.263	-96.637	5	2001	2008	4.076	3.47	5.64	7.0
3	3 BEAUMONT RESEARCH CT	30.0668	-94.2866	5	2001	2011	2.8	2.938	4.848	6.3
4	4 BENBROOK DAM	32.647	-97.443	6	2002	2008	3.783333	3.743333	5.96	6.9533
5	5 BRAUNIG LAKE	29.25	-98.38	7	2001	2010	2.83	2.962857	4.674286	6.2542
6	6 BUCHANAN DAM	30.733	-98.43	5	2007	2011	2.682	3.51	5.774	7.2
7	7 CANYON DAM	29.87	-98.196	9	2001	2011	3.192222	3.353333	5.173333	6.
8	8 CHOKE CANYON DAM	28.467	-98.252	10	2001	2011	3.269	3.989	6.158	7.7
9	9 COLETO CREEK RESERVOIR	28.715	-97.174	8	2004	2011	2.4475	2.49875	3.83625	4.503
10	10 DELL CITY 5 SSW	31.88	-105.226667	6	2001	2009	4.026667	5.638333	10.501667	12.7
11	11 EAGLE LAKE	29.633	-96.38	7	2001	2011	2.912857	3.205714	4.98	6.8985
12	12 FALCON DAM	26.558	-99.137	6	2004	2011	3.876667	4.673333	7.6	9.6716
13	13 GEORGETOWN LAKE	30.683	-97.7168	5	2001	2009	2.878	2.85	4.022	5.
14	14 GRANGER DAM	30.7	-97.349	5	2001	2008	3.714	4.064	5.216	7.2
15	15 INGRAM	30.15	-99.35	8	2002	2011	3.13	4.175	6.41875	7.963
16	16 IOWA PARK	33.916	-98.65	5	2002	2009	3.624	4.626	7.136	8.8
17	17 JOE POOL LAKE	32.635333	-96.968667	3	2005	2008	3.29	3.68	5.936667	7.
18	18 LAKE BASTROP	30.15	-97.26	4	2001	2004	2.7875	2.7525	4.005	6.
19	19 LAKE FORK	32.816	-95.53	7	2002	2011	2.825714	3.48	5.494286	7.0585
20	20 LAKE GRANBURY	32.416	-97.75	8	2002	2011	3.05125	3.315	5.775	7.60
21	21 LAKE J.B. THOMAS	32.583	-101.1	3	2001	2009	2.996667	3.883333	6.596667	9.2033
22	22 LAKE LIMESTONE	31.533	-96.53	9	2002	2011	4.078889	4.113333	5.825556	7.4066
23	23 LAKE LIVINGSTON	30.633	-95.01	9	2002	2011	3.188889	3.576667	5.163333	6.8633
24	24 LAKE TAWAKONI	32.85	-95.88	4	2005	2011	2.6125	2.92	5.695	7.71

For example, here is a nice chart of the monthly distribution of pan evaporation at Lake Travis.

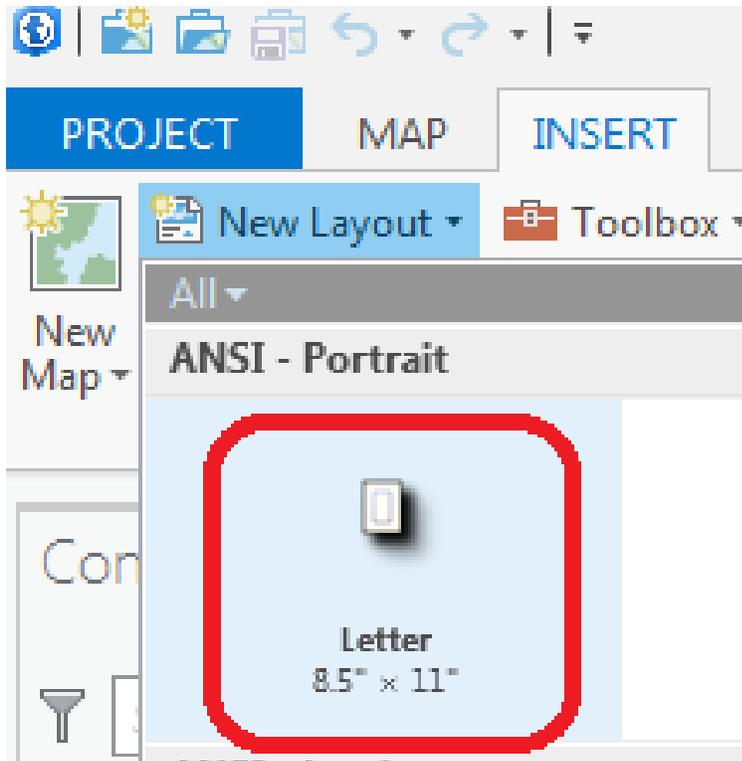


To be turned in: Prepare a chart of the monthly distribution of pan evaporation at one of the evaporation sites. What is the ratio between the pan evaporation in the largest month compared to the smallest month?

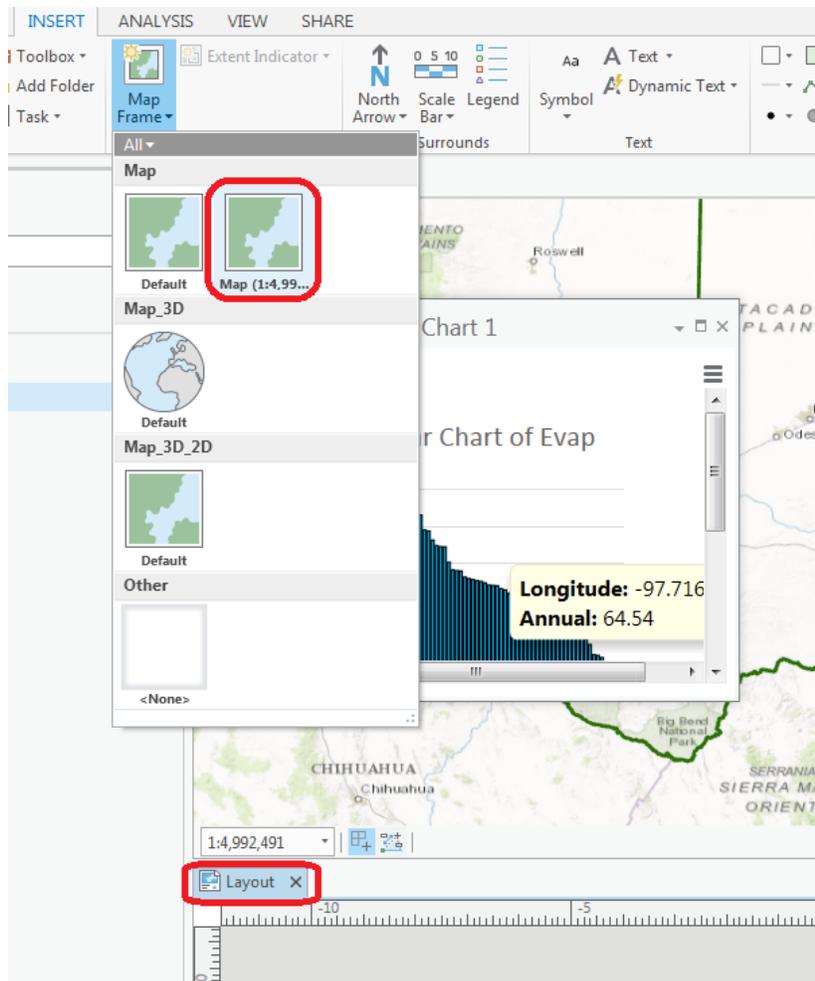
8. Making a Map Layout

Now we are going to create a formal map of evaporation in Texas that includes the charts that we've created.

Under the *Insert* tab, select **New Layout** and pick the "Letter" layout.

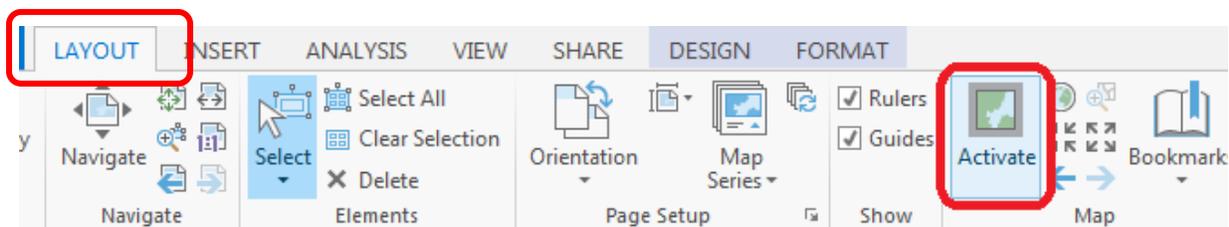


You should now see the layout frame on the bottom portion of the screen. Add a Map Frame to your layout by making sure the Layout is selected and then going to *Insert*, Map Frame/Map (the name of your current map).

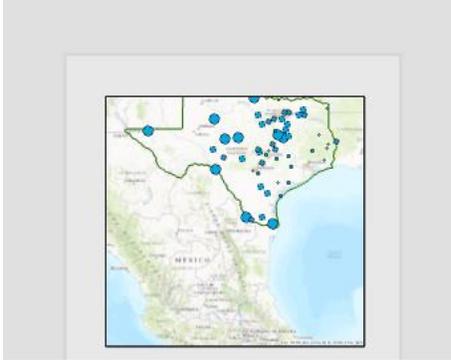


Reduce the size of the data frame in the layout (i.e., rectangle where the spatial data is contained) -- to make room for the graph -- by clicking on the map and moving its handlers.

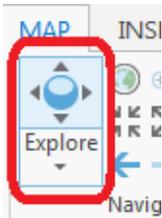
Now, in order to center your map within the map data reference, first select **Layout**, then click **Activate**.



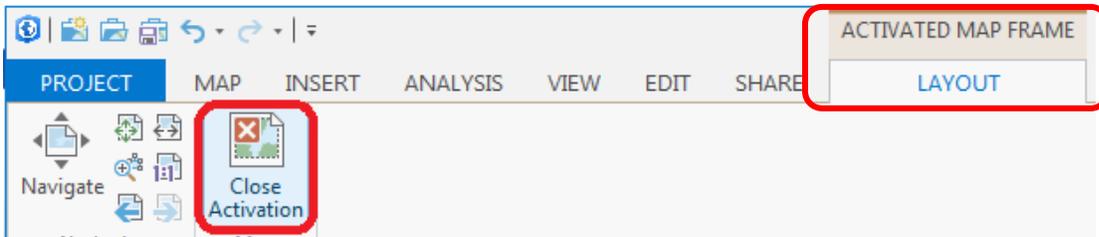
Once **Activate** has been clicked, the **Layout** display region should have a faded paper background as shown in the following image.



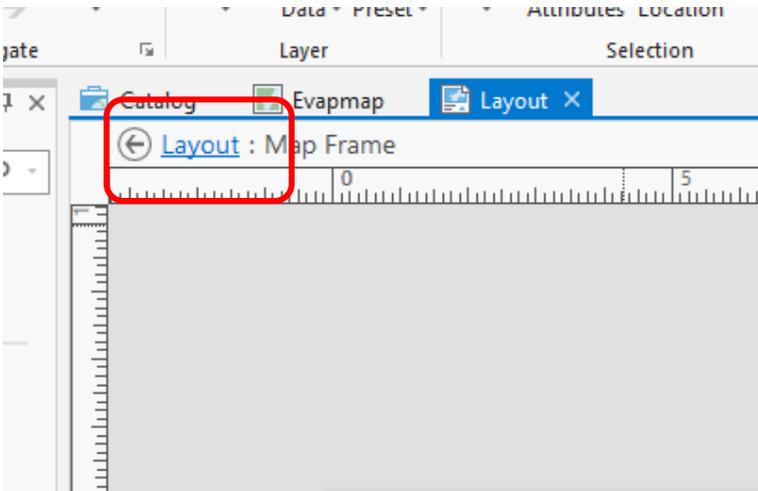
Next, select the **Explore** key and pan/zoom over the map until it is centered over Texas at the scale you want.



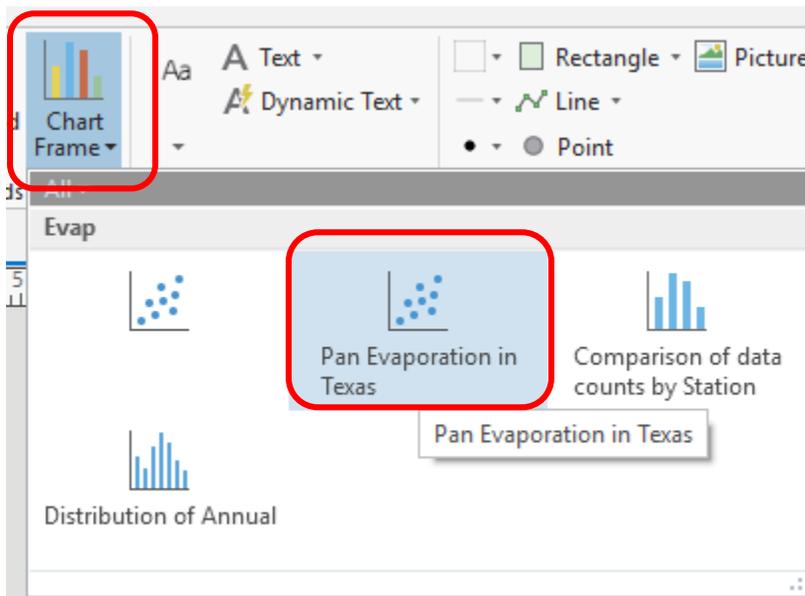
When you are finished adjusting the map, go to *Layout* and select **Close Activation**.



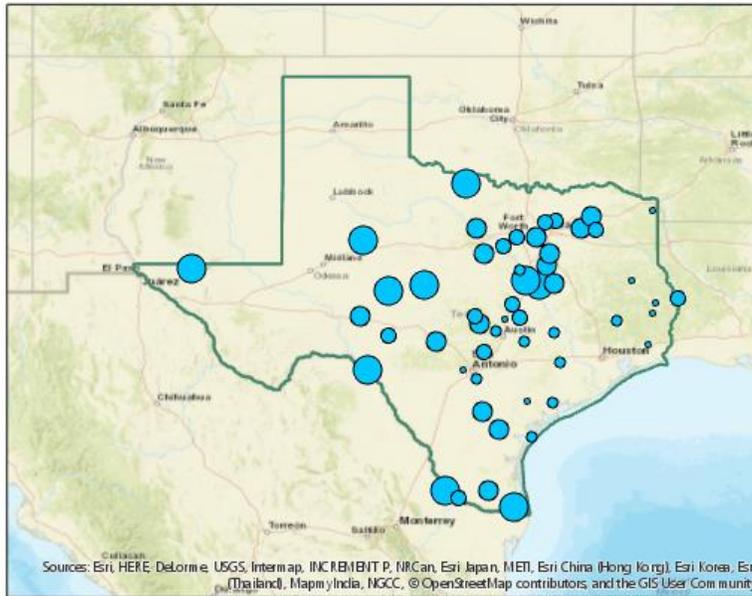
You can also, while the map is activated, click on the back to Layout link to close activation



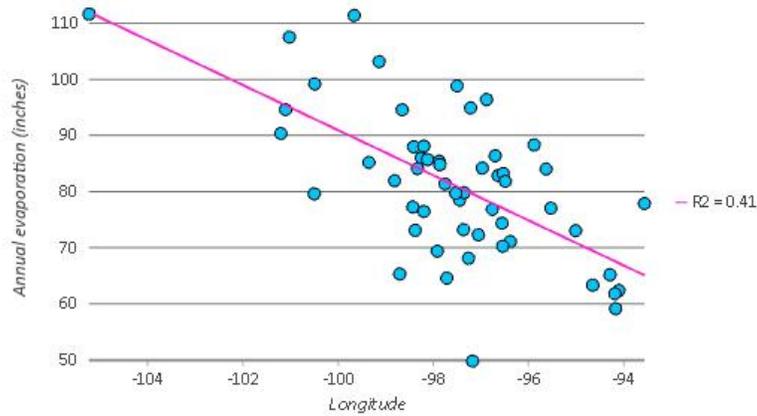
Now we would like to add a chart to the layout, in the empty space below the map. Click on Chart Frame and select the Pan Evaporation in Texas Chart



The chart should appear in your layout. Drag it to below the map and size it how you like. The map is shown below in ArcGIS Pro with the chart below it. It may seem as if some of your lines have disappeared in the chart image but that is just because of the scale of the display.

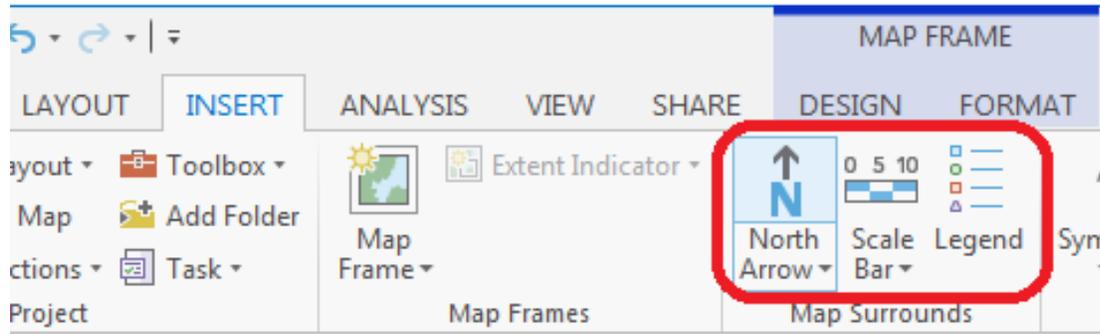


Pan Evaporation in Texas



Keep saving your ArcGIS Pro document as you proceed through the map making steps so that if you mess up something you can get back the work you've already done.

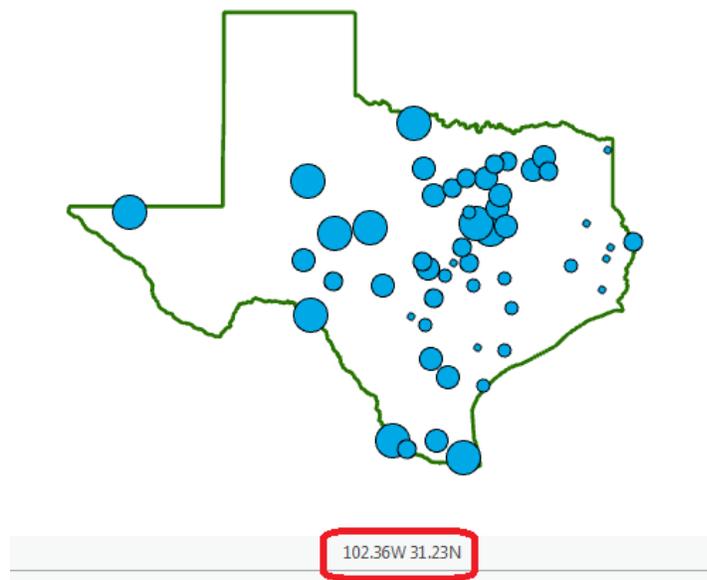
You can also insert a **North Arrow** and a **Scale Bar** under the *Insert* tab.



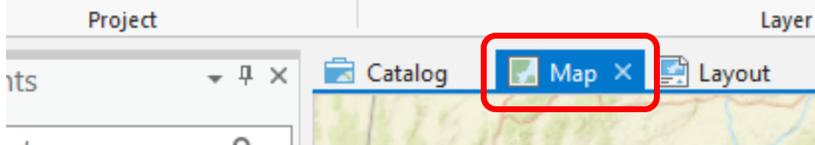
When you put up the scale bar you can select the distance units to be displayed. I have used miles.



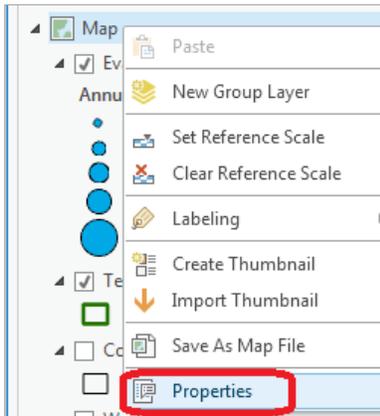
Note that if you look at the bottom right of ArcMap in Data View you see coordinates in Longitude and Latitude. This is an indication that the map is being displayed using geographic coordinates. It is not strictly correct to use a length scale when data is displayed in geographic coordinates as lengths are different in the North-South and East-West directions. You will learn more about this in future classes.



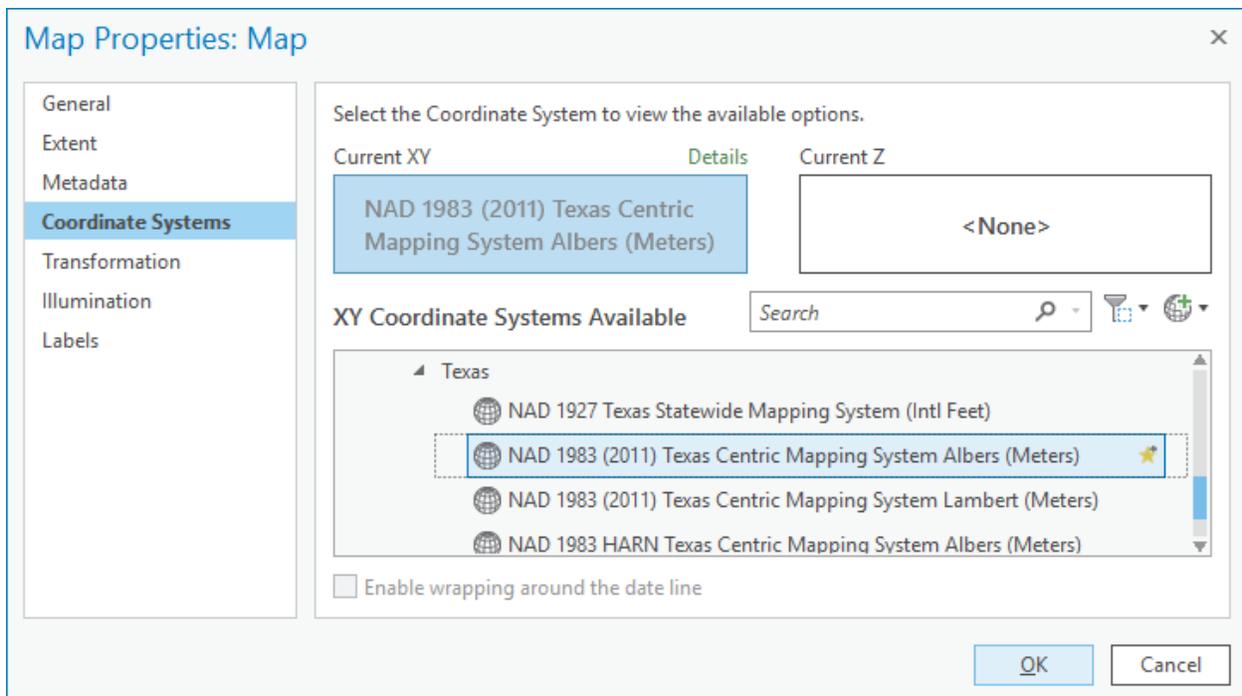
To change the coordinate system, switch to the Project Map tab at the top of the map display area,



Right-click on the **Map** entry in the table of contents and select properties.

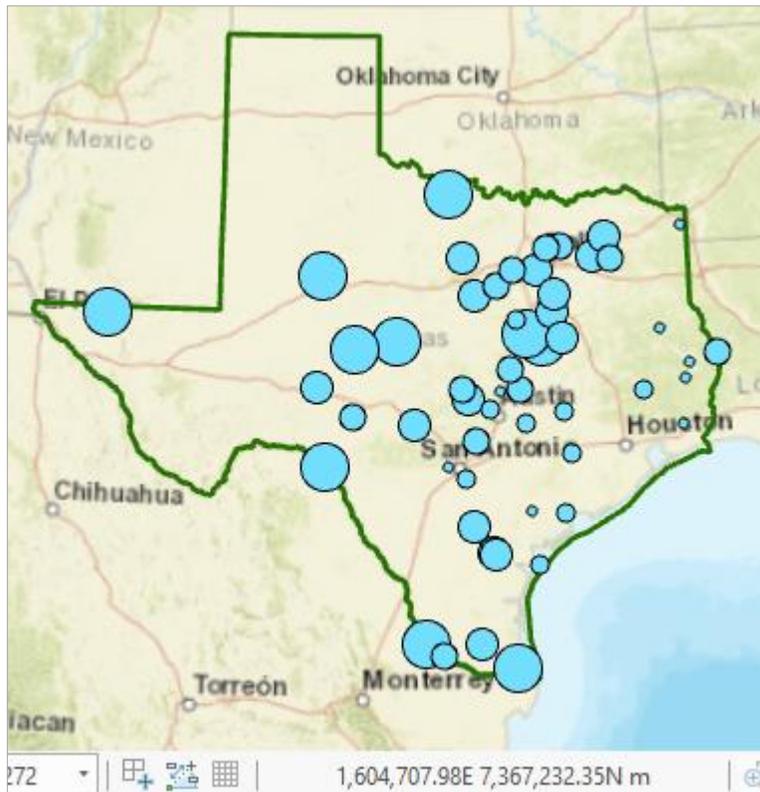
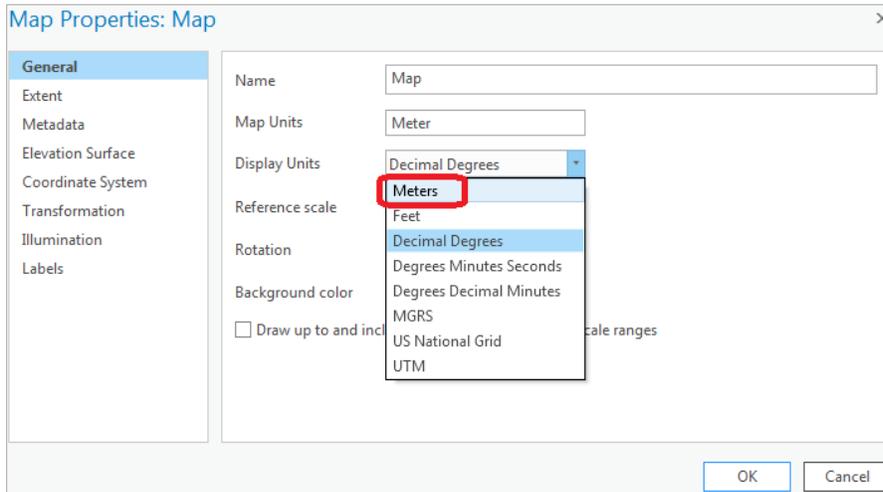


Map is the name of the **Data Frame** used to display information in ArcGIS Pro. In **Map Properties** click on **Coordinate System** and navigate to **Projected Coordinate Systems -> State Systems -> Texas -> NAD 1983 Texas Centric Mapping System Albers (Meters)**. Click OK.



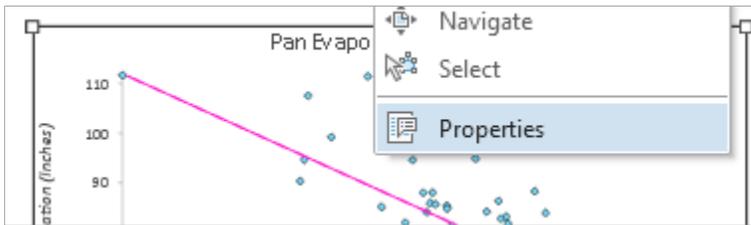
Note that for this exercise it does not really matter which coordinate system we select, but we need a projected coordinate system so that the scale bar is correct. Note that the display of Texas is adjusted according to the new projection.

To change the display units, select the **General** tab in the **Map Properties** and change “Display Units” from Decimal Degrees to Meters.

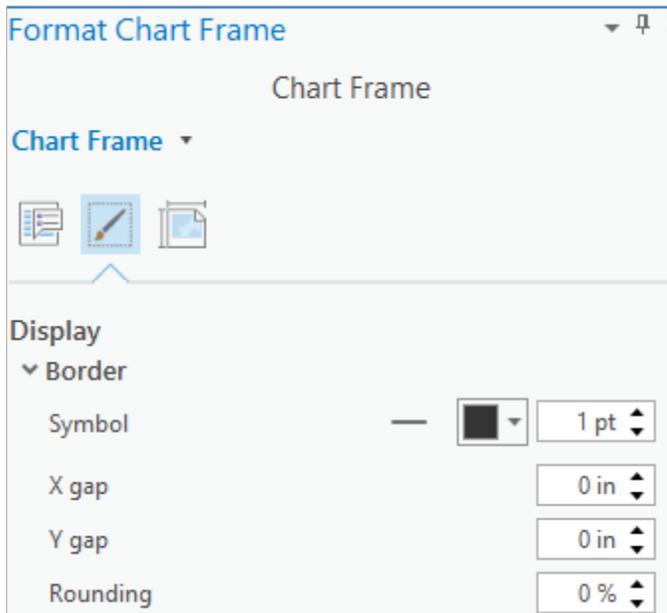


The above map shows corrected display units as well as a Texas map corrected to a more appropriate coordinate system (note the slight tilt). These are called **Easting (E)** and **Northing (N)** units and are in meters, instead of Longitude and Latitude as we had before.

Right click on the Chart and select Properties

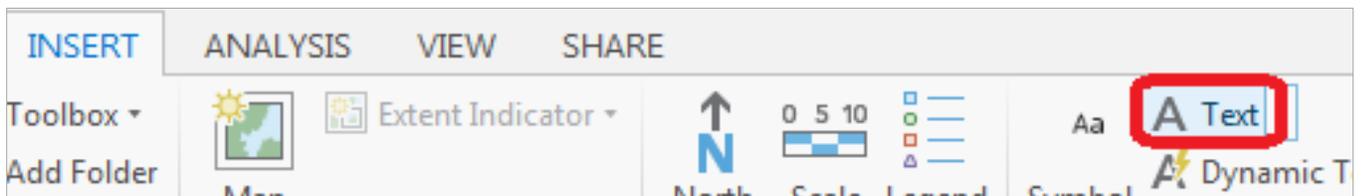


Then in the Display tab with the little pen, choose a grey color for the Border Symbol and 1pt as its width. Now you'll see your chart with nice border around it.



Save your Project so you make sure you don't lose your work to this point.

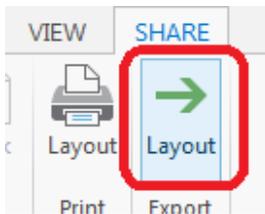
Switch back to Layout and select **Text** from the *Insert* tab to insert a Title.



Type the text you would like for your title, and resize the window to automatically resize the font size. Add a second title including your name and the date.



You can export your map from ArcGIS Pro using by clicking **Layout** in the “Export” section under the *Share* tab. You have the choice of many export formats (PDF, TIFF, JPG etc.). You can also control the resolution. Here use the TIFF option so that you have a detailed graphic image. You can store this file as **Ex1.tif** in your data file.

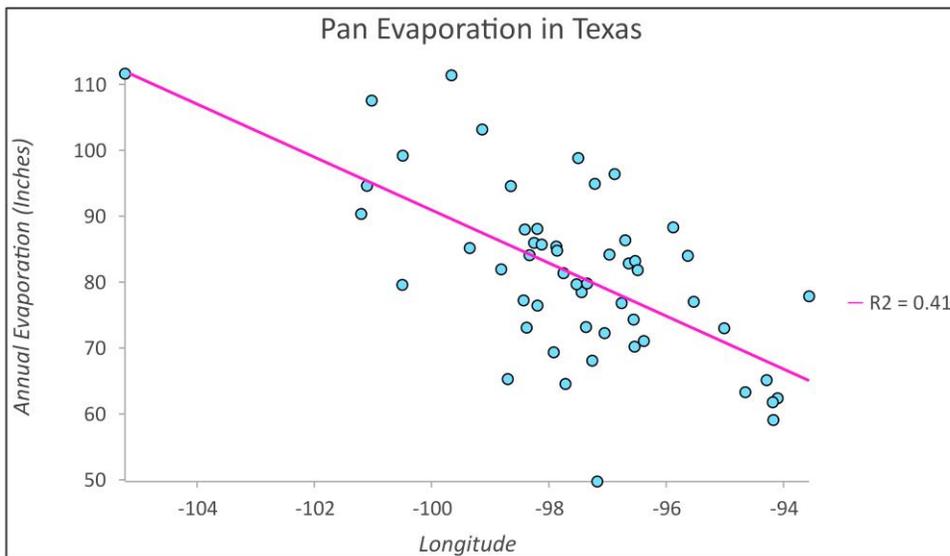
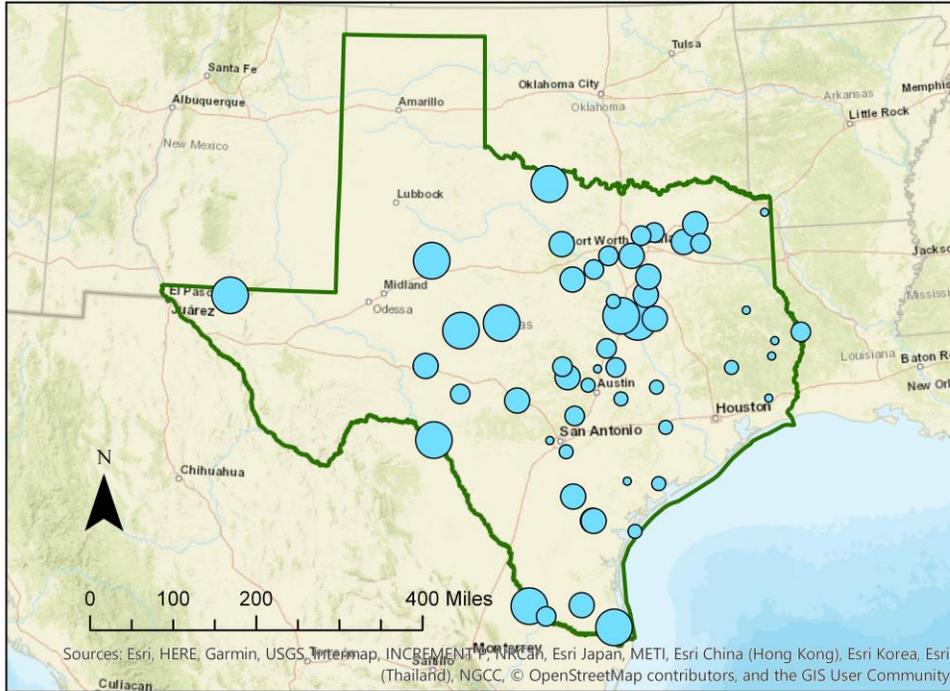


Then you can add it to a Word document using **Insert/Picture** and loading this **.tif** file. This preserves the crisp resolution of the ArcMap display in a word document.

Here is the resulting completed map and chart combination. This has been inserted into this Word document by loading the .tif graphic file that you just created. This is a good way of including maps and layouts from ArcGIS Pro in your Word document for a homework exercise.

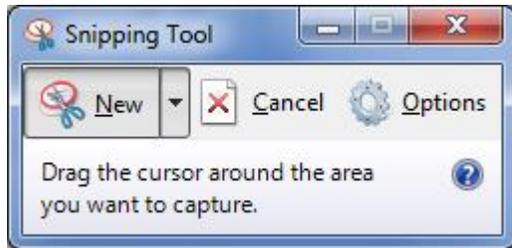
Pan Evaporation in Texas

David R. Maidment, 5 Sept 2018



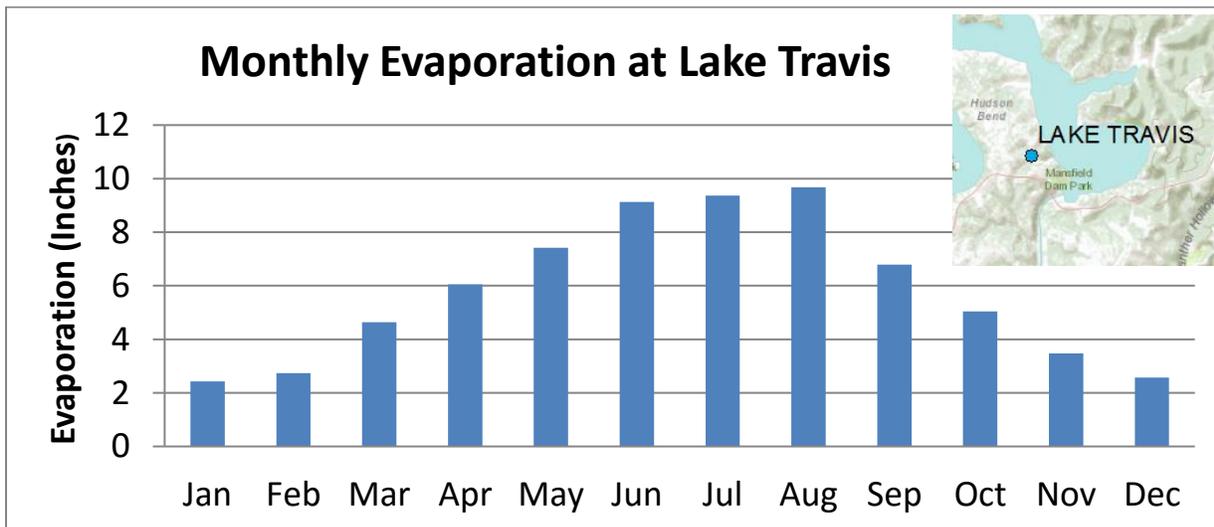
Helpful Tip:

A simpler procedure is to simply copy the screen to the clipboard and crop out the part that you want, saving it to a file for later use. That is how all the images in this exercise were prepared. To copy any image, use the Snipping Tool in **All Programs/Accessories** on your Windows Desktop interface



Drag the cursor around the area that you want to capture and you'll see it copied into a new display, then use **Paste** to insert this snippet into a specific location in your document. If you only want to capture the active frame, press **Alt + Print Screen** and then Paste it to the new document. With this approach you do not have as much control over the resolution of the image, but this approach is a lot easier if you do not require publication quality graphics.

This approach can also be used to add a map to a chart in Excel:



The manipulations just described transfer objects from one application to another.

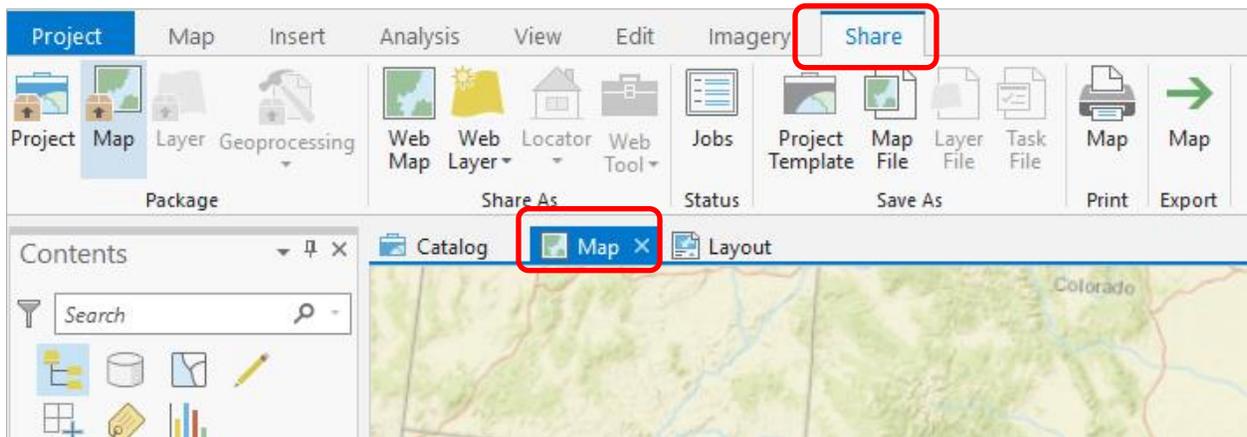
To be turned in: Prepare an ArcMap map layout in it showing a map of Texas with gages, coupled with a graph showing monthly evaporation data plotted from the gages. In the presentation of information on maps and charts it is important to include sufficient labeling detail so that the information can be clearly and unambiguously interpreted. You should include a scale bar to indicate distance, a north arrow to indicate direction and labels or legends with units wherever they are needed to interpret map or quantitative values.

9. Sharing a Map Online

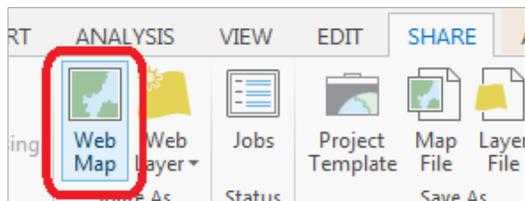
Now, let's suppose that you would like to share your map with your colleagues. This can be done with ArcGIS Online by using the ArcGIS Pro interface. Before creating an online map, you'll want to make sure you're still logged in to ArcGIS Online in your ArcGIS Pro instance (check the upper right-hand corner of the screen).



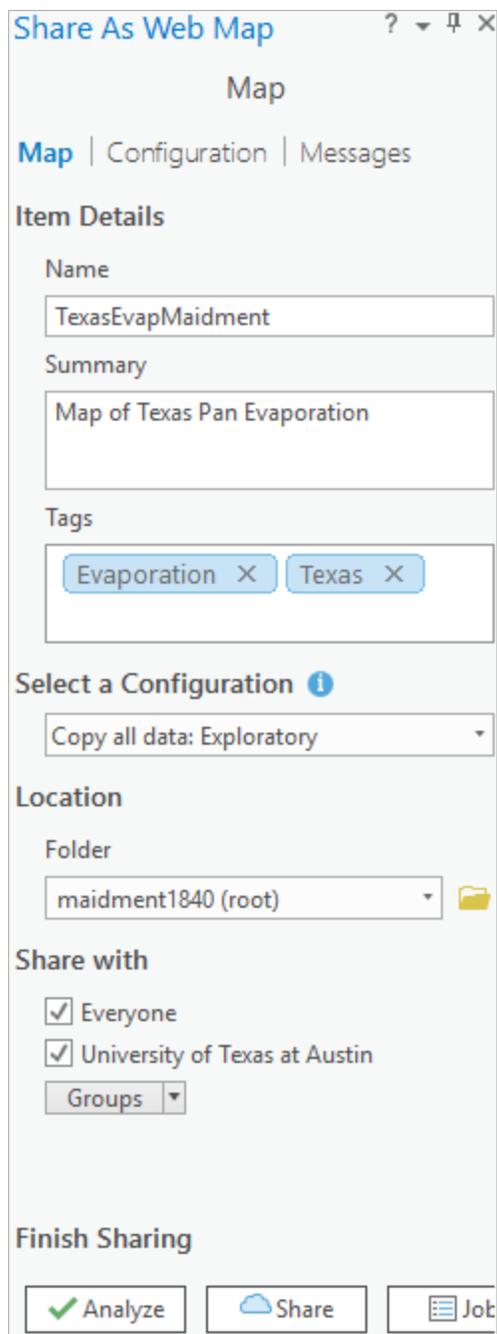
After you're sure you're logged in, go to your Map and the *Share* tab.



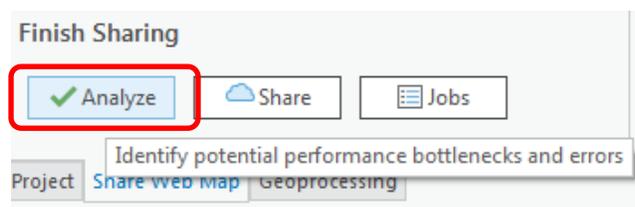
Select **Web Map**.



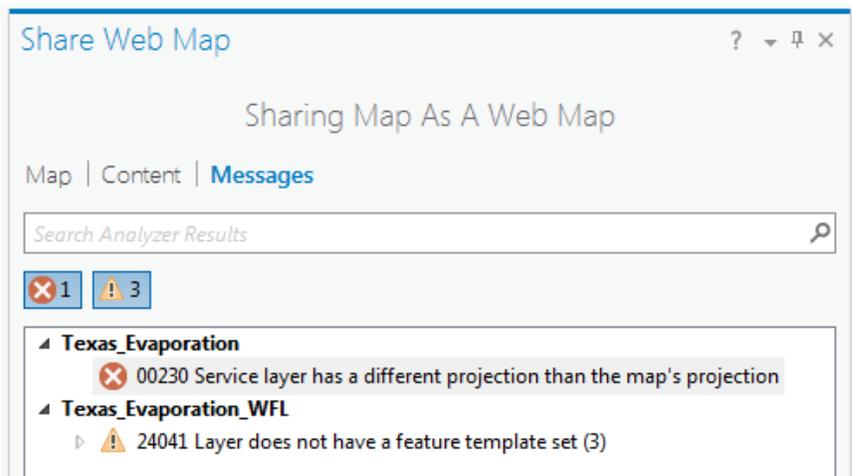
A sidebar will appear on the right where you will be able to give your map a **Name, Item Description, and Tags**. Note that the name cannot hold spaces. Fill out these sections, and select your University under *Sharing Options*. This will enable all other group users to have access to your shared Web Map!



Before sharing your map, click **Analyze** to check that your map has all criterion required for publishing.

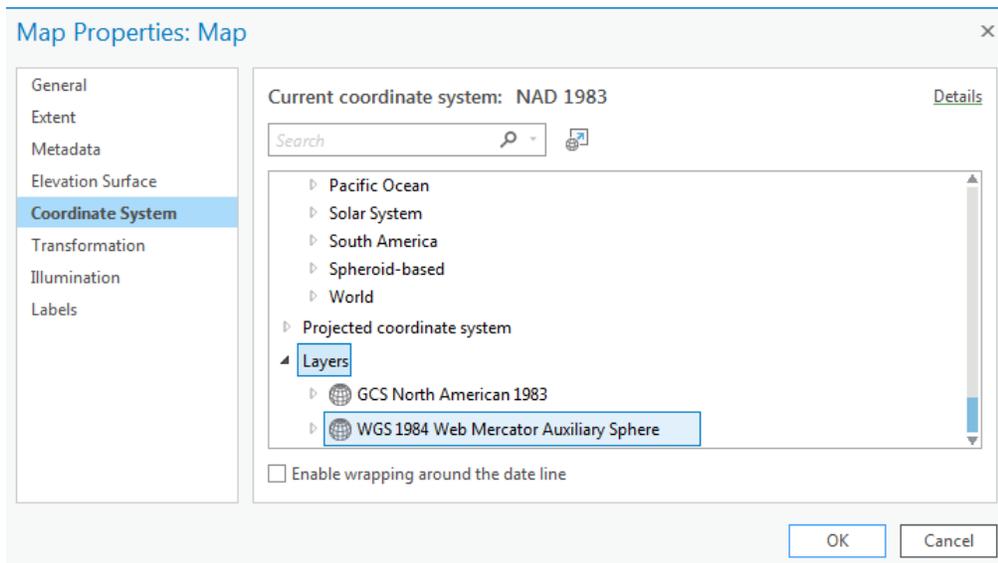


You should receive an error that looks like this:



Remember when you previously changed the map's coordinate system to **NAD 1983 (2011) Texas Centric Mapping System Albers (Meters)**? Regrettably, this new coordinate system is different than the coordinate system for the basemap you are currently using (all basemaps use the **WGS 1984** global coordinate system). Hence the service layer (the basemap using **WGS 1984**) has a different projection than the map's projection (which you changed to **NAD 1983**).

A basemap is required for sharing a webmap, and the ArcGIS Pro basemaps cannot be changed from **WGS 1984**; therefore, all maps must be changed to this global projection before publishing online. To change the map projection, go to map properties, scroll to the bottom and expand "layers" (this shows all projections that currently exist in any of the map's layers), and select **WGS 1984 Web Mercator Auxiliary Sphere**. Now **Analyze** your map again for webmap sharing.



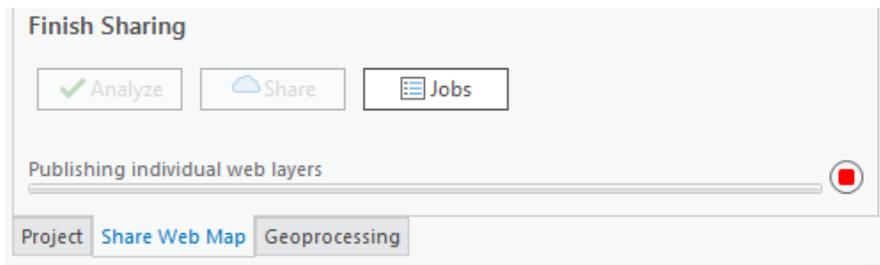
I ignored warnings about Layers not having a feature template set after reading Help on this (found using Google) that one solution is to Do nothing and have a default feature template created.

<http://pro.arcgis.com/en/pro-app/help/sharing/analyzer-warning-messages/24041-layer-does-not-have-a-feature-template-set.htm>

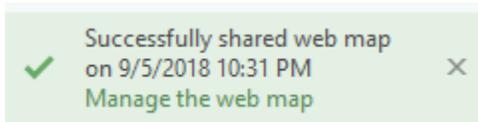
Now that your error is gone, click **Share** to create a web map from your ArcGIS Pro map.



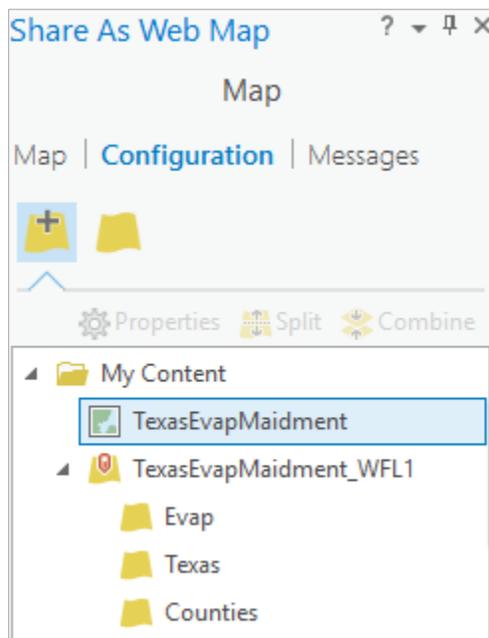
. Once you have selected **Share**, a loading screen should appear that looks like this:



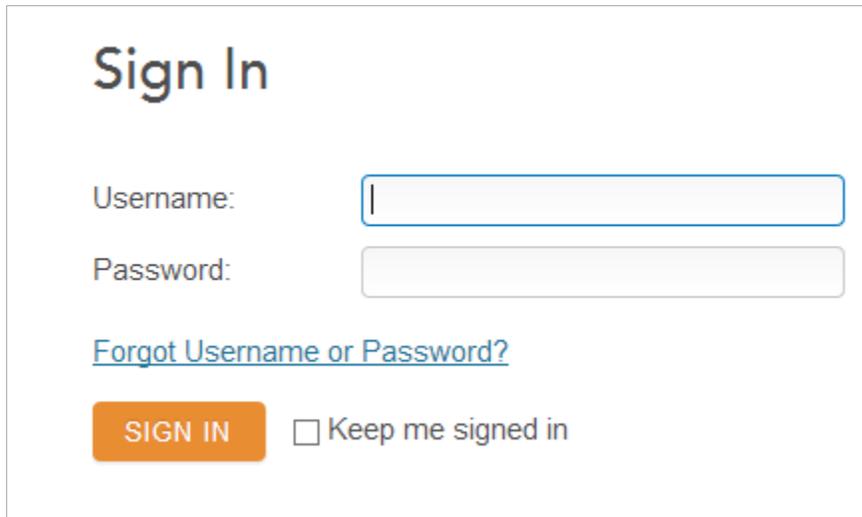
Once your web map has been successfully published you will receive a confirmation message.



You can also view your webmap in the *Configuration* tab within the **Sharing Web Map** pane.



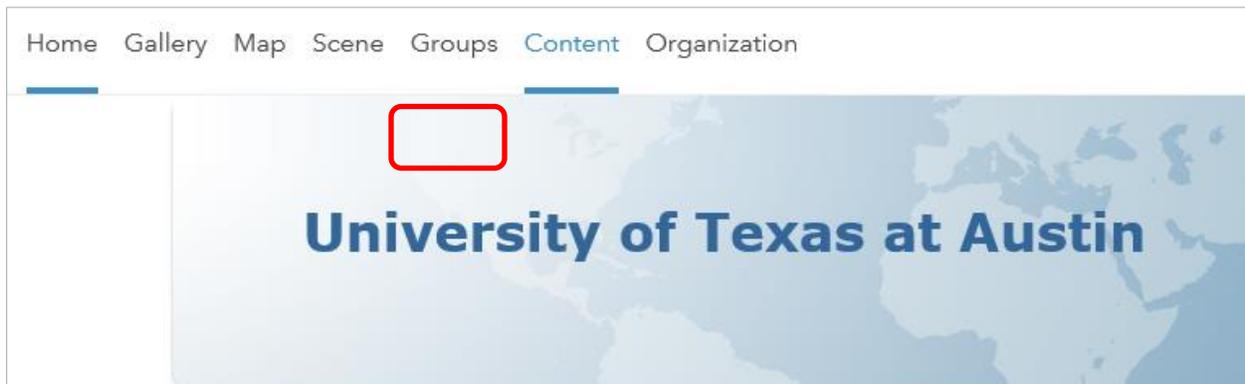
Following publishing, proceed to ArcGIS Online to view your webmap online. Go to <http://www.arcgis.com> and sign in with your ArcGIS Online Username and Password



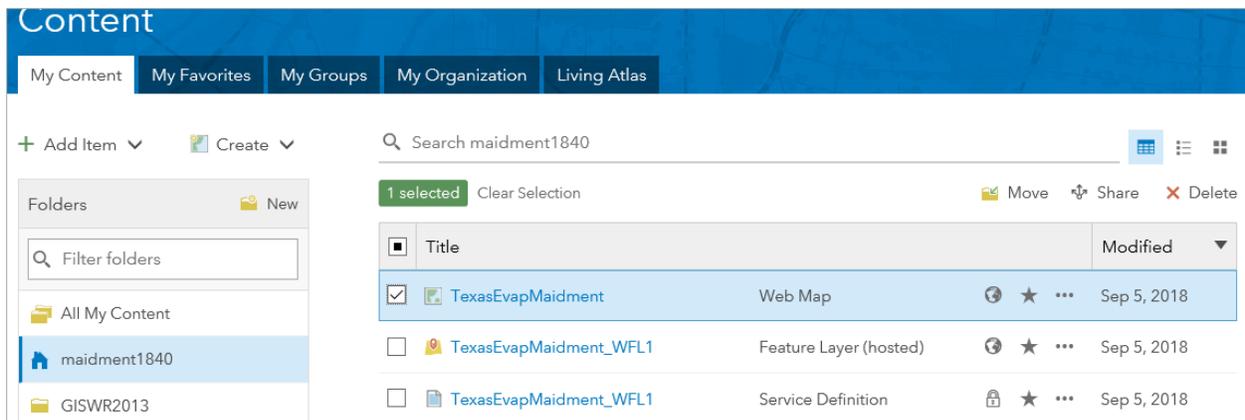
The image shows a 'Sign In' form with the following elements:

- Sign In** (Section Header)
- Username:** [Text Input Field]
- Password:** [Text Input Field]
- [Forgot Username or Password?](#) (Link)
- SIGN IN** (Button)
- Keep me signed in (Checkbox)

The landing page should look similar to the screen below. Click on **Content**



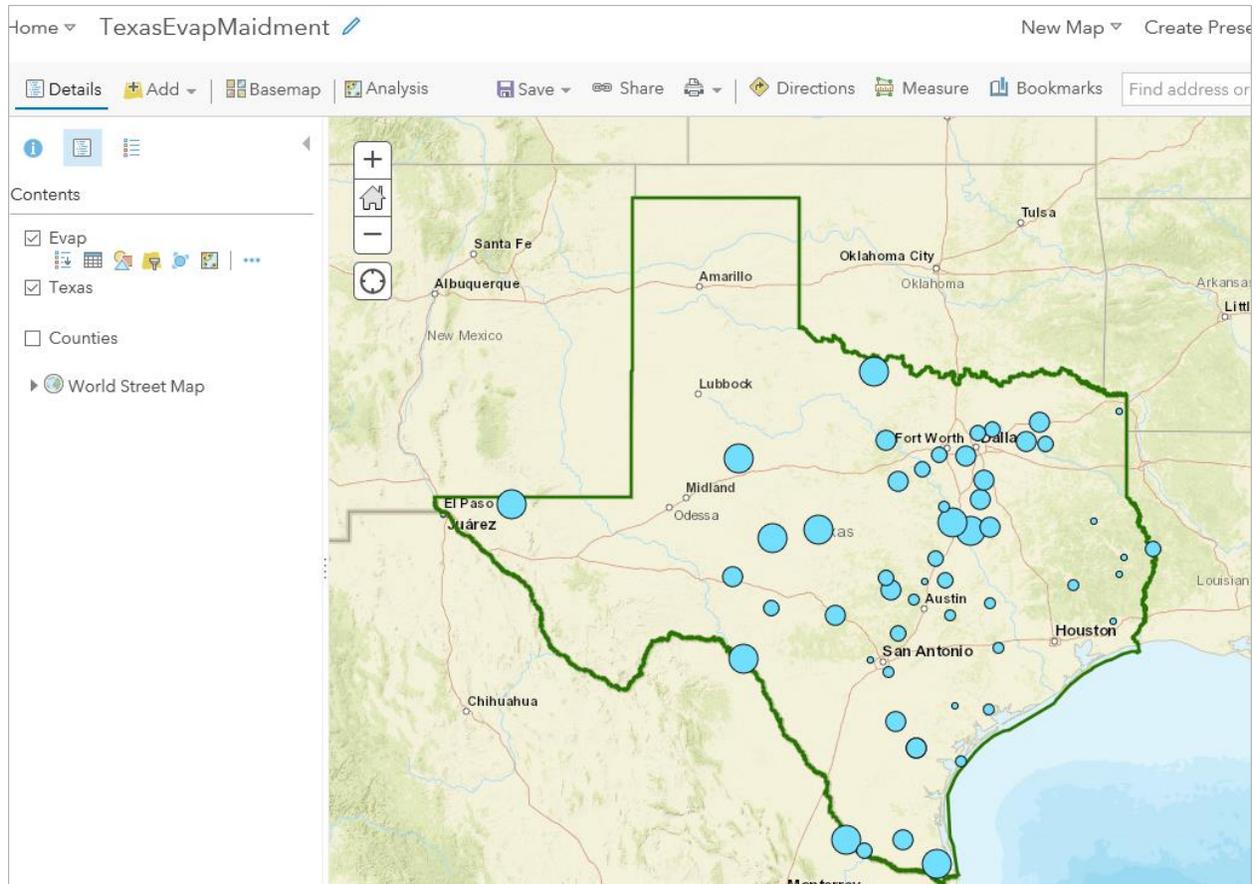
This opens a section where you can manage the content you have added to ArcGIS.com. Click on the Title link for the **Web Map** you just created.



Now select **Open in Map Viewer** from the screen that loaded. Note that this can be done one of two ways: by hovering over the map thumbnail on the left side of the screen, or by selecting the blue **Open in Map Viewer** button from the right side of the screen.



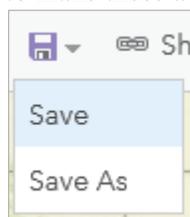
You should now see your ArcGIS Pro map displayed online on the World Wide Web for the people you have shared it with to have access to. Very cool!

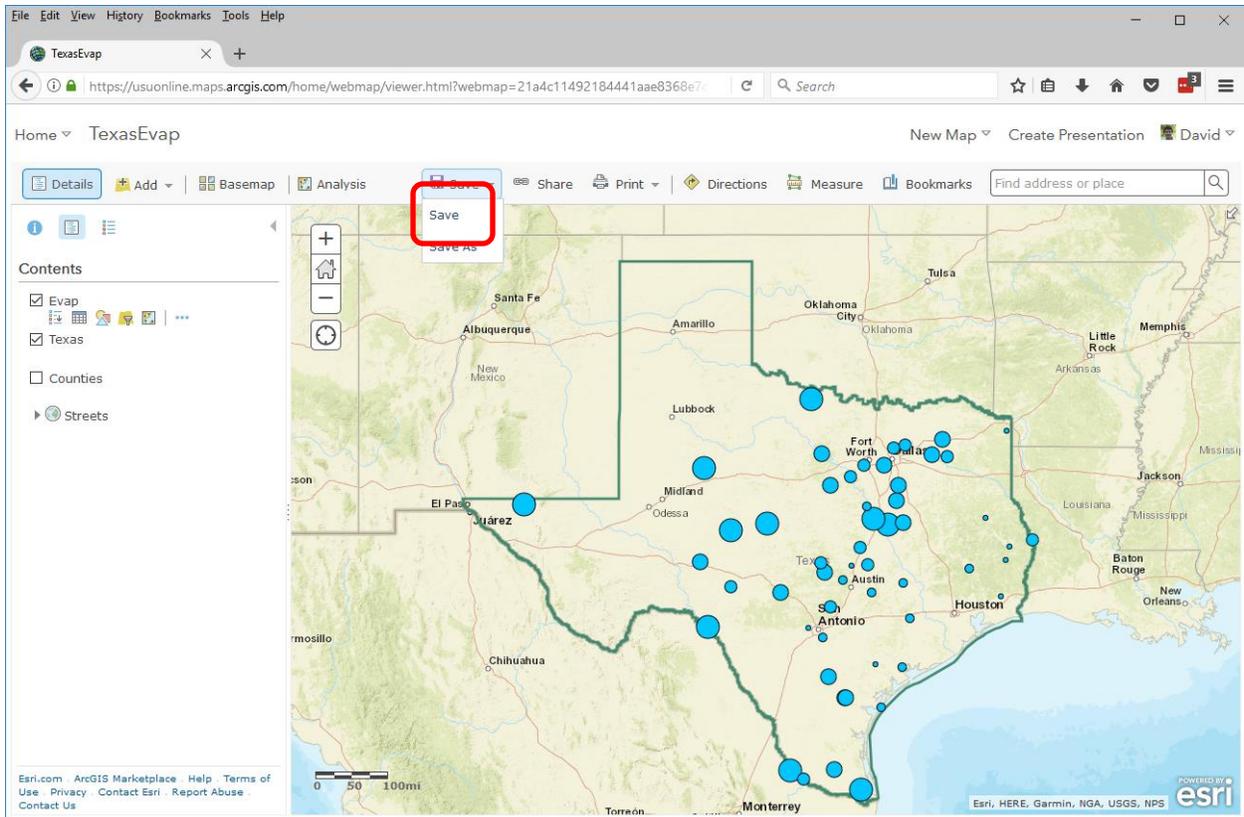


The online web mapping environment provides considerable GIS functionality, and is part of a general trend towards cloud based software (like Google Docs). It is conceivable in the future that a Desktop GIS may not be needed and you do everything in the Browser. At the current stage of development ArcGIS Pro and ArcGIS Online are closely aligned and interoperable.

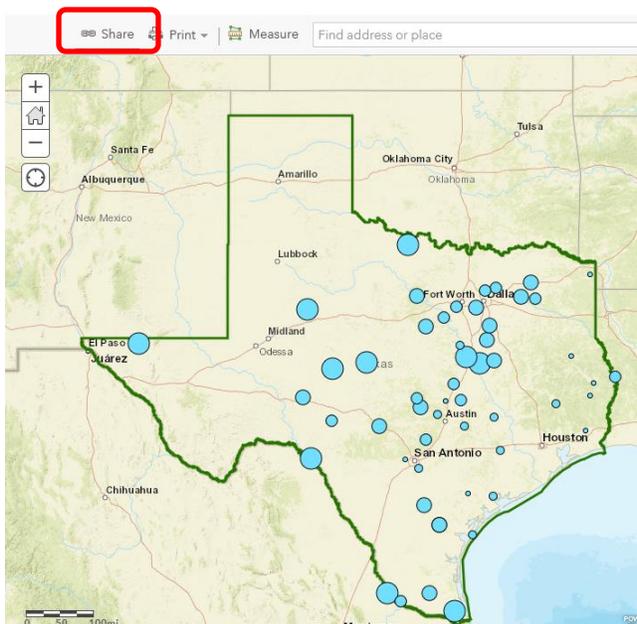
To illustrate some of this functionality, let's change the Basemap. Click **Basemap** and select **Streets** to set the Street basemap layer.

Once you are sure your basemap is as you want, click **Save** to save your webmap (otherwise you'll have to make these adjustments every time you open up your map).





Once you are finished, click on **Share** at the top of the screen.



In the pop-up screen that appears, copy the hyperlink and turn it in so that I can view it online.

Share

Choose who can view this map.

Your map is currently shared with these people.

Everyone (public)

University of Texas at Austin

Members of these groups:

Center for Research in Water Resources

CUAHSI

NRC Urban Flooding

Texas Drought

Texas Flood Response

World Water Online

Link to this map

Share current map extent

Embed this map

To be turned in: Provide the web link for your map so that I can view your map online. Your URL should be similar to the following: <https://arcg.is/1aaKGH> Be careful that there is no space at the end of the web address.

Summary of Items to be Turned In:

(1) Find the Latitude of the most Northern and Southern locations in Texas and the Longitude of the most Western and Eastern locations in Texas. What is the North-South extent in degrees of Latitude? What is the East-West extent in degrees of Longitude? Measured in Decimal Degrees, is Texas wider than it is taller or the other way around?

(2) Use the values for Longitude of the most Western and most Eastern locations in Texas to make an estimate of Pan Evaporation at those locations. By how much does the expected pan evaporation increase as you go from East to West in Texas? Why is this so?

(3) Prepare a chart of the monthly distribution of pan evaporation at one of the evaporation sites. What is the ratio between the pan evaporation in the largest month compared to the smallest month?

(4) Prepare an ArcMap map layout in it showing a map of Texas with evaporation gages, coupled with a graph showing evaporation data plotted from the gages. In the presentation of information on maps and charts it is important to include sufficient labeling detail so that the information can be clearly and unambiguously interpreted. You should include a scale bar to indicate distance, a north arrow to indicate direction and labels or legends with units wherever they are needed to interpret map or quantitative values. Let's see some nice cartography!!

(5) Provide the web link for your map so that I can view your map online. Your URL should be similar to the following: <https://arcg.is/1aaKGH> Be careful that there is no space at the end of the web address.

The assignment is due in a week from the date it was assigned in class.

*UT Austin: Please submit your solution **as a PDF document** through Canvas to assignment "Exercise 1".*

USU: Please submit your assignment as a single Microsoft word or PDF document in Canvas.