

Georeferencing & Digitizing

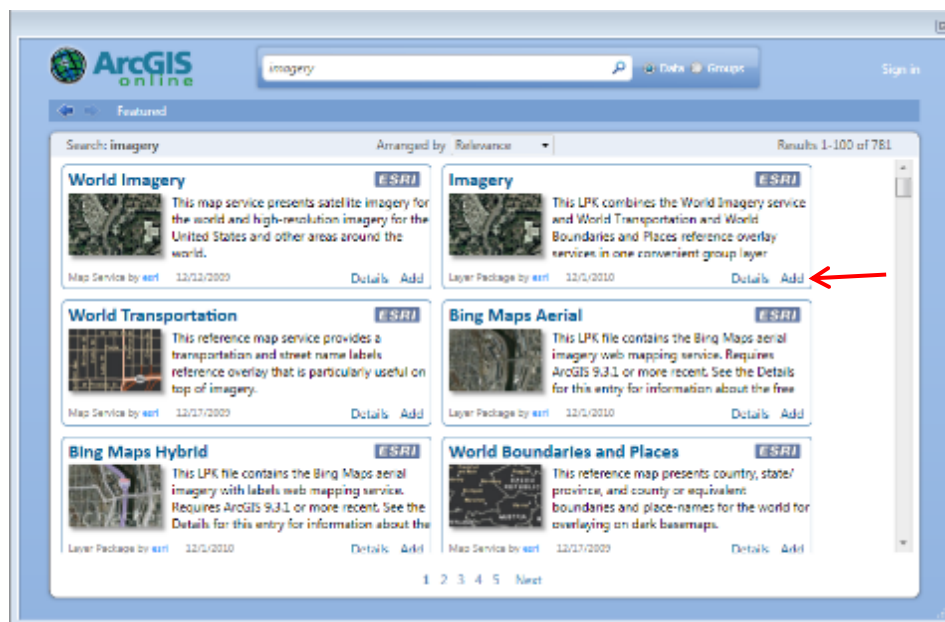
Written by Patrick Florance, revised March 29, 2015



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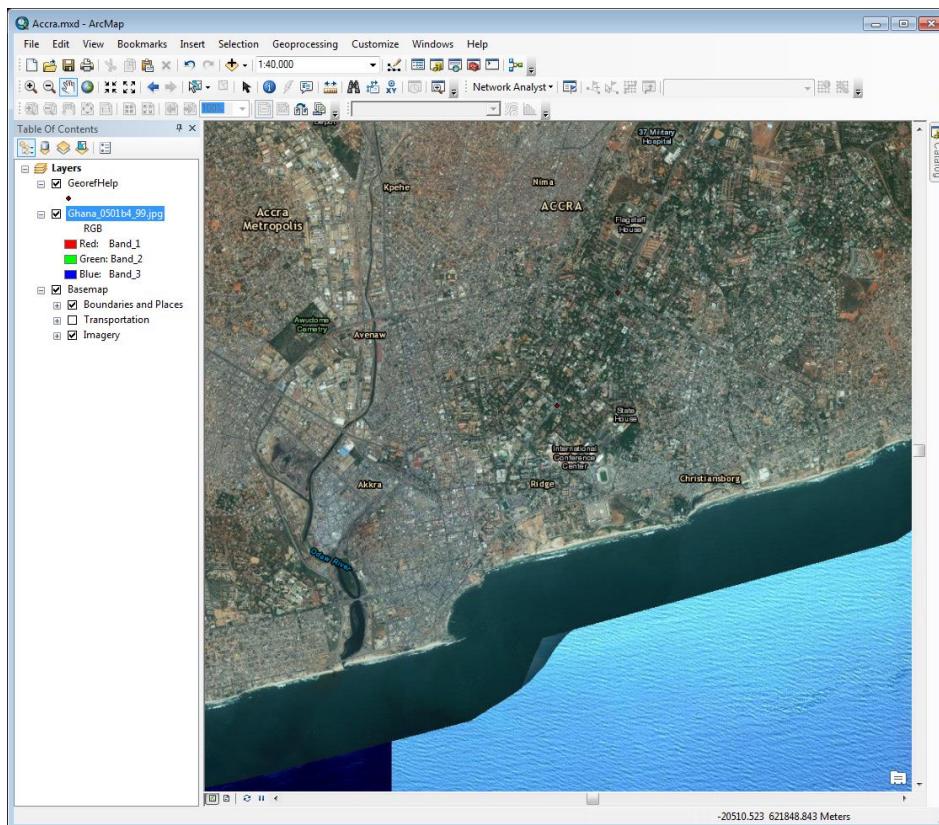
Part 1: Georeferencing

1. If not already done, map the following network drive as S:\rstore2.tufts.ad.tufts.edu\gisprojects\$
2. Navigate to S:\Classes\DHP_P207\Georeferencing Exercise. Copy the entire *Georef_Exercise* folder to your H drive, and change its name to “Accra”.
3. Start ArcMap with a new empty map. Navigate to **File** → **Add Data** → **Add Data from ArcGIS Online**. This is an online database from ESRI with free data layers to add to your project. A browser window should open.
4. Search for the layer called *Imagery*. Click *Add* below the *Imagery* layer.

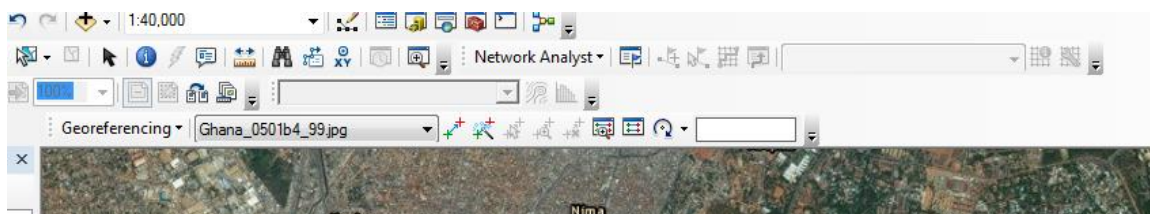


5. In the Catalog window, connect and navigate to your Accra folder. Select *GeorefHelp.shp* and add it to your project. If you receive a warning about using a different coordinate system, accept this warning by clicking **Close**.
6. Add *Ghana_0501b4_99.jpg* to your project. Note that if you click the ‘+’ to expand the jpeg in Catalog, you will see three raster layers. You could add all three separately, but they will not appear formatted, so add the whole *Ghana_0501b4_99.jpg* file. An error message will pop up reporting that some data sources are missing spatial reference information. We will be adding spatial reference information in this exercise, so click **OK**.
7. Save your map projects as Accra.mxd in your project folder.

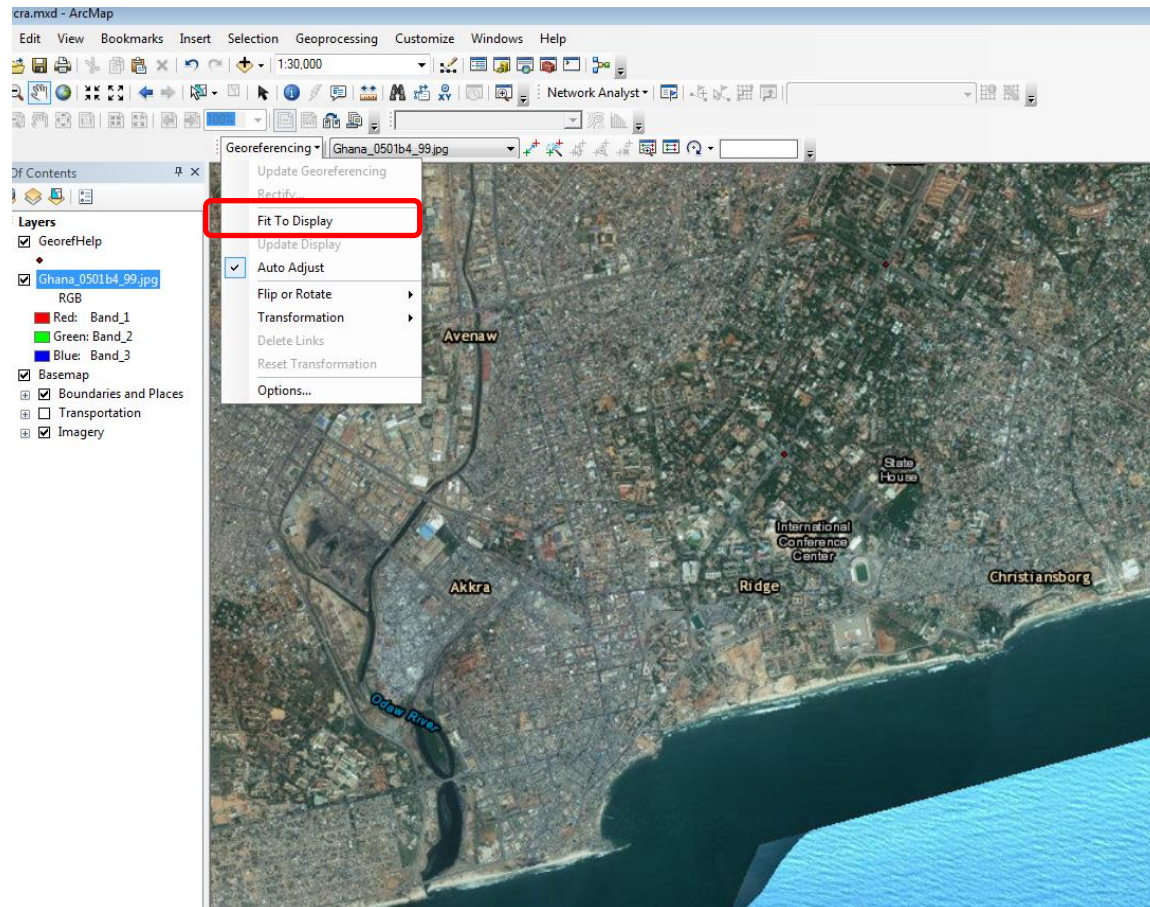
8. In your ArcMap project, you should now have a basemap imagery layer, the GeorefHelp shapefile, and Ghana_0501b4_99.jpg listed in the table of contents. Make sure the *Ghana_0501b4_99.jpg* is on top of the basemap, and the GeorefHelp is on top of the *jpeg* layer.
9. If you cannot see your imagery (i.e. if it appears black on the project screen) **right click on Basemap and select “Zoom to layer”**. You should now see an imagery dataset for the entire world. The *Ghana_0501b4_99.jpg* may not be visible; we will fix this soon.
10. Notice that the *Basemap* layer has sub layers. **Turn on Boundaries and Places and Imagery**. Zoom to Accra, Ghana. Zoom in until you can see the higher resolution imagery in which buildings and streets are visible.



11. Add the georeferencing toolbar. Navigate to **Customize→ Toolbars→ Georeferencing**. Like any other toolbar in ArcMap, you can dock it if you like by moving it up into the toolbar area.
12. Notice on the toolbar the dropdown menu containing the layer name *Ghana_0501b4_99.jpg*. This menu is crucial to georeferencing; if you have multiple files in your table of contents, this dropdown menu ensures you are georeferencing the intended image. Make sure *Ghana_0501b4_99.jpg* is selected.

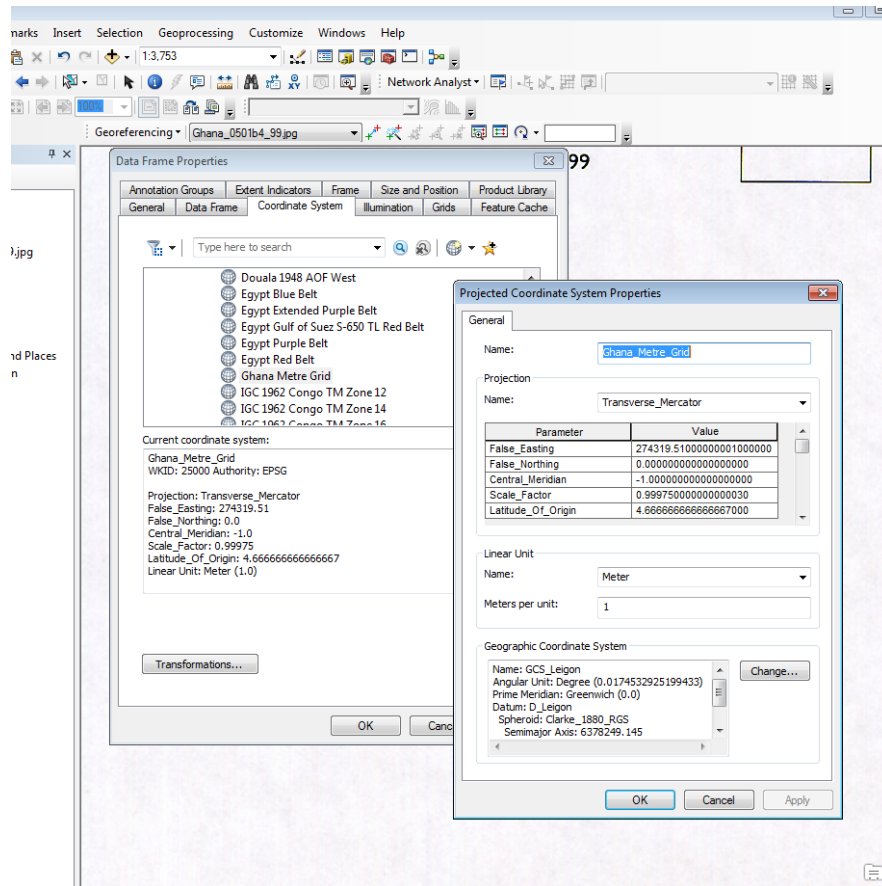


13. Click the **Georeferencing** dropdown menu from the toolbar, and click **Fit to Display**.



14. You should now see the *Ghana_0501b4_99.jpg* layer on the map screen. Fit to Display makes sure that both data sources are visible.
15. Before we can georeference, we need to make sure the projections are set for the project. Using the **Zoom tool**, find the projection information for the Ghana topo map jpeg.
16. You will find a detailed description of the projection of this map, which we need to now use to set your map projection. Ensuring your data is in the right projection will substantially increase the quality of the georeferencing. Right click on **Layers** in the Table of Contents. Navigate to **Properties** → **Coordinate System** and scroll up to make sure you are browsing the Projected Coordinate Systems, not the Geographic Coordinate Systems.

Because the topo map used the Ghana National Grid projection, we will select this projection, and make sure ArcMap has similar settings to those listed on the map. Within the Projected Coordinate Systems folder, navigate to **National Grids** → **Africa** → **Ghana Metre Grid**. Note that when you select this coordinate system (with one click) there is a list detailing settings of the coordinate system. These can be modified, if need be. Right click on the projection name and select **Copy and Modify**.



17. Inspect this information. Note that the projection used is Transverse Mercator, same as the projection listed on the topo map. Compare the Latitude of Origin on the Arcmap properties screen to that listed on the topo map. Why are these numbers different?

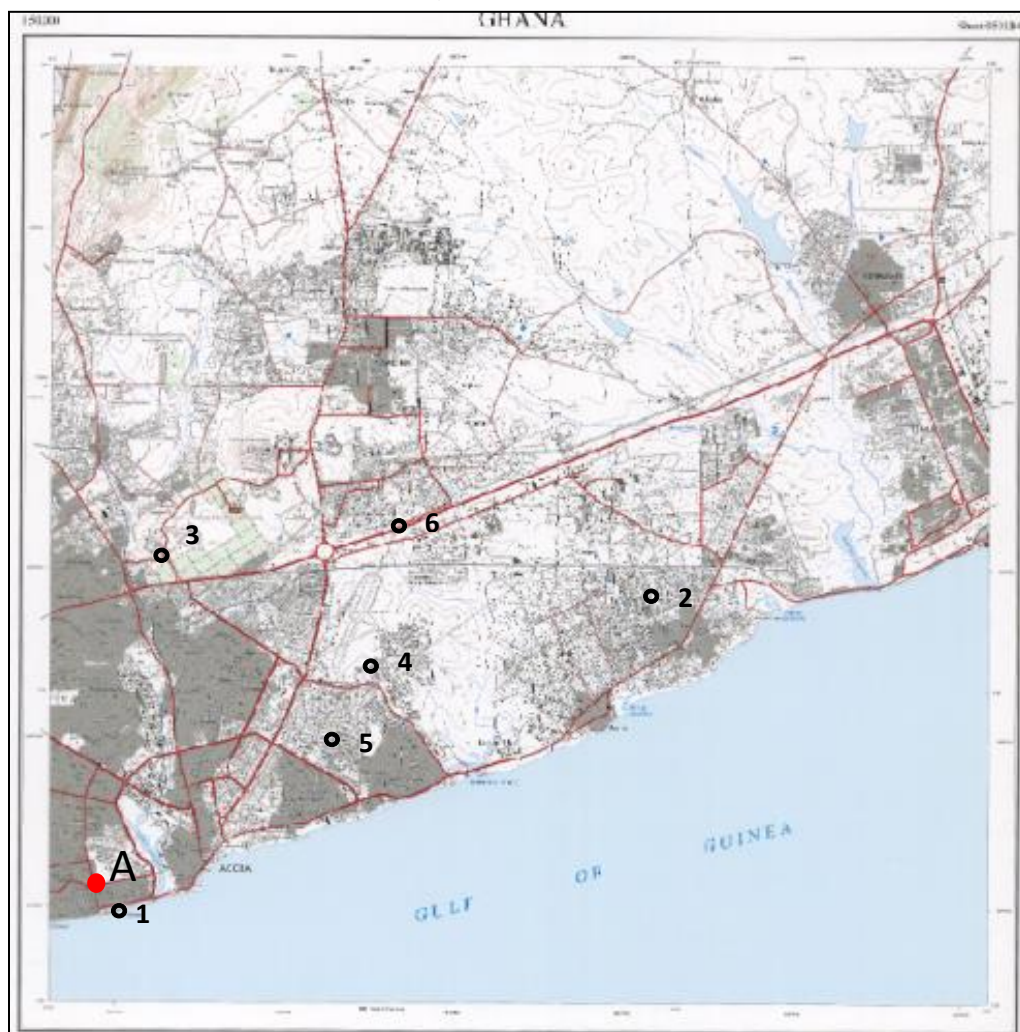
Use <http://www.satsig.net/degrees-minutes-seconds-calculator.htm> to ensure that the Latitude of Origin is the same in your ArcMap projection as is listed on the paper version of *Ghana_0501b4_99.jpg*. Hint: ArcMap is listing the coordinate system properties in decimal degrees; the topo is in degrees, minutes, seconds.

18. When you are satisfied, click OK to close both the Coordinate System and Data Frame Properties windows. Select **Yes** when prompted to use the different coordinate system. Navigate back to **Layers** → **Properties** → **Coordinate System**. Note that the coordinate system is now set to Ghana_Metre_Grid.
19. **Save your map.**
20. Now that the projections are set, we can begin georeferencing. Georeferencing is a tool which allows for digitized copies of maps to be imported into ArcMap, and then linked to certain features to transform the map to a real-world coordinate system, so that information from the paper map can be extracted to vector data with a spatial reference. Since this is a topographic map, we could use the coordinate system on the map itself to georeference the map; however, we are going to learn the commonly used feature linking method.
21. **Zoom** to Accra again and fit *Ghana_0501b4_99.jpg* to display again, if necessary. We need to select points to georeference to the imagery. Examples of good types of points to use are anthropogenic features:
 - a. Road intersections
 - b. Towns, when both datasets have a point representing the location

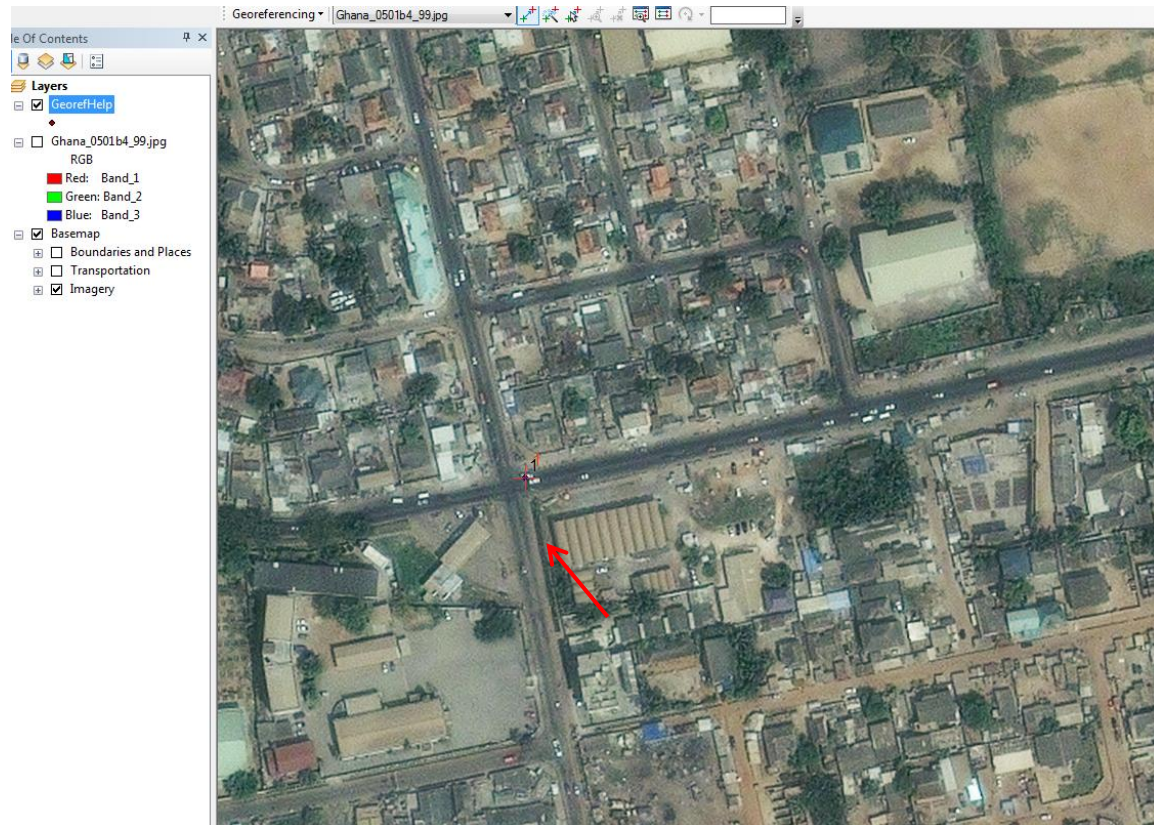
22. Turn off Boundaries and Places to speed up draw time.
23. Right click on the *GeorefHelp.shp* layer, open the layer properties and go to the **Labels** tab. Make sure *Label features in this layer* is checked. The Label Field should be set as "Id". Set the text symbol to a larger font size so you can see the labels easily. Click OK to close the properties box.
24. On the Georeferencing toolbar navigate to the **Add Control Points** icon (with the red and green crosses). **Click it.**



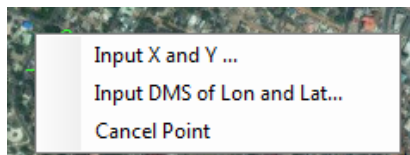
25. Your cursor has now turned into a cross. However, you still have the functionality of being able to zoom in and out with this tool, either by using the scroll on your mouse, or the Zoom Tool on the basic Tools bar. You can also turn on and off the layers in your table of contents, or change the settings of Fit to Display. Knowing this is very helpful for Georeferencing.
26. Zoom on the topo map *Ghana_0501b4_99.jpg* to the location labeled "A" on the map below. **Click your cross cursor on the intersection**, being as accurate as possible. Zoom in as far as necessary to make sure your point is accurate. **Once you click in this location you have created one control point.** (Note: if your cursor is not a cross, relick the Add Control Point button).



27. Turn off *Ghana_0501b4_99.jpg* in the Table of Contents. Locate this same intersection on the imagery and click once in the center of the intersection. Use *GeorefHelp.shp* as a guide: the intersection will be the point “1”. Remember, you can still zoom in and out, and turn on/off layers as needed. If you lose the control point cursor, just click the Add Control Points tool again.



You have now created a second control point that is linked to the first, and the two together are called a “link”. If you turn *Ghana_0501b4_99.jpg* back on, you will see that the map has shifted somewhat.



28. Do these same steps for the remaining points in numerical order. (If need be, look at the listed points in the *GeorefHelp* attribute table. Right click desired row and select “Zoom to Layer”.) If you accidentally click on the wrong location for your first point, simply right click and select “Cancel Point” before you click the second point to finish creating the link. You will learn how to delete links later in the tutorial. *Ghana_0501b4_99.jpg* has now been shifted according to the control points/links you have created.

29. **Select the Link Table.** This is located near the Add Control Point Button.



The link table lists each set of control points made, and its residual error. The residual errors for each link made are then added up to reach the Total RMS (Route Mean Square) Error. This error represents the difference

between the locations of control points on *Ghana_0501b4_99.jpg* from the control points made on the Imagery file.

As of now, the total RMS error is fairly high. You can fix this by deleting points. Select the last point you made, which should have the highest residual error. It will highlight in blue on the link table, and yellow on your map. Uncheck the selection box on the left hand side of the link table, and the point is deleted. Your total RMS error should be lower. Close the Link Table once you have your five points.

Link								
			Total RMS Error:		Forward: 2.96904			
	Link	X Source	Y Source	X Map	Y Map	Residual_x	Residual_y	Residual
<input checked="" type="checkbox"/>	1	671.649599	-5550.291536	358785.095820	95911.780669	1.15977	-2.57319	2.82248
<input checked="" type="checkbox"/>	2	3207.706532	-4049.665918	371664.364747	103619.521130	1.06638	-2.36598	2.59519
<input checked="" type="checkbox"/>	3	879.135199	-3851.607545	359791.102987	104588.554727	0.565332	-1.25431	1.37582
<input checked="" type="checkbox"/>	4	1552.858520	-4998.415964	363256.238621	98752.400875	-2.00561	4.44988	4.88097
<input checked="" type="checkbox"/>	5	2013.258966	-3700.478366	365564.942622	105384.066068	-0.785864	1.74361	1.91252

☒ Auto Adjust
☐ Degrees Minutes Seconds

Transformation: 1st Order Polynomial (Affine)
 Forward Residual Unit : Unknown

30. You still should visually check your georeferencing for accuracy. **Navigate to Customize → Toolbars → Effects.** Make sure both your imagery and the *Ghana_0501b4_99.jpg* are turned on in the Table of Contents. Select *Ghana_0501b4_99.jpg* as your target layer. Click on the **Swipe Layer** icon, which will turn your cursor into a small black triangle. Click on any area of *Ghana_0501b4_99.jpg* and hold down; notice that half of the *Ghana_0501b4_99.jpg* is removed, and you are able to see how well streets line up.



31. Navigate to the Georeferencing toolbar. Click **Georeferencing → Update Georeferencing.**

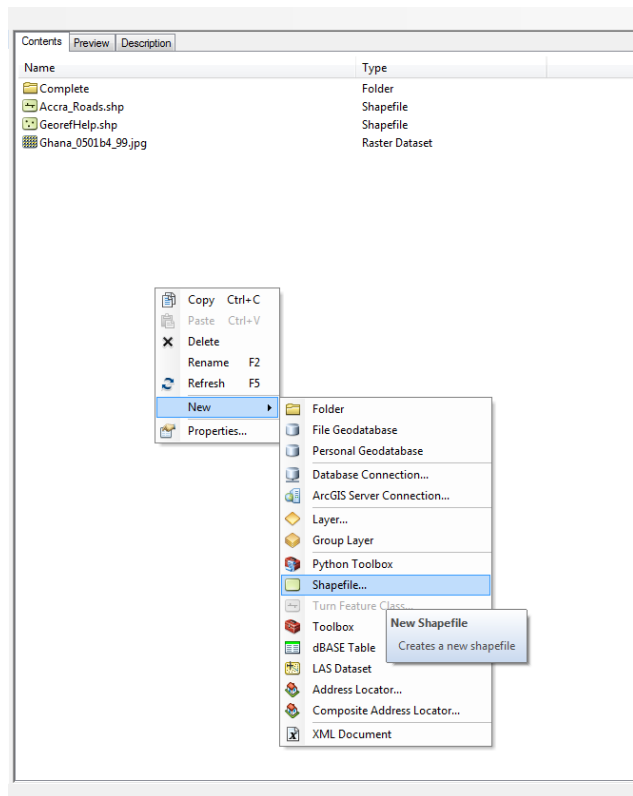
Note that now, the control points are no longer visible, and *Ghana_0501b4_99.jpg* is stretched so that its geographic locations and borders are as close to the imagery as possible. Save your project.

Part 2: Digitizing

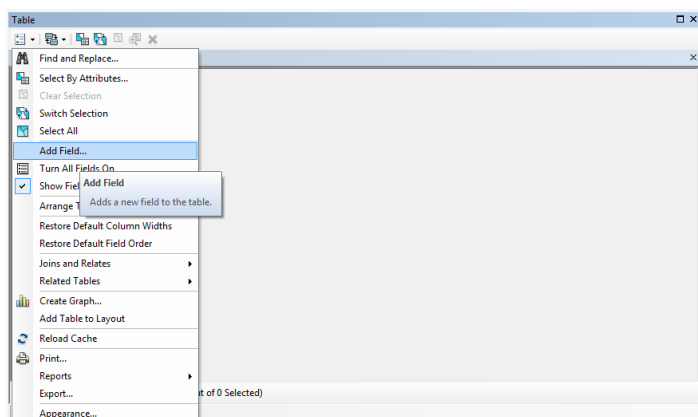
In this portion of the lab, we will use *Ghana_0501b4_99.jpg* and the *Imagery* layer to extract data, which we will make into shapefiles.

1. **Turn on *Transportation and Boundaries and Places*** and zoom out a bit. Notice how incomplete these datasets are, in comparison to the detailed road networks and buildings recorded on *Ghana_0501b4_99.jpg*. Often, international data sets are incomplete, and researchers need to create their own. Digitizing tools allow for these datasets to be created. **Turn off *Basemap***. Because you will be digitizing first from the jpg, turning off the imagery layer will speed up processing.

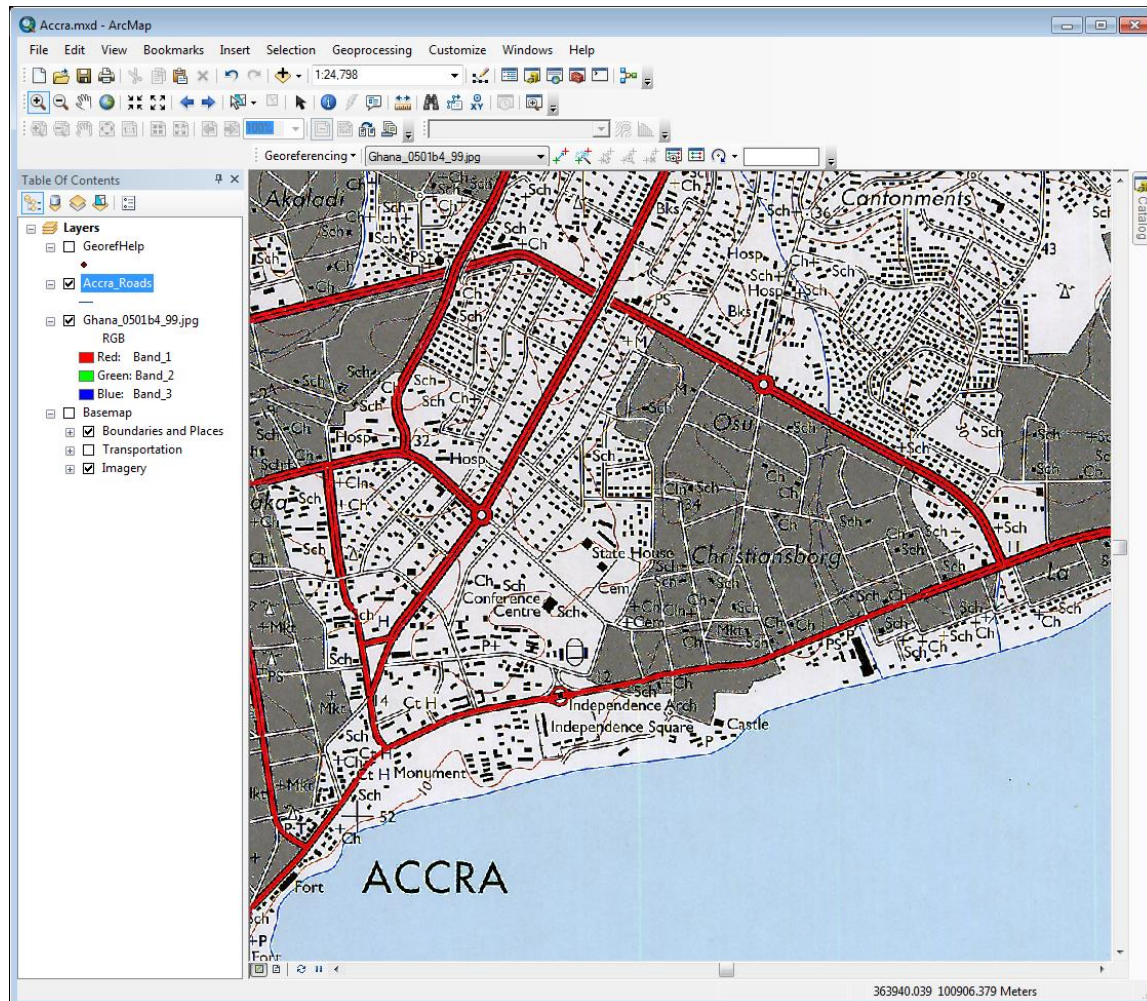
2. **Zoom in to the legend on *Ghana_0501b4_99.jpg*.** Note how Class 1 versus Class 3 roads are represented. You will be vectorizing these roads.
3. Open Arc Catalog from the Windows Start menu. Navigate to your project folder. Right click in the Contents frame. Click **New→ Shapefile**.



4. Name your shapefile “Accra_Roads”. For Feature Type, select Polyline. For the coordinate system, click edit and then navigate to/select Ghana Metre Grid. Click OK twice. Leave Arc Catalog open, as we will be creating more shapefiles.
5. In ArcMap, refresh your project folder and then add the *Accra_Roads.shp* file to your map. Open its Attribute Table. There is no data associated with this shape file yet; you will create this information from *Ghana_0501b4_99.jpg*.
6. In the Attribute Table, navigate to **Options Dropdown Menu** in the upper left hand corner and select **Add Field**. Name this field “Type”, and select the Text option from the dropdown menu. Click OK and close the table.

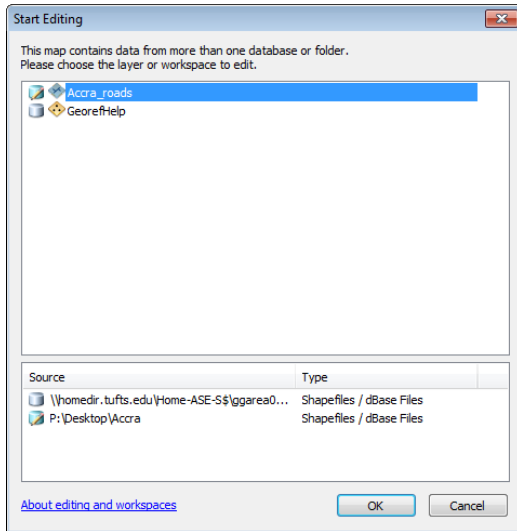


7. Zoom to the Christiansborg area of Accra:



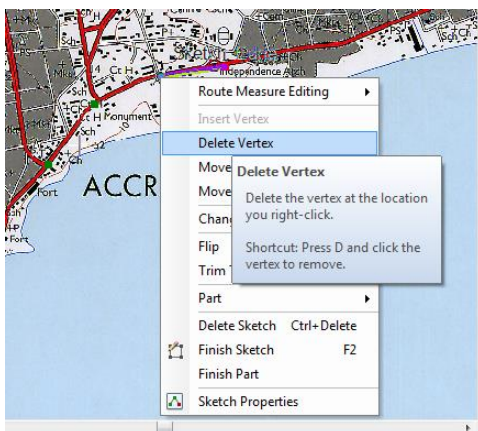
8. If the Editor Toolbar is not displayed, load it by selecting **Customize→Tool Bars→ Editor Toolbar**. On the Editor toolbar, click **Editor→ Start Editing**.

A pop up window will ask you which file you'd like to edit. (If no window pops up, click Editor→ Editing Windows →Create Features). Select *Accra_roads*. Like the Georeferencing toolbar, we need to make sure the correct feature is selected. This is very important. If you do not select the right shapefile (the one you want to edit), you could alter another shapefile without meaning to. Changes done in an editing session can be undone, but **only until they have been saved**. Generally, you will save frequently, so be careful about selecting the right feature to edit!

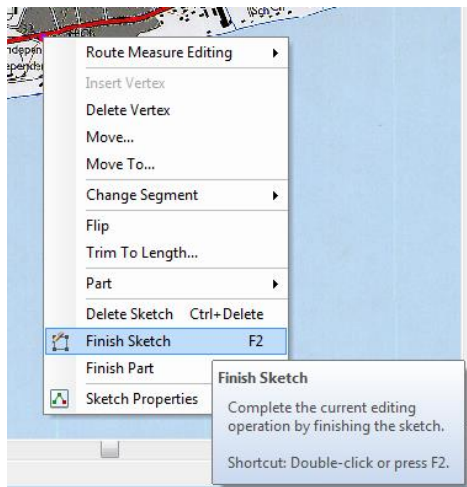


9. Snapping Toolbar – Before editing, ensure snapping is enabled:
 - a. Make sure you are in an edit session.
 - b. On the Editor toolbar, go to Editor→Snapping→Snapping toolbar. In the new Snapping toolbar, click the Snapping menu and make sure *Use Snapping* is checked.
 - c. Click the Snapping menu on the Snapping toolbar and click *Snap To Sketch*.
 - d. Turn on at least one snap type from the top of the Snapping Toolbar, such as edge or vertex snapping. For example, when vertex and edge snapping are enabled, you can snap to vertices and edges within the sketch in addition to other features in the map.
10. The Editor toolbar has several functions; we will focus first on drawing lines. Click the pencil icon on the Editor toolbar to open the Create Features window if it didn't automatically open. Click on *Accra_Roads*, and then on the line tool under Construction Tools at the bottom of the window.

Try drawing with your cursor. Click once to begin a segment, and then again to add a vertex. Right click on the second vertex and hit finish part. Start a new segment and make three vertices, **right click on the last vertex and hit Finish Sketch**. Look in your attribute table and notice that you drew two separate segments, but that they are one data entry. You must select finish sketch for every separate *segment* you would like in your attribute table. Now create another segment with three vertices again, right click and select finish part. Right click on top of one of the vertices and select Delete Vertex. This option allows you to delete one vertex, helpful if you have drawn several.



11. Draw some more lines. Try right clicking before finishing a line. On this dropdown menu, there are many options. You have the option to delete the sketch, finish the segment (after at least two points), or to finish the sketch. Click Finish Sketch.



12. Once you finish the sketch, you will see your drawing highlighted in blue. Right click on the *Accra_Roads* attribute table. Note the line you drew is selected. Push the delete key on your keyboard. This will delete your lines. Using the “Delete Sketch” option noted above does the same; deleting from the attribute table is helpful when you have several lines.

Practice drawing straight lines, and curved lines. You can also try the free hand tool. Be sure to **delete them before beginning the next step.**

13. Use these tools to digitize the main roadway, highlighted below, as a single line.



14. When completed, right click and select Finish Sketch.
15. Navigate to the pull down menu under Editor in the toolbar. Click Save Edits. **Saving edits is very important; all work will be lost unless you save them before you stop an editing session.** In the pull down menu, **stop your editing session.**
16. Open the *Accra_Roads* attribute table. You will see an entry in the table representing the main road you digitized. We now need to indicate the type of road this is.

17. Start an editing session. Notice that when you start an editing session, the attribute table adds a row; this is for adding another entry. Don't worry about this row. Try clicking the gray square in the left-hand margin next to your digitized road in the attribute table. Notice that ArcMap then selects it.
18. In the row which represents your digitized road, double-click the entry box under "Type" until you see a cursor. Type in "Main Road" without the quotation marks. Then, hit Enter.

FID	Shape *	Id	Type
0	Polyline	0	Main Road

*Note: If you made a series of lines to represent this main road, you will need to write in the type for each entry in the Attribute Table. When doing so, make sure to have written "Main Road" exactly the same each time. Copying and pasting is suggested.

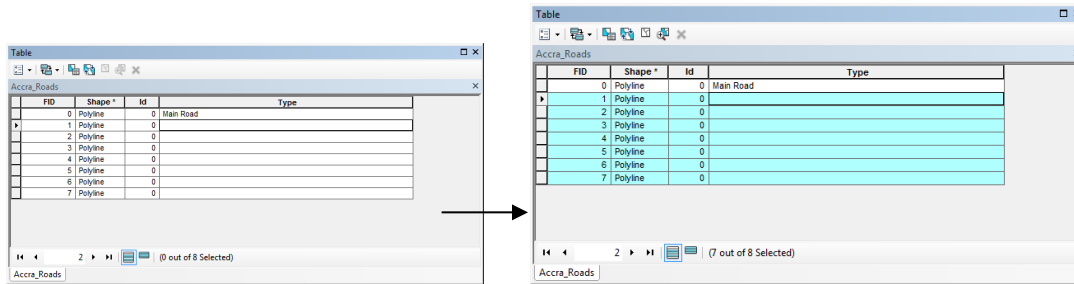
When you are finished, select **Save Edits** from the Editor toolbar dropdown menu. **Then, click Stop Editing.** Likely it is difficult to see the road you just made. To make it easier, click the small line underneath your *Accra_Roads* layer in the Table of Contents. Symbology should appear. Choose a bright color, and increase the thickness of your line to 4.

19. Now we will digitize the Class 3 roads within the main road area. Try digitizing the following road:

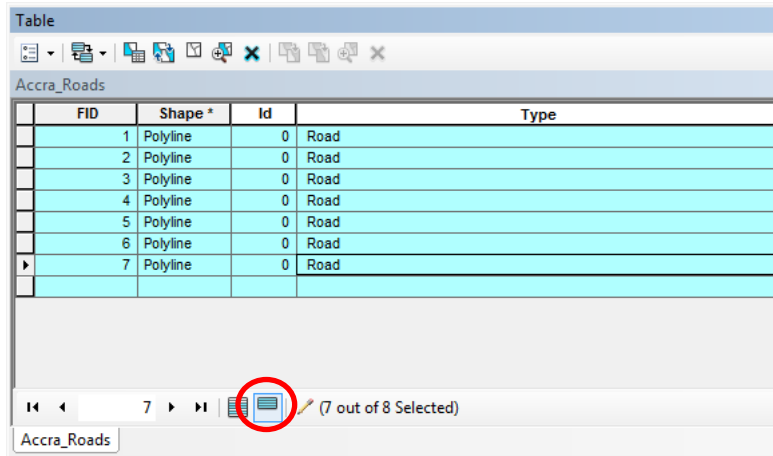


20. Digitize a few more of the Type 3 roads in the study area. When you have finished, save your edits and stop the editing session.
21. Open the *Accra_Roads* attribute table. Your table should show an entry for each road you have made; the main road(s) from Step 15 listed with type as "Main Road", the newer roads with a blank type.

22. Click the small gray square next to your first new road, and drag it until you have selected all of the new roads.



Click Show Selected Records (on the bottom of the attribute table). This isolates your selected entries, which should be the type 3 roads. Start the editing session again. Click on the first entry box below “Type” and type in the word “Road”. Highlight, copy and paste this (either by using CTRL C and V or by right clicking) into the rest of the boxes in the column.

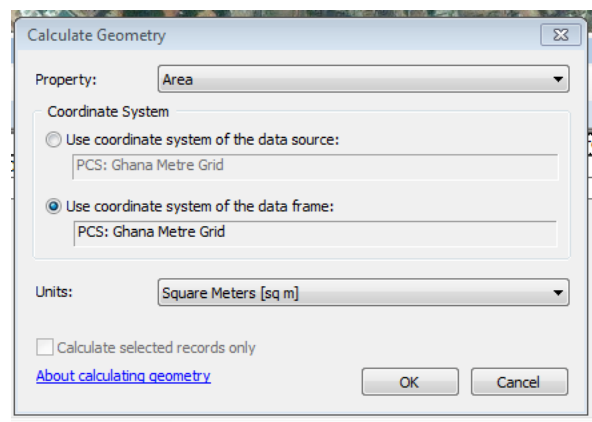
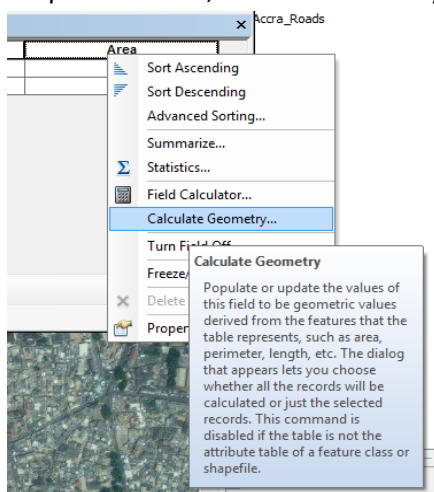


Copying and pasting is recommended because ArcMap will cluster these entries as a group of the same type. If one or more of the entries was listed as a different way (ie “road” “ROAD” etc.) they would not be grouped with the cluster. This is important when symbolizing the map, or when running analyses. **Save your edits and stop editing.**

23. We will now digitize some points. Navigate back to Arc Catalog. Make another shapefile, but this time, set the Feature Type as “Point”. Name the file *Accra_Buildings*. Be sure to change the projection.
24. Add *Accra_Buildings* to your map. Open the attribute table, and add a new text field. (Note: if you are unable to add a field, make sure you don’t have an editing session open.) Name this field “Type”. Click ok and exit the table.
25. Start your editing session, and change your target layer to *Accra_Buildings*. Click on the pencil tool in the editor toolbar if the Create Features window is not open. Make sure to select *Accra_Buildings* in the Create Features window, and then select the point tool from the Construction Tools below.

Note: If *Accra_Buildings* does not show up in the window, click on the filter icon in the top left of the Create Features window and select “Show all templates.”

26. Within the Christiansborg area of Accra, click once on the location of a school (you may want to check the legend on the map to see how these are represented). This point now represents one location. Digitize some of the schools in the region, and save your edits. Stop the session.
 27. Open the attribute table of *Accra_Buildings* and restart the editing session, making sure *Accra_Buildings* is set as your target layer for editing. Enter “School” for each type of building, as done in previous steps. Be sure to copy and paste, or be very careful while typing the name. Click save edits, and stop editing when you are finished.
 28. Digitize a couple hospitals in the region. Again, open the attribute table and label these points as “Hospital”. Make sure when selecting entries, you are only selecting those representing hospitals!
 29. Use these same steps to digitize a few churches in the area. Make sure to change the “Type” in the attribute table. Enter “Church” for type. And again, make sure you are changing the name for the right entry; it is suggested you do one type at a time to avoid confusion.
 30. Turn off the *Ghana_0501b4_99.jpg*. We will now digitize off of the satellite imagery.
 31. Open Arc Catalog and create a **polygon** shapefile, called *Accra_OpenSpace*, with the proper projection. Back in ArcMap, add *Accra_OpenSpace* to your map. Turn on *Imagery* in your Table of Contents.
 32. Right click on *Accra_OpenSpace* in the Table of Contents to open the attribute table. Click Table Options→ Add field. Name this field “Type”, and make it a text. Add another field. Name this second field “Area” and select **double** as the type.
 33. Zoom in to the Christianborg area again and find an area of open space in the imagery.
 34. Start the editing session. Select *Accra_OpenSpace* from the popup window. Open the Create Features window if it is not already open by clicking on the pencil icon in the Editor toolbar. Make sure you select *Accra_OpenSpace* in the Create Features window and select the polygon construction tool at the bottom.
 35. Begin to digitize your polygon, in the same way you would a line. Notice that, when digitizing a polygon, after two points have been added, you have a set of connected vertices.
- Digitizing a polygon is very similar to digitizing a line. You can delete vertices in the same way, as well as end a sketch. Use your skills from creating lines to digitize the open space.
36. When you are finished, save your edits and stop the session. Open the attribute table for *Accra_OpenSpace*. You should see one entry. Start the editing session again, and under “Type” enter “Open Space”.
 37. Now, right click on “Area” and select “Calculate Geometry”. Select the “Area” option from the Property dropdown menu; “use coordinate system of the data frame” option; and square meters as units. Click OK.



You have just calculated the area of your open space polygon. The size should appear in the entry box below “Area”.

38. Save your edits and stop editing.

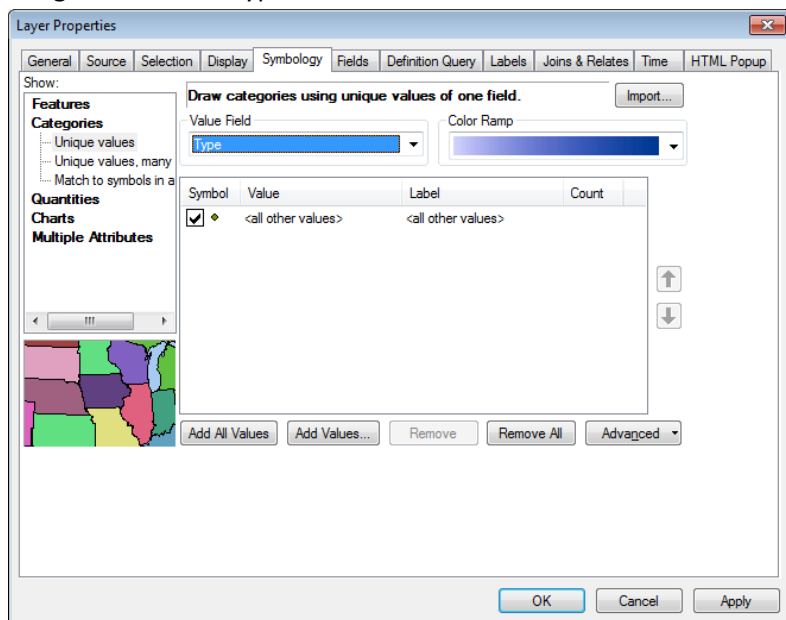
Part 3: Editing Metadata

Normally you would create metadata here; however we will do this later in the course.

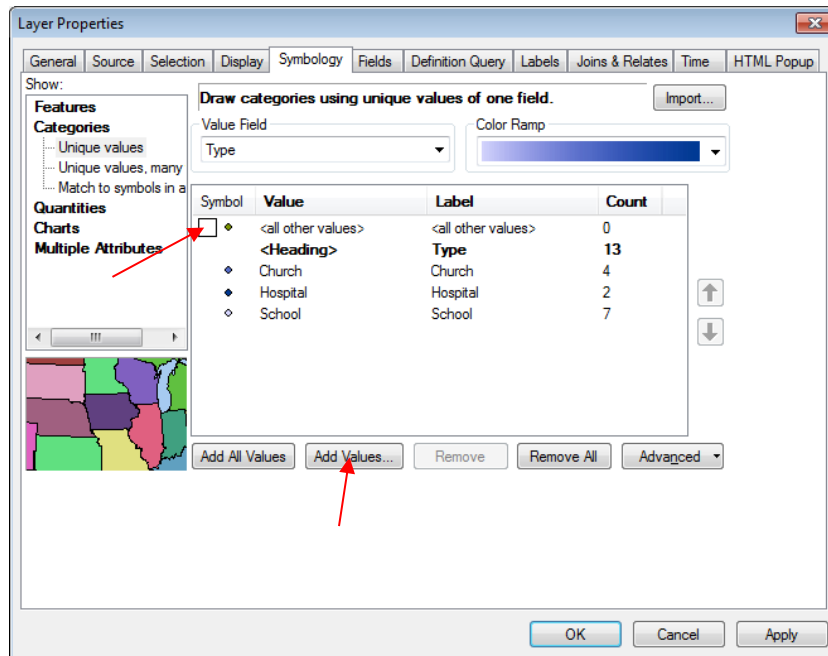
Part 4: Symbolize your Data.

Be sure to change the symbology for each of your shapefiles (*Accra_Roads*, *Accra_OpenSpace*, and *Accra_Buildings*). For example, the *Accra_Buildings* shapefile we created has several categories. As of now, each building type looks the same on your map. You can adjust the symbology so each looks different.

1. Right click on *Accra_Buildings*. Navigate to Properties→ Symbology. On this screen, there are several options for adjusting how the shapefile will appear. Because we want our map to focus on the categories of buildings, select Categories→ Unique Values. To the right of the Symbology dialogue box, you will see “Value Field.” Click this dropdown box, and you will see Id and Type. These are the fields in your attribute table which can be used as categories. Select “Type”.



Now, click the “Add All Values” button at the bottom. Your categories will appear, with counts.



2. Uncheck the box next to <all other values>.
3. Double click the circle next to Church. A symbology dialogue box appears. Select the type of symbol shape, color, and size that you want. Do this for all of your values, and click OK when done.
4. Repeat these steps for *Accra_Roads*, making sure the Main Road and Roads entries are distinguishable from one another in some way. Change the color of the *Accra_OpenSpace* polygon to your taste.