Geography 220 – Georeferencing & Editing

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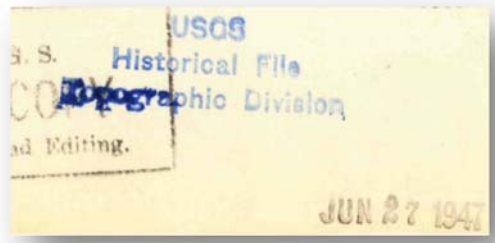
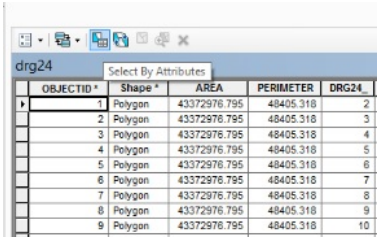


Georeferencing is the term we use for taking a digital image and fixing it to real world coordinates. We often think that most GIS information is stored on a server somewhere, but in reality it typically exists on a dusty sheet of paper, buried in a map drawer or file cabinet. To make maps and aerial images useable in ArcGIS we must first **digitize** them and then set them into their real world coordinates. You will get some experience with this today by georeferencing both a modern and historic topographic map for the area around Placerville, California.

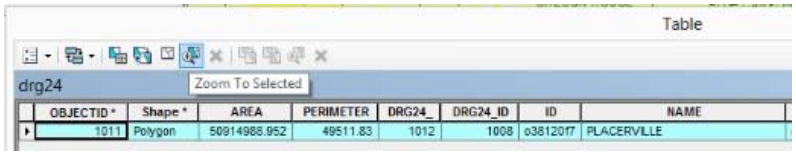
Open the *georeferencing.mxd* file in your *geog220_maps* folder. You will see two feature classes, "plss" shows the Public Land Survey System sections for the State of California. This system is used throughout most of the United States to divide land in a rational way. It is also a useful reference point when trying to place digital images. The other feature class, "drg24" represents the boundaries for all California USGS 1:24,000 quadrangles (topographic maps). To begin our georeferencing, we first need to zoom to our area of interest.

1. Right click on "drg24" in the table of contents window and open the attribute table.
2. Click Select by Attributes and write the necessary expression to select the map with the name "Placerville".



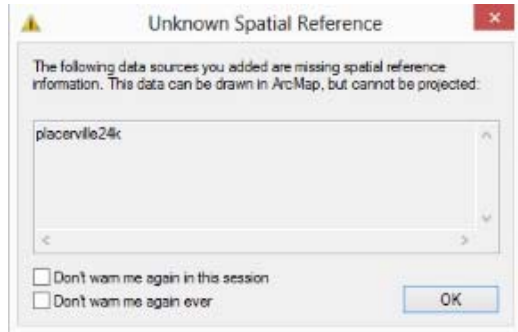
OBJECTID *	Shape *	AREA	PERIMETER	DRG24_
1	Polygon	43372976.795	48405.318	2
2	Polygon	43372976.795	48405.318	3
3	Polygon	43372976.795	48405.318	4
4	Polygon	43372976.795	48405.318	5
5	Polygon	43372976.795	48405.318	6
6	Polygon	43372976.795	48405.318	7
7	Polygon	43372976.795	48405.318	8
8	Polygon	43372976.795	48405.318	9
9	Polygon	43372976.795	48405.318	10

3. Click the Zoom to Selected button and close the table. This should take you right to where the Placerville map belongs.

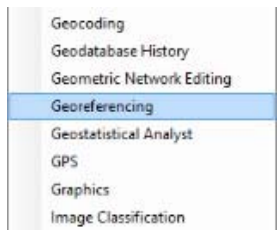


OBJECTID *	Shape *	AREA	PERIMETER	DRG24_	DRG24_ID	ID	NAME
1011	Polygon	50914988.952	49511.83	1012	1008	03812017	PLACERVILLE

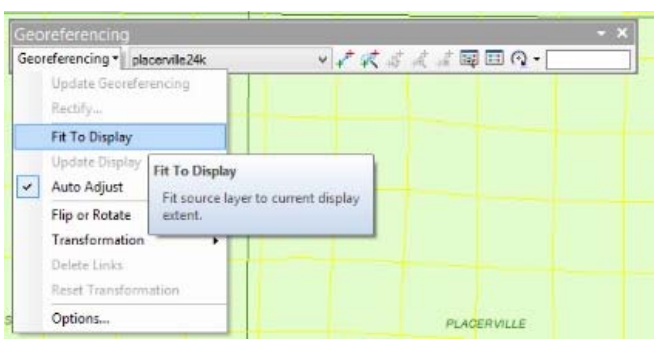
4. Now add the placerville24k raster image from geog220.gdb. You should get a warning about an "unknown spatial reference." Don't worry, that's what we are going to fix. Click "ok."



5. Right click at the top of ArcMap to pull up the toolbar menu and click "georeferencing."

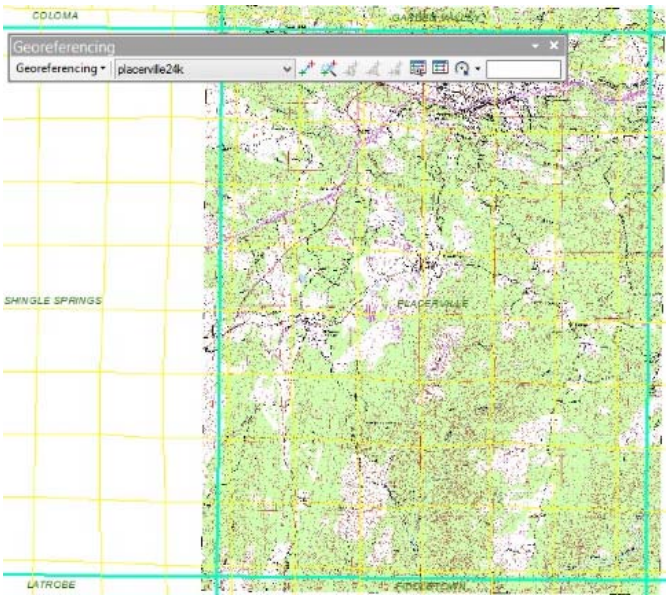


6. Click the dropdown arrow next to "georeferencing" and click fit to display. Because "placerville24k" is selected in the box to the right, ArcMap will draw the image in the current extents of your data frame.

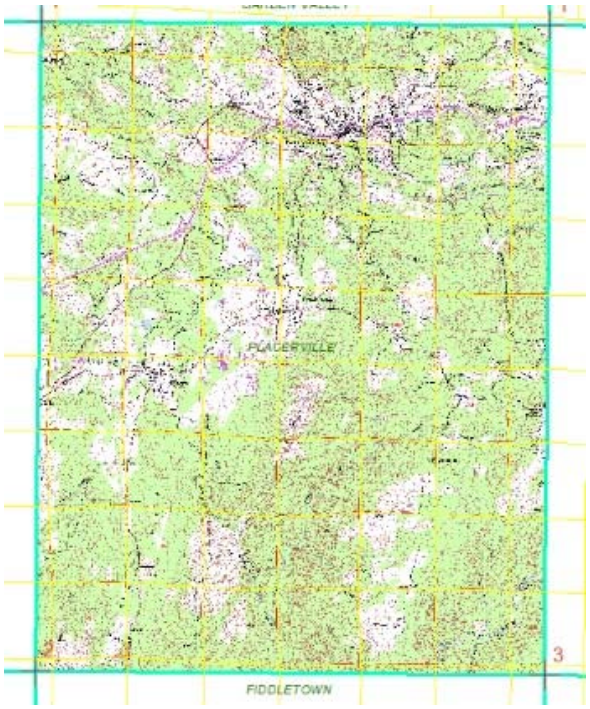


7. Because "placerville24k" is positioned underneath the "drg24" feature class, you cannot see it. Symbolize "drg24" with no fill color and a bright outline color and larger outline width so that it stands out from the map.

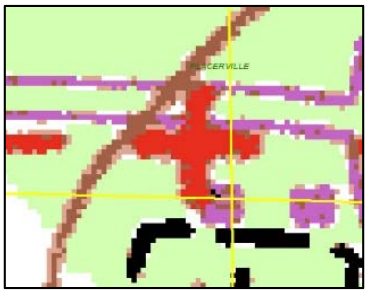
8. Zoom to the northeast corner of the map. Its northeast corner needs to be in the exact same location as the "drg24" corner. Click on the Add Control Points" button on the Georeferencing toolbar and left click once on placerville24k's northeast corner, then left click once on the corresponding northeast corner of the drg24 feature class. You should see the raster image move. You have just told ArcMap where that corner belongs in the real world.



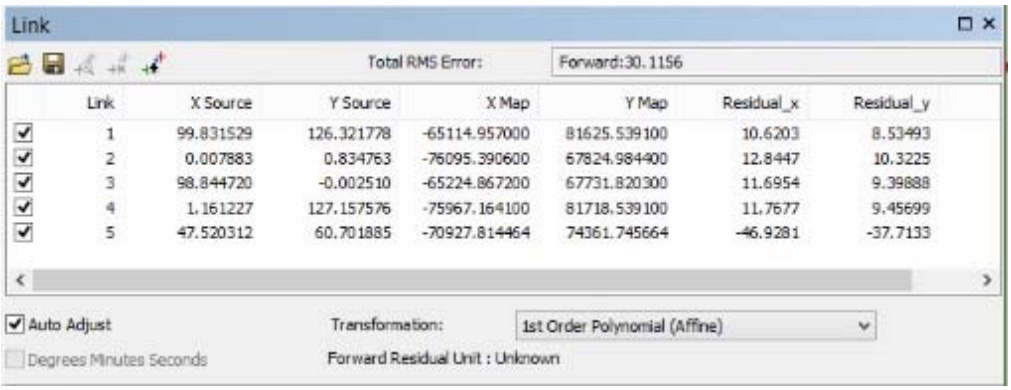
9. Zoom out and then zoom to each remaining corner and repeat the process. If the corner appears to be in the correct location, still add a control point to ensure ArcMap knows it actually belongs there. Clicking in the same spot three times accomplishes this. You should have control points for each of the four corners when you are done.



10. While the map looks pretty good, if you zoom in you can see the PLSS feature class and the red section lines on the map don't always match. This could be for several reasons (most likely the PLSS feature class isn't designed for this scale). Regardless, it would be nice for our different map layers to match.

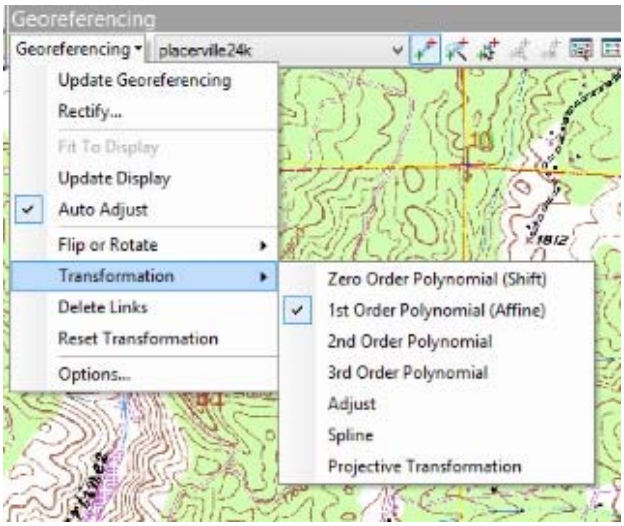


11. Begin zooming into the PLSS section corners and adjusting the map to the PLSS feature class. Add as many control points as you can and then zoom out to see the complete map. Open the "map link viewer" from the georeferencing toolbar. If you make a mistake you can select it from the list and delete the bad control point. Keep this window open, because we'll use it in a few more steps.



Link	X Source	Y Source	X Map	Y Map	Residual_x	Residual_y
1	99.831529	126.321778	-65114.957000	81625.539100	10.6203	8.53493
2	0.007883	0.834763	-76095.390600	67824.984400	12.8447	10.3225
3	98.844720	-0.002510	-65224.867200	67731.820300	11.6954	9.39888
4	1.161227	127.157576	-75967.164100	81718.539100	11.7677	9.45699
5	47.520312	60.701885	-70927.814464	74361.745664	-46.9281	-37.7133

12. Once you have created as many control points as possible, you still may see some locations where the raster image and the feature classes don't line up perfectly. You can fix this using one of the "transformations" found in the georeferencing toolbar.
    a. The "Shift" and "Affine" transformations work well with simple geometric shapes.
    b. The 2nd or 3rd order polynomial transformations are designed to really begin to tweak your raster by twisting and curving lines. These transformations require more control points to work; the options



will be grayed out if you haven't set enough.

c. The Adjust transformation is designed to maintain a compromise of global and local accuracy.
d. The Spline transformation is the classic "rubber sheeting" method of stretching the raster across control points as if it were made of rubber. Spline is a good choice if you know your control points are perfectly placed, because it forces the raster to fit them (which can cause distortion farther out from the points). Because the scale of our PLSS feature class is questionable, this would not be a good choice.
e. Projective Transformation is new to ArcGIS 10.2 and is designed for scanned maps, according to ArcGIS 10.2 Help.

13. Experiment with the different transformations to see what happens. While you do so, pay attention to the total RMS error value in the Map Link Viewer window. RMS stands for Root Mean Square, and shows the difference between where you clicked to place a control point and where the control point actually wound up. The idea is that a lower RMS error means a more accurate georeferencing job, but some critical thinking should be used to interpret this number. After all, it is only as good as the control points you give it…
14. Once you have your Placerville map exactly as you want it, click Update Georeferencing from the toolbar. This will save your work and make sure that in the future the raster is drawn exactly where it should be.

Our next map to georeference is an historic map of Placerville from 1893. Historic maps like this can be a wonderful asset when conducting historic or even prehistoric work. Unfortunately, our map doesn't have any PLSS information, nor does it match our drg24 feature class. So we have a great resource without much to help us place it.

15. Add the placerville_1893 raster to ArcMap. You can use the same MXD file from above.
16. Make sure it is selected in the georeferencing toolbar and click "Fit To Display."

17. Zoom to one of the corners, you should see a latitude and longitude coordinate. These coordinates are all we have to go on in terms of where to place this map.
18. We don't have a feature class representing latitude and longitude lines, but can we can improvise. We will now make a table that we can use to generate points for georeferencing. Open the Windows program Notepad.exe or a similar simple text editor.
19. In Notepad, type the following:

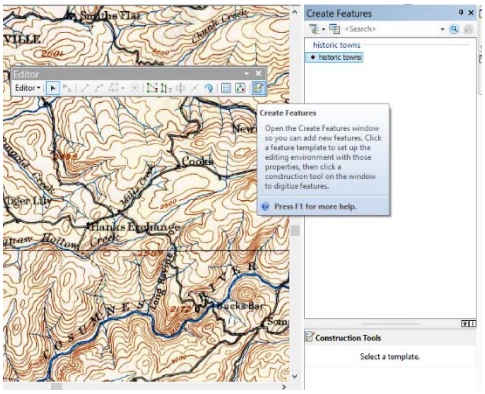
```
x,y
-120.5, 38.5
-120.67, 38.5
-120.83, 38.5
-121, 38.5
-121, 38.67
-121, 38.83
-121, 39
-120.5, 39
-120.67, 39
-120.83, 39
-120.5, 38.67
-120.5, 38.83
```

20. Click save and call the file "pville_points.txt". You have just created a simple table to generate twelve points to use in our georeferencing.
    a. The **negative numbers** indicate that these longitude values are west of the Prime Meridian, while the **positive numbers** indicate that these latitude values are north of the Equator. They are crucial to this table.
    b. We could have created a table in a program like Excel, but that can sometimes create headaches when working with ArcGIS. When making a simple table like this, a simple program is your best choice.
21. Add the "pville_points.txt" table into ArcMap. Right click it and select "Display x,y data." The x and y fields will populate automatically, but make sure you select edit under "Coordinate System of Input Coordinates" and choose the geographic coordinate system "NAD 1927" (while the map is older than this datum, the USGS recommends using it). Ignore the error it gives you.
22. Right click on "pville_points.txt Events" in the Table of Contents and click "Zoom to Layer."
23. You now have twelve points to which you can georeference your historic map. Repeat the process from above to place the map exactly where it belongs.

Creating a new feature class

You have two georeferenced maps, but the next cool step is to create new vector data based on the map information. A scanned map gives you a nice picture, but it is a static object. By creating a new feature class based off of the map data, we can have a dynamic version of the information.

24. In ArcCatalog, navigate to the geog220 geodatabase. Right click on the "georeference" feature dataset, select "new" and "feature class."
25. In the window, type "hist_towns" for name, "historic towns" for alias, and select "point features" under type. Click next, leave the "default" selected and click next again. In the next window, add a new field called "name" and make it a text field with a length of 75 characters. Click finish.
26. This new feature class will be added to your Table of Contents. Right click on it and select Edit Features → Start Editing.
27. Add the editor toolbar if it isn't already visible in ArcMap and click on the Create Features on the end of the bar. Select the "historic towns" feature at the top, and then the point option under Construction Tools. This will change your cursor and allow you to click wherever you would like to add a point.



28. Pan around the historic map and click anywhere there is a historic town or settlement. Open the attribute table after you place each point and type in the name of the town. When you are done, click the dropdown button on the Editor toolbar, click "save edits" and then "stop editing".

References

Allord, G.J., and Fishburn, K.A., 2011, Standards for scanned U.S. Geological Survey historical topographic quadrangle collection: U.S. Geological Survey Techniques and Methods, book 11, sec. B, chap. 3, 14 p.