Dr. Matthew Sisk
Office: Library 131
matthew.sisk@nd.edu

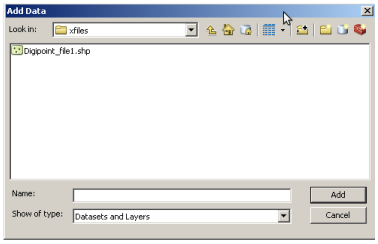
Georeferencing in ArcGIS

In this workshop, you will gain an understanding of the process of georeferencing. First, you will work with a scanned map of South Bend, which already has projection information but has not had this information digitally encoded in the image itself (i.e., georeferenced). Second, you will use this newly registered map to georeference an aerial photograph that does not have any associated information.

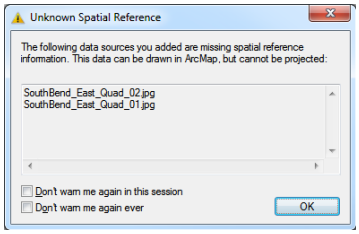
I. First, prepare the demonstration data

a. Download **GeoReferencing_DemoData.zip** from the CDS website and extract it into a temporary folder
   1. You can either double click on the file and drag the contents to the folder where you want it
   2. Or, right click on it and choose Extract.
   3. This should leave you with two image files

b. Load ArcMap though the start menu
   1. ArcGIS is a little weird about adding data. You first have to map a connection to the folder.
      i. First, you can Add Data directly from within ArcMap by clicking the button with a plus in a yellow diamond :
      ii. This will bring up the Add Data window.
      iii. In this window, click on the icon of a folder with a plus sign:
      iv. This will let you map to a particular folder that will then always be present in your folders list (unless, of course, you delete it).
      v. I would recommend choosing the root folder (something like H:\) and not the specific folder you put the data in. This will let you navigate more easily later.



c. Add the image **SouthBend_East_Quad.jpg**
   1. You will get a warning about the lack of coordinate system. This is normal as this is a simple digital scan of a map. Our job now is to tell the computer what area of the world this image covers.



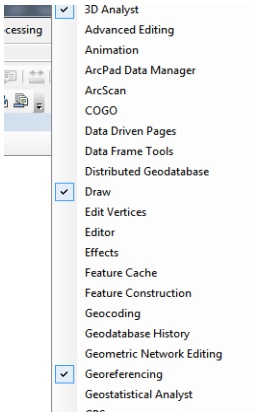
II. Basic ArcMap Skills

a. You will navigate around the map by experimenting with the zoom and navigation tools:
   1. Adjust the scale of the view with the Zoom In and Zoom Out tools.
   2. Zoom in at a fixed increment with the other two zooming tools (and).
   3. To zoom out to a scale that encompasses all of the data in the map, click Zoom to Full Extent .
   4. To zoom out to the full extent of a single layer, right-click that layer's name and choose Zoom to Layer.
   5. To return to the previous view, click Return to Previous Extent .
   6. Define a scale by manually entering it into the Scale box 1:53,561,939 .

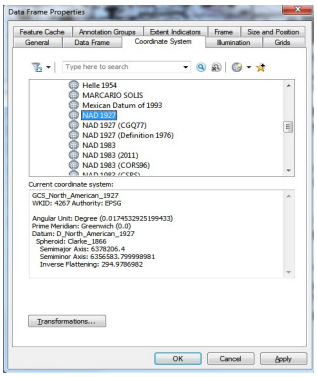
III. Georeferencing scanned maps

a. In this first part we will use the Georeferencing tools in ArcGIS to add location information to the scanned map.

b. To begin with we must activate the Georeferencing toolbar in ArcMap.
   1. Right click on a gray area at the top of the screen. For example, under the toolbars
   2. Then choose "**Georeferencing**"
   3. This will activate the Georeferencing toolbar

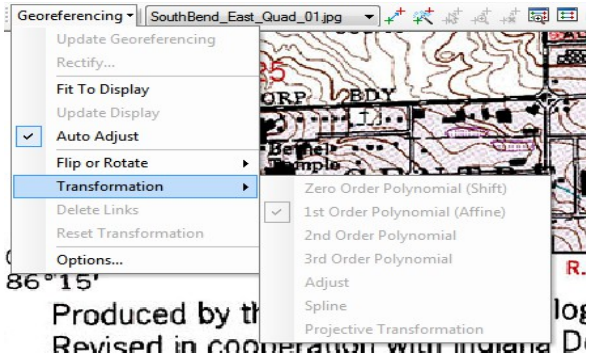


c. Now we should tell ArcMap what projection it should use.
d. First, find the projection and datum for the map.
    i. Make sure (the bottom half) is visible.
    ii. Zoom to the bottom and look at the coordinates.
        a. These are clearly in Latitude and Longitude, so we are dealing with a Geographic Coordinate System. In fact, there are actually UTM coordinates on this map too, but they are harder to interpret, so we will reference it first in lat/long and then re-project it into UTM.
    iii. Now we need to find the Datum used by this map.
        a. This is usually at the bottom of the map.
        b. Here it is **North American Datum 1927**.

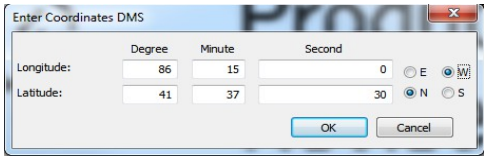


2. Access the **Data Frame Properties** by either double clicking **Layers** in the Table of Contents or right clicking and choosing Properties
    i. Go to the Coordinate System tab. It should initially say **No Coordinate System** under the Current Coordinate System: section
    ii. In the top part of the window, navigate to **Geographic Coordinate Systems → North America → NAD 1927**
    iii. Make sure to choose the one without anything after it
    iv. It may also be useful to choose the General Tab and change the display units to Degrees, Minutes, Seconds
    v. Select OK to exit the window.
3. You should note that now, when you run your mouse over the image the bottom right corner shows decimal degrees as the unit.
    a. Please note that these coordinates are meaningless. The image is not georeferenced yet. These are the pixel numbers for the image if each was a decimal degree. It is only the viewer that thinks they mean something.

e. Now we will begin defining Ground Control Points and telling ArcMap the coordinates for them.
1. The Georeferencing toolbar has a few new buttons
    i. First, clicking on Georeferencing gives us a new menu where we can control settings and create new, referenced, files
        a. For now simply verify that Auto Adjust is checked and the Transformation is 1st Order
    ii. The second box is the layer that we are actively manipulating. In complex ArcMap documents it is easy to reference the wrong layer, so always be careful about which is selected.
        a. For now, **SouthBend_East_Quad.jpg** should be the active layer.
    iii. The next button rotates the images independent of GCPs. If you need to do this, always do it first.
    iv. The second real button (two crosses) sets a GCP and its corresponding tie point. This is the most important one

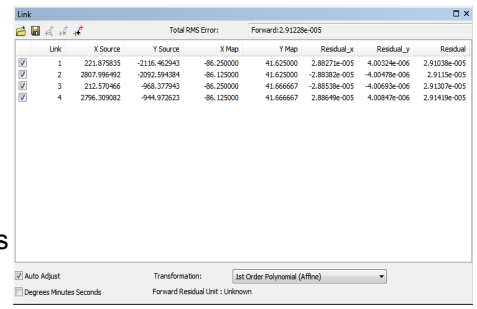


    v. The final button pops up a table of all of the current GCPs in the image.
2. To get started, you should now zoom in on the bottom left corner of the map such that the coordinates are visible and fill most of the viewer.
3. Activate the Add Control Points tool ( ) and click once on the bottom left corner of the map
4. If you move the mouse it should now show you the line connected to that point.
5. To set the coordinate, right click on the corner of the map and choose **Input DMS of Lat/Long**
    i. If you have a map in decimal degrees or UTM you would choose the other option



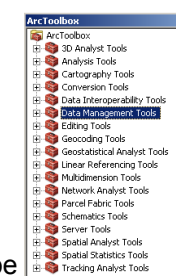
6. Enter the coordinates as shown on the map and choose OK.
    i. Longitude is 86º 15' 0" West
        a. The minutes (") are not listed, so we know it is blank
    ii. Latitude is 41º 37' 30" North

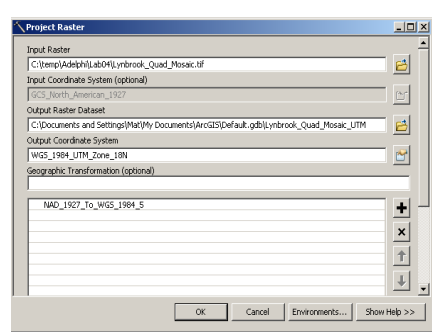
7. The map should now disappear, it has moved to its accurate location.
8. To find it again right click on the layer in the Table of Contents and choose **Zoom to Layer Extent**
9. Now zoom in on the bottom right corner and enter that coordinate.
   i. This second coordinate changes the size of the map more than its location.
   ii. Longitude is 86º 07' 30" West
      a. This has decreased. We are moving to the East along the bottom of the map
   iii. Latitude is 41º 37' 30" North
      a. This does not change. We are going along the bottom of the map which has the same Latitude
10. Zoom to the top left corner
   i. Here, the top coordinate is not exactly at the corner
      a. Place a coordinate where it says 41º 45"
   ii. Longitude is 86º 15' 0" West
   iii. Latitude is 41º 45' 0" North
11. These three points should be enough for our 1st Order polynomial Transformation, but we are going to add a forth to check the error.
12. Zoom to the top right corner and repeat the process as above. You should notice that the default values are closer to accurate each time
13. Now, display the GCPs by clicking the button on the Georeferencing toolbar
14. The far right column shows the residual error value for these points.
   i. This is basically the difference (in map units) between the expected and real coordinates.
   ii. If any of these values is larger than 0.005 for degrees or 5 for meters you may have made a mistake.
15. Now, you can either save this referencing information to display the image or totally change the file.
   i. To update the referencing information of the file choose **Georeferencing → Update Georeferencing**
   ii. To save everything in a new file choose **Georeferencing → Rectify**
   iii. It is very important to do one of these before starting on the second half.



IV. Re-projecting maps

a. We now have a map projected in Latitude and Longitude using the NAD 1927 Datum,
b. As presented in the lecture, it is best to have the maps in a UTM based Projected Coordinate System.
c. There are multiple ways to do this, but the most accurate is by a tool in the ArcToolbox, a series of premade geoprocessing scripts.
d. Access ArcToolbox by clicking on ( ) or going to **Geoprocessing → ArcToolbox**
e. This will bring up a new window which you can dock where you see fit
f. Within ArcToolbox you should select **Data Management → Projections and Transformations → Raster → Project Raster**
g. This will bring up a new window with several options
   1. The **Input Raster** should be the **SouthBend_East_Quad.jpg** file.
   2. The **Input Coordinate Reference System** should be filled in automatically
   3. The **Output Raster Dataset** you should set. S**outhBend_East_Quad_UTM.tif** would be a good choice
   4. Click on the button to the right to set the **Output Coordinate System**.
      i. This should pop up a new window. Choose **Select.**
      ii. Then in the popup go to **Projected Coordinate System → UTM → WGS 1984 → Northern Hemisphere → WGS_1984_UTM_Zone_16N**
   5. The **Geographic Transformation** should fill in automatically
   6. Click OK and the file should be created.





V. Georeferencing imagery

a. Here we are going to use the now Georeferenced quad sheet to assign coordinates a small aerial photograph

b. VERY IMPORTANT

1. Close your current ArcMap Document!!
   i. The document you have been working in is in Lat/Long, so any new images will be referenced to this coordinate system, by starting over with your new UTM image, you prevent a lot of errors.

c. Open a new viewer and add the reprojected image: S**outhBend_East_Quad_UTM.tif**

d. Verify that you are working in UTM by looking at the coordinates or in the **Data Frame Properties**

e. Now add the **Aerial1998_SB_East.jpg**

f. You should not be able to see it because it has no spatial reference and ArcGIS defaults to thinking that each pixel is one map unit starting at zero.
   i. The puts it at the equator.

g. Unfortunately, this means we will have to zoom back and forth until the image is referenced.

h. Make sure that the Georeferencing Toolbar is visible and that the **Aerial1998_SB_East.jpg** image is selected.

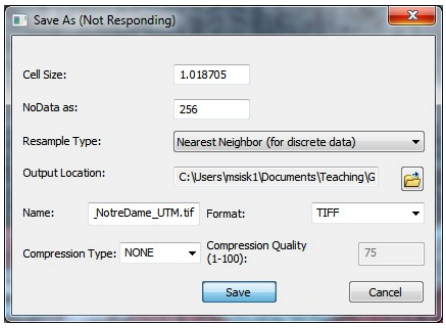
i. Right-click on **Aerial1998_SB_East.jpg** in the Table of Contents and choose **Zoom to Layer**.
   i. Look at the coordinates, they should be much smaller than the other UTM coordinates.

j. You will need to find four ground control points. I would look for ones that are at the four corners of the quad sheet or slight outside.
   1. The junctions of roads and the edges of buildings are good GCPs
   2. Shorelines, the edges of fields or forests are likely the change and do not make good GCPs.
   3. You should make use of the back and forward zoom arrows for the first few.

k. When you find the first point use the Add Control Points tool ( ) to tie it to the Quad sheet.

l. Repeat as was presented in the proceeding section on Georeferencing by coordinates.

m. Choose **Georeferencing** → **Rectify** when you finish
   1. In this new window:
      i. Leave **Cell Size** as it is
      ii. Change **NoData as**: to 0
      iii. Leave **Resample Type** as is
      iv. Next to **Output Location** click on the folder icon
         a. Navigate to your folder on the N drive, but only click one to highlight it, so that the Name of the folder (Lab03) appears un the Name box. Then click **Add**.
         b. Basically, in this menu you are defining the location of the folder separate from the name of the file
      v. Change the Name to **Aerial1998_SB_East_UTM.jpg**
      vi. Click **Save**
      vii. You should now add this new file into to your Map Document
         a. If it lines up correctly go ahead and remove **Aerial1998_SB_East.jpg** by right clicking on it in the Table of Contents and choosing Remove



VI. You should now have two georeferenced images that you can use in any GIS application.