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Ethiopian Strategy Support Program II (ESSP II)

An Introduction to Geographical Information Systems

Training Manual

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Ethiopia Strategy Support Program II (ESSP II)

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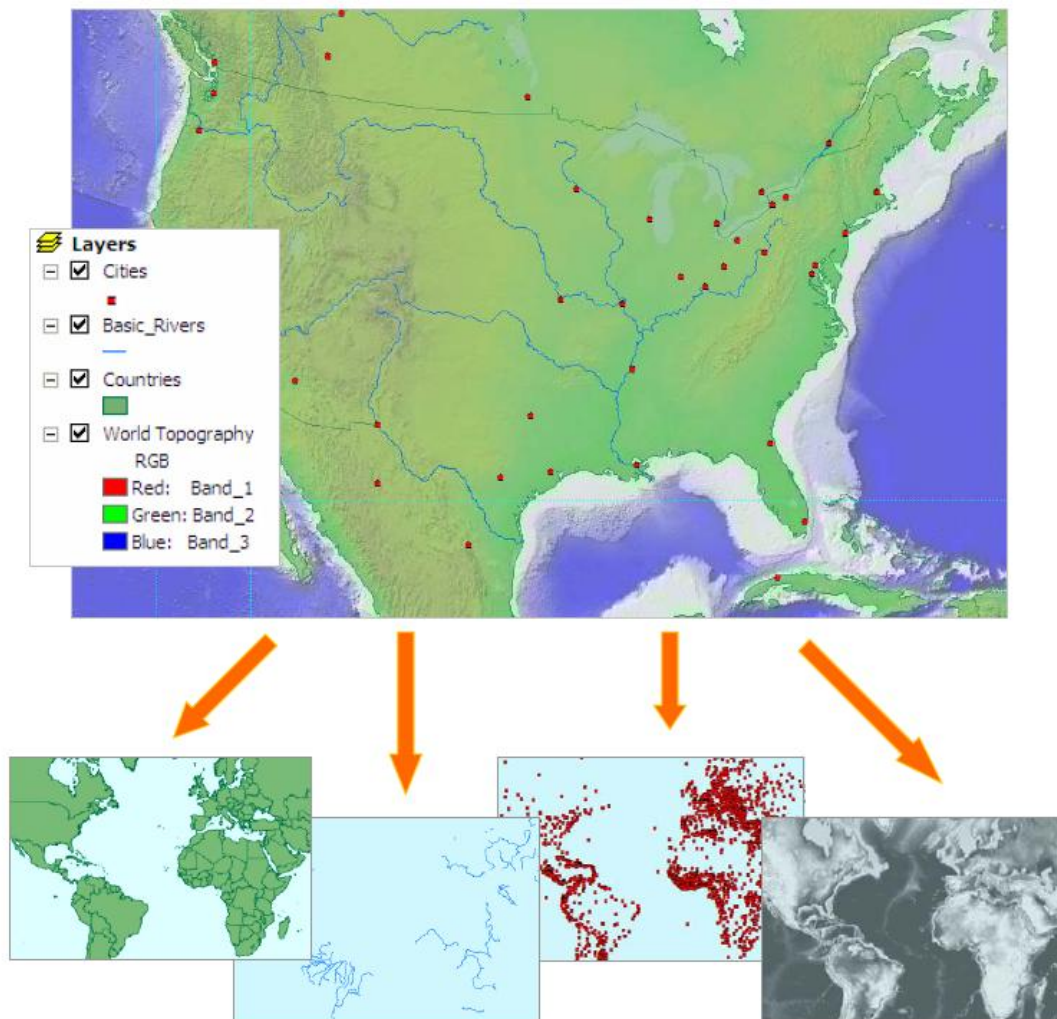
Lab 01: Introduction

Introduction - Basic principles of GIS

GIS is a technology used to view and analyze data from a geographic perspective.

GIS links location to information, and layers that information to give a better understanding of how it interrelates. A GIS map is therefore composed of many layers, or collections of geographic objects that are alike. You choose what layers to combine based on your purpose. The following map contains four layers, Cities, Rivers, Countries, and Topography (elevation data).

→ Remember: A **Map** is made up of **Layers**



In the preceding map, the “Cities” layer is made up of many different cities, and the “Rivers” layer of many different rivers. The same is true of the “Countries” layer. Each geographic object in a layer, - each city, river, lake, and county – is called a Feature.

→ Remember: **Layers** contain **Features**

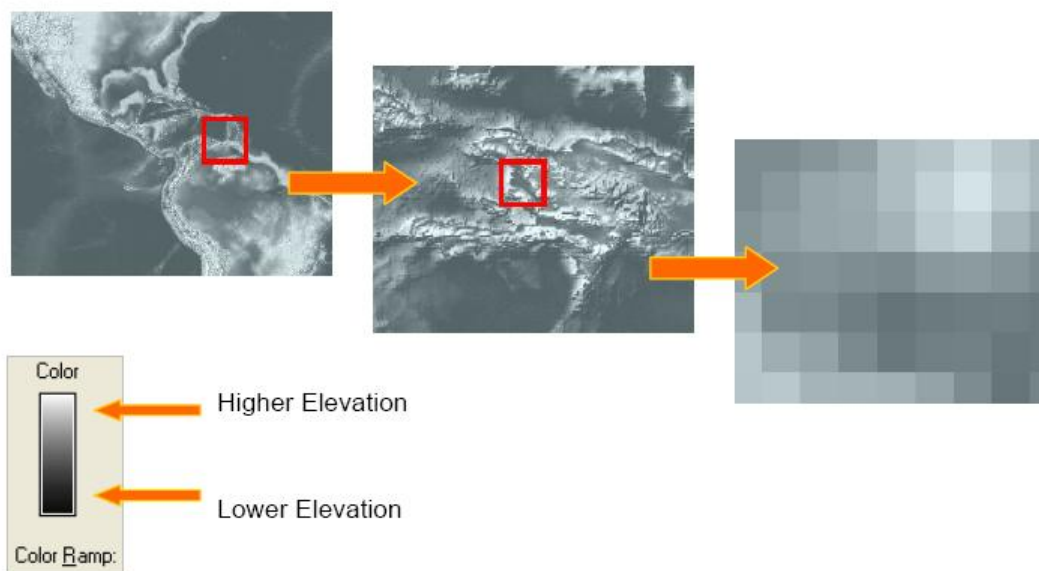
In any GIS software, geographic features are represented as one of three geometrical forms, a *polygon*, a *line*, or a *point*. Polygons represent things large enough to have boundaries, such as countries, lakes or other large tracts of land. Lines represent narrow, linear features, such as roads, rivers or pipelines. Points are used for things too small to be represented as polygons, such as cities on a map of the United States, or schools on a map of DC. Polygons, lines and points are collectively called **Vector Data**.

→ *Remember:* **Features** can take the form of **Points**, **Lines** and **Polygons**, and are known collectively as **Vector Data**.

Not all layers contain Features, The topological (shaded relief) layer you see above is not a collection of geographic objects in the same way the other layers are. It is a single continuous expanse that changes from one location to another according to the height/depth of the Earth's surface. A geographic expanse of this type is called a *Raster*. We use Rasters because unlike rivers, or countries, things such as elevation, temperature, rainfall or wind speed have no distinct shape.

A Raster is a matrix of identically sized square cells or pixels (much like a digital photograph). Each cell represents a unit of surface area, and contains a measured or estimated value for that location. When displaying this information, colors are assigned to the individual pixel values along a ramp scale.

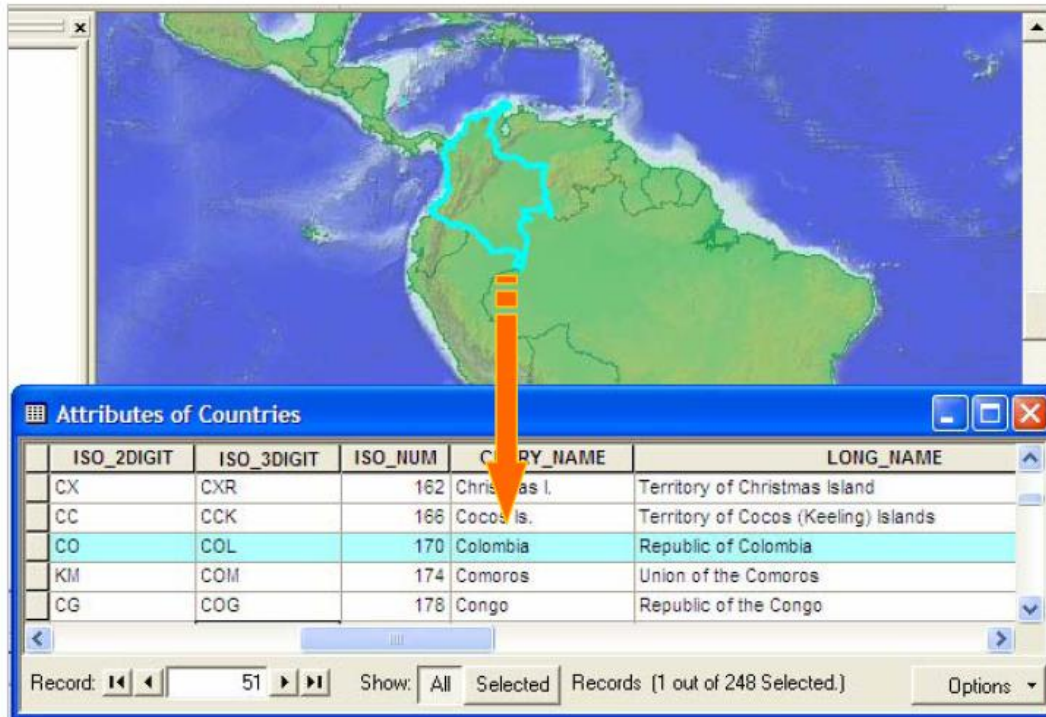
→ *Remember:* **Layers** also contain **Rasters**



There is much more to an individual feature than its shape and location, and GIS files have the potential to incorporate this additional information. There is a great amount of information that may be gathered about any one feature. A country has population, a capital, a system of government, leading imports and exports, average rainfall, mineral resources and many other things. Roads have grading systems, speed limits, number of lanes, and one or two-way systems.

Information about the individual feature of any one layer is stored in a table. The table has a record (row) for each feature in the layer, and a field (column) for each category of information. These information categories are called attributes; therefore, these tables are commonly referred to as "Attribute Tables". Each object (or "feature") on a GIS map is linked to a row of information in an attribute table.

→ *Remember:* **Layers** contain **Features**, and each **Feature** is linked to a row of information in the **Attribute table**

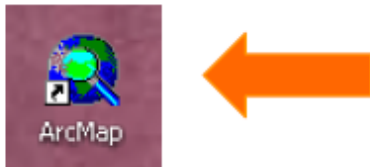


Now, let's get started making our own map!!!

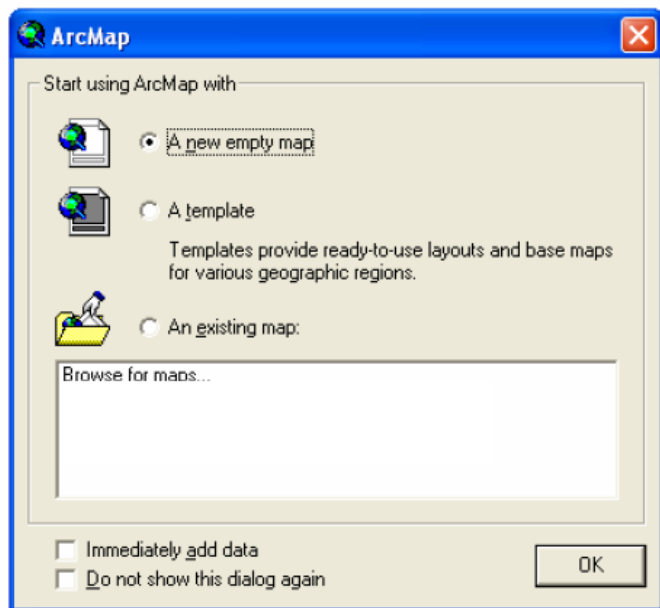
Lab 01: Exercise

The ArcMap interface and adding data

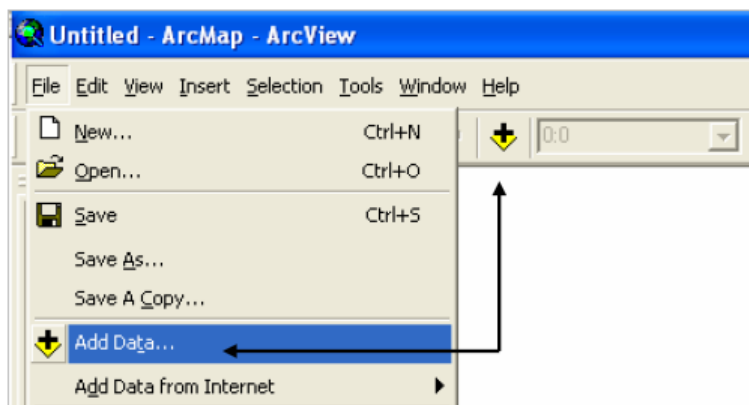
1. Start ArcMap by double-clicking the ArcMap icon on your computer desktop.
(Alternately, click the “Start” menu, point to “All Programs”, point to “ArcGIS” and select “ArcMap”)



2. You may receive the following welcome screen, if so, select “a new empty map,” and press OK. If you do not receive this screen, ArcMap has selected a blank map by default.

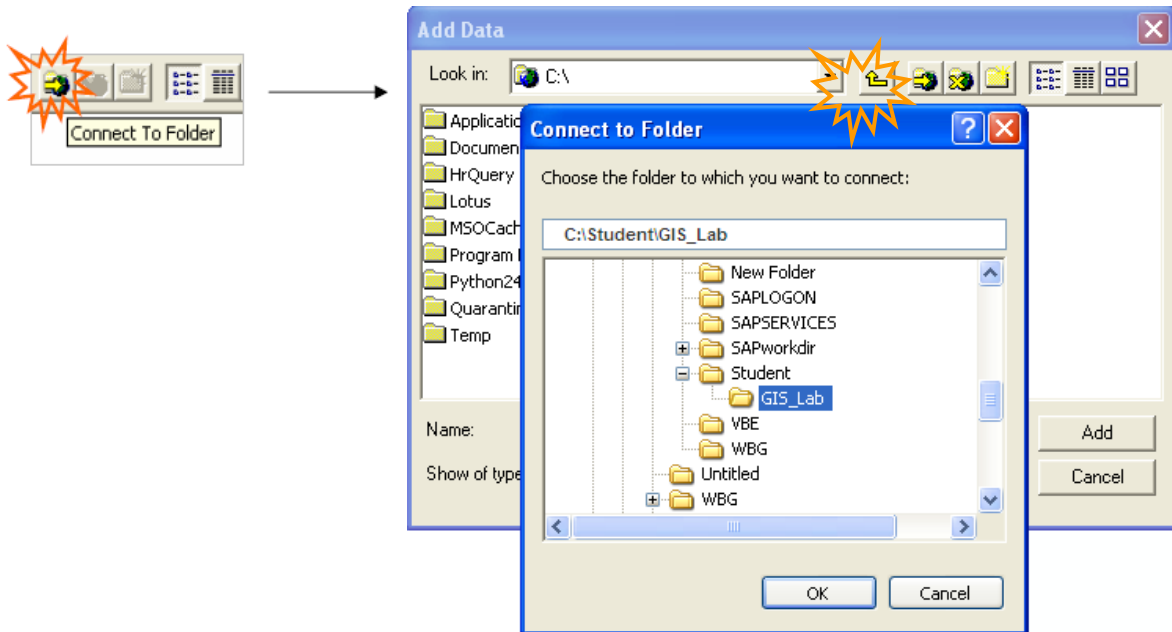


3. You are now looking at the basic ArcMap screen with its various menus and tools. To begin with, we will add some data. From the “File” menu, select “Add Data”. (You will notice that the “Add Data” icon is replicated on the main tool bar. You will find that this is the case for many of the tools and functions within ArcMap.)



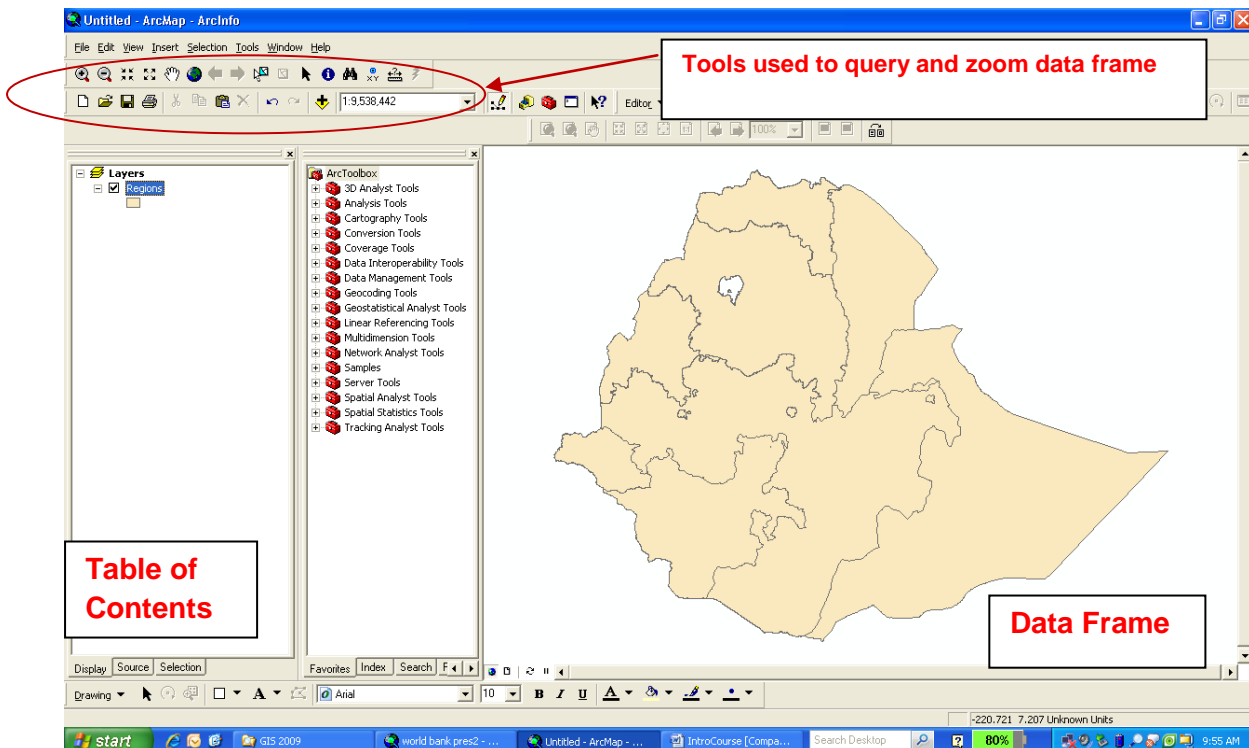
4. In the “Connect to folder” window, navigate to the location of your Tutorial folder: “D:\Student\GIS_Lab_2011”, and click OK.

You will only have to do this step once. By establishing this connection, you will be directed to your GIS lab folder each time you return to it and add new data to the map. It's like creating a shortcut.




5. Now open the folder “Lab_01”, and select the file named “Regions”.

(If a warning box pops up when you attempt to add data at any point, just click OK)



6. The outline of Ethiopia should now be visible in your map window. Notice that on the left hand side of the screen you have a box containing a short list, beginning with the word “Layers.” This

box is called the Table of Contents, and it lists the names of the various data layers in the map. It shows the color symbol used to draw each layer, and tells you by means of a check mark, whether or not the layer is visible.

7. Left click on the various (+) & (-) boxes in the Table of Contents window, noticing how the Table of Contents changes. It works in a similar way to a data tree within Windows Explorer. Click on the checked box next to the "Regions" Layer to turn the layer off, click it again, and the map reappears.
8. The main window of the ArcMap interface is called the Data Frame. It is where your data is displayed and manipulated. The various toolbars can be found both above and below the Data Frame. Many of their functions are also replicated in the standard drop down menus to the top left.
9. In order to make the map more detailed, we will add further layers. Add additional data by using either the "File" menu, or click on the "Add data" icon . You will be taken back to the "Lab01" folder. Select "Cities.shp" and holding down the "ctrl" key select "Rivers.shp" and "Lakes.shp". Click Add. The fact that you now have multiple layers in your map is represented in your Table of Contents. Make sure that you see the "Regions", "Cities", "Lakes" and "Rivers" shapefiles in your Table of Contents on the left of your screen.

Navigation using the ArcMap toolbars


10. Hold down your left mouse button over "Cities.shp" and drag it down below your "Regions.shp" file. What happened to your map? The Table of Contents window controls the various layers of your map. Whichever layer is on top in the Table of Contents, will also be the topmost layer of your map. Move the other layers around to see how this property works.

IMPORTANT NOTE: In order to drag files to reorder them, your table of contents must be in the Display mode, look at the bottom of the table of contents and make sure that the Display tab is selected). Click on the Source tab at the bottom of the Table of Contents. Now that you are in this tab, you can see where each data source came from. Try to reorganize your shapefiles so "Regions" are on the top again. Notice that you cannot move the order of your shapefiles unless you are in the Display tab. Click on the Display tab again at the bottom of your Table of Contents in order to change order of your shapefiles in the Table of Contents.

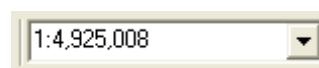



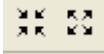
11. On your screen are various tool icons. By moving your mouse over each icon in turn, a pop-up box will alert you to the name and/or function of that particular tool. Many of the tools, though new, are self-explanatory, and many others, such as the "Drawing" tools, are quite similar to those found in basic Windows programs. The most basic toolbar within ArcMap contains the navigational tools:




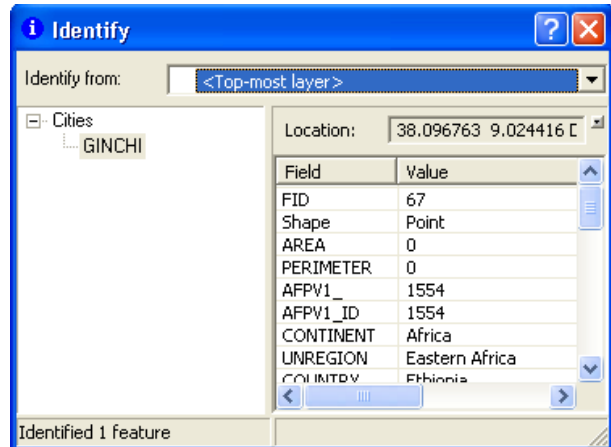
12. Locate the "Zoom In" tool . Using this tool, draw a box around Addis Ababa by left click and hold while you draw a box. Now, select the tool that looks like a hand. This is called the "Pan" tool. Use it to 'grab' the map and move it around in order to see other areas of your map.


13. On your toolbar, you will see the scale box.



14. Using the “zoom in” / “zoom out”  or the “fixed zoom in” / “fixed zoom out”  tools, adjust the map until your scale shows approximately “1:2,000,000”. You may also manipulate the scale box by directly typing the required scale.

15. Switch to the identify tool  and click on any one of the diamonds representing the cities. The “Identify Results Dialog” shows you various facts about the feature that you have selected. Using the Identify tool, you can see the information associated with each city in the pop up dialog.



16. Now click on the tool called “Full Extent” . This resizes your map to cover the full area of your largest feature (all of Ethiopia).

17. Click on the tool for “Previous Extent”  and it will take you back to your last zoomed in view.

Now that we have explored a little on how to maneuver the basic tools in the map viewer format, we will now look at the data that are behind the shapefiles, these data are very similar to an excel table.

Feature Attribute Tables

In GIS, a feature on a map may be associated with a great deal of information – more than can be displayed at any given time. This information is stored in an **Attribute Table**. A data layer’s attribute table contains a row (or record) for every feature in the layer and a column (or field) for every attribute, or category of information. When you clicked on one of the ‘Cities’ points in Step 17 (above), the information you saw in the identity results dialog was the information stored in the **Attribute Table** for the “Cities” Layer.

18. Click on the “Add data” icon. You will be taken back to the “Lab_01” subfolder. Select “Zones.shp” and click “Add”. You may have a warning message pop up, just press the OK tab; we will cover this in the next lab. In the table of contents, right click on the new data layer “Zones.shp”, and click the option “Open Attribute table”.
19. Scroll down the table. There are 74 records (record one is numbered as 0 – see first observation in the table under column heading FID), one for each zone in Ethiopia.

20. There are multiple attributes, or fields. The “FID” field contains a unique identification number for every record. The “SHAPE” field describes the object geometry (Point, Line, Polygon). Among other attributes is the Zone name (EASE_ZoneN), its corresponding Region code.

FID	Shape *	OBJECTID	Z4ID	EASE_Z4ID	EASE_ZoneN	REGION_R2I	EASE_Z6ID	Area_km2	Shape_Leng	Shape_Area
0	Polygon	1	0101	0101	Western Tigray	01	010100	24651.639216	8.840653	2.062609
1	Polygon	3	0103	0103	Easetern Tigray	01	010300	5795.04492	5.123122	0.485374
2	Polygon	4	0102	0102	Central Tigray	01	010200	10327.343231	5.802723	0.864498
3	Polygon	7	0202	0202	Zone2	02	020200	29719.097944	8.065838	2.48092
4	Polygon	29	0301	0301	North Gonder	03	030100	45486.128346	14.883025	3.783169
5	Polygon	31	0104	0104	Southern Tigray	01	010400	9408.097349	5.629796	0.784358
6	Polygon	34	0105	0106	Mekele	01	010600	24.289371	0.220693	0.002029
7	Polygon	43	0308	0308	Wlag Hemira	03	030800	8478.994163	4.895377	0.706362
8	Polygon	47	0201	0201	Zone1	02	020100	33086.254264	7.712639	2.743567
9	Polygon	49	0204	0204	Zone4	02	020400	11022.29935	4.020151	0.91641
10	Polygon	65	0302	0302	South Gonder	03	030200	14607.450289	5.962336	1.212199
11	Polygon	69	0303	0303	North Wollo	03	030300	12702.071544	5.727648	1.05478
12	Polygon	76	0602	0602	Metekel	06	060200	26517.421181	8.683132	2.188726
13	Polygon	82	0307	0307	West Gojam	03	030700	13412.846933	9.397418	1.108678
14	Polygon	95	0304	0304	South Wollo	03	030400	17212.240204	7.450175	1.424688
15	Polygon	102	0311	0311	Bar Dar Sp. Zone	03	031100	6.728075	0.098078	0.000558
16	Polygon	106	0309	0309	Awri	03	030900	6346.155558	4.808264	0.524448
17	Polygon	108	0310	0310	Oromia Zone	03	031000	4072.658964	4.434618	0.336817
18	Polygon	114	0205	0205	Zone5	02	020500	5355.731732	4.469969	0.44252
19	Polygon	116	0603	0603	Asosa	06	060300	14537.872886	8.160334	1.193811
20	Polygon	117	0306	0306	East Gojam	03	030600	14185.54544	6.134114	1.172112
21	Polygon	119	0203	0203	Zone3	02	020300	16439.741082	6.882345	1.356502
22	Polygon	134	0501	0501	Shimle	05	050100	30684.533086	8.07995	2.528019
23	Polygon	153	0305	0305	North Shewa (K3)	03	030500	16077.219047	9.036183	1.325998
24	Polygon	164	0604	0604	Kemashi	06	060400	8948.175608	11.487186	0.735885
25	Polygon	174	0406	0406	North Shewa (K4)	04	040600	11269.335837	7.429462	0.929063
26	Polygon	178	0402	0402	East Wellega	04	040200	22180.514992	8.47837	1.825229
27	Polygon	183	0502	0502	Jigga	05	050200	13373.506893	5.302517	1.096115
28	Polygon	195	0401	0401	West Wellega	04	040100	24315.509249	8.857265	1.992091
29	Polygon	204	0405	0405	West Shewa	04	040500	21812.154774	7.043331	1.794341
30	Polygon	217	0410	0410	East Harerghe	04	041000	23543.577928	8.659682	1.931201
31	Polygon	223	1501	1501	Dire Dawa	15	150100	1052.651008	1.606146	0.086776

21. The order in which the fields are displayed can be rearranged, much like in excel. Click once on the field name in order to highlight it, then, click a second time (you should see a white arrow), to drag it to your preferred location. Rearranging the data like this has no adverse effects on the database or map.


22. Field data may also be sorted. Right Click on the field “NAME”. You will have option to sort “Ascending” or “Descending”. Depending on the field type, the data will be sorted in alphabetical or numerical order. Sort and resort this field and observe the effects on the table arrangement.

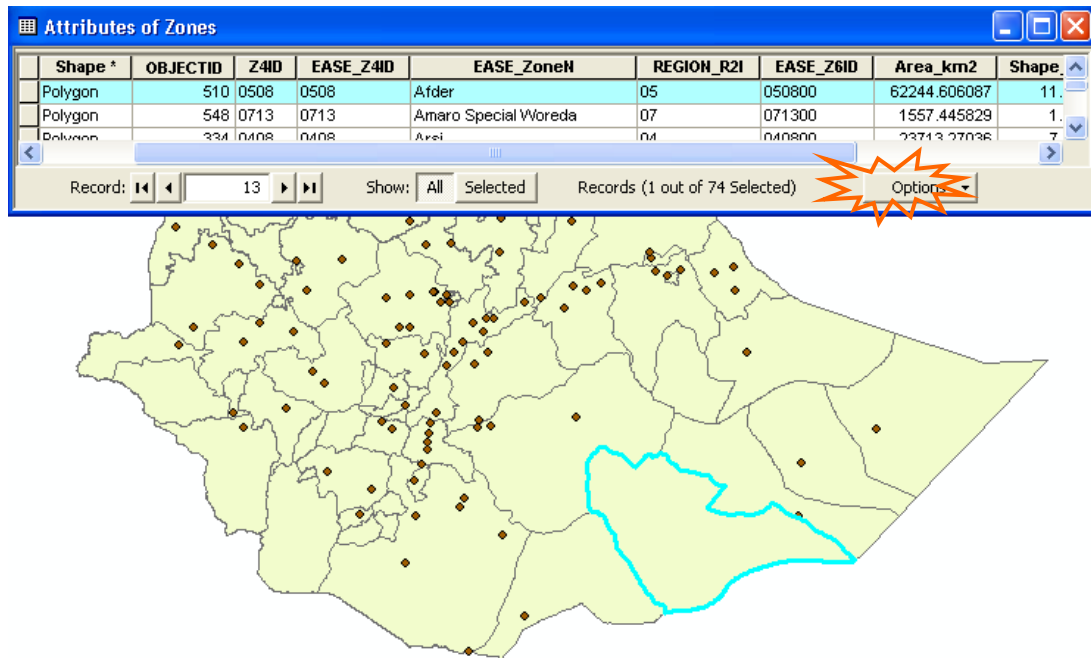
FID	Shape *	OBJECTID	Z4ID	EASE_Z4ID	EASE_ZoneN	REGION_R2I	EASE_Z6ID
65	Polygon	510	0508	0508	Afder	05	050800
69	Polygon	548	0713	0713	Amaro Special Woreda	07	071300
45	Polygon	334	0408	0408	Arsi	04	040800
19	Polygon	116	0603	0603	Asosa	06	060300
16	Polygon	106	0309	0309	Awri	03	030900
51	Polygon	397	0411	0411	Bale	04	041100
15	Polygon	102	0311	0311	Bar Dar Sp. Zone	03	031100
68	Polygon	530	0720	0718	Basketo Special Woreda	07	071800
61	Polygon	470	0711	0711	Benchi Maji	07	071100
66	Polygon	514	0412	0412	Borena	04	041200
71	Polygon	557	0714	0714	Burji Special Woreda	07	071400
2	Polygon	4	0102	0102	Central Tigray	01	010200
59	Polygon	462	0719	0717	Dawuro	07	071700
35	Polygon	277	0504	0504	Deghabur	05	050400
70	Polygon	553	0716	0716	Derashe Special Woreda	07	071600
31	Polygon	223	1501	1501	Dire Dawa	15	150100
1	Polygon	3	0103	0103	Easetern Tigray	01	010300
20	Polygon	117	0306	0306	East Gojam	03	030600
30	Polygon	217	0410	0410	East Harerghe	04	041000
34	Polygon	273	0407	0407	East Shewa	04	040700
26	Polygon	178	0402	0402	East Wellega	04	040200
46	Polygon	356	0503	0503	Fik	05	050300
41	Polygon	313	0708	0710	Gamo Gofa	07	071000
67	Polygon	526	0705	0705	Gedeo	07	070500
60	Polygon	465	0507	0507	Gode	05	050700


23. Records, as well as fields can be highlighted. When a record is highlighted in a table, its corresponding feature is highlighted in the map. A highlighted record or feature is said to be “Selected”.

24. Right click on the field “NAME” and Sort Ascending. Click the grey tab at the left edge of the first record in the table, (Afder). This record is now selected. See below.

FID	Shape *	OBJECTID	Z4ID	EASE_Z4ID	EASE_ZoneN
65	Polygon	510	0508	0508	Afder

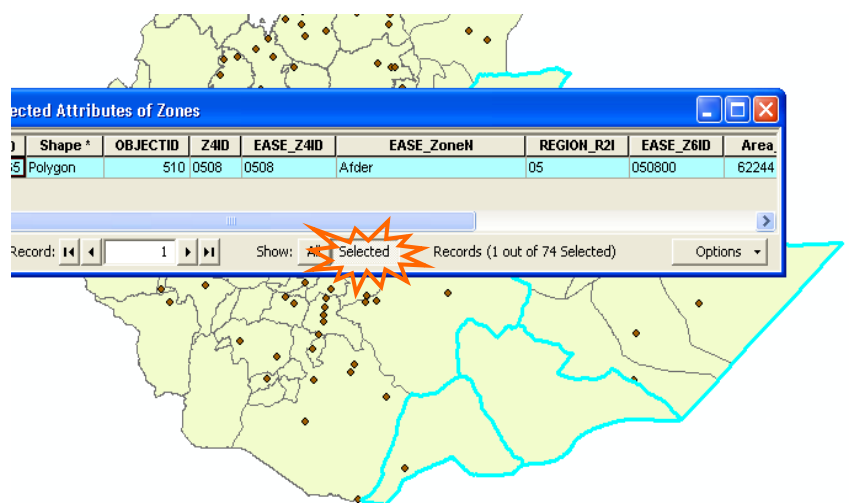
25. Move or minimize the attribute table in order to see the map more clearly. The Afder zone should be highlighted. You may have to use the “Zoom to Full Extent”  to spot the selected district.




26. To unselect this record, Select the “Options” tab on the bottom right-hand side of the Attribute table, and click “Clear Selection”.
27. You can also select objects in ArcMap directly from the map window. Close the attribute table for now. Pan to the Southern Area, and select a zone using the following “selection” tool from the main toolbar. 

28. Reopen the attribute table for “Zones.shp”. On the bottom-center of the attribute table, click on the button “selected”. The district you selected should appear as the only record in this list.

See how the link between table and map works; Items selected in the map are also selected in the table, and visa versa. When you select a zone, and you see that more is being highlighted than just the zone, this is because the select tool selects the related area with each area file in the table of contents. So, not only did you select Afder Zone, but you also selected Somali Region. You can open the Regions Attribute table and click on the “Selected” tab, you will see that Somali Region is selected.



29. Now unselect this record by selecting the “Options” tab on the bottom right-hand side of the Attribute table, and click “Clear Selection”. Close the attribute table. If you still have an area that seems selected on your map, you can use the “Unselect” button  to unselect everything in the Data Frame.

Symbolizing Features

Symbolizing features means assigning them colors, markers, sizes, widths, patterns, transparency and other properties by which they can be recognized on a map. Data Layers added to Arc Map have default Symbology. Points are displayed with small circles or diamonds, and polygons (or shapes) have a fill color and outlines. The colors for points, lines and polygons are randomly chosen.

30. First, turn off the “Zones” layer, by clicking the little black check mark to the left of the layer name “Zones”.

31. Then, use the “Zoom to Full Extent”  button to return to a view of entire Ethiopia.

In the Table of Contents, double-click on the color symbol for “Regions” layer.

The Symbol Selector dialog opens.



32. The scroll box on the left contains predefined symbols. The options frame on the right allows you to pick specific colors and set outline widths. Choose a color of your preference for both Fill and outline.



33. Next, we will work on the Symbology for the Cities. In the table of contents, double click on the point symbol for the “Cities” layer. The Symbol Selector dialog opens once again. In the scrolling box of predefined point symbols, click “Circle 1”. In the “Options” frame, click the drop-down arrow to change the symbol size to 4 points.

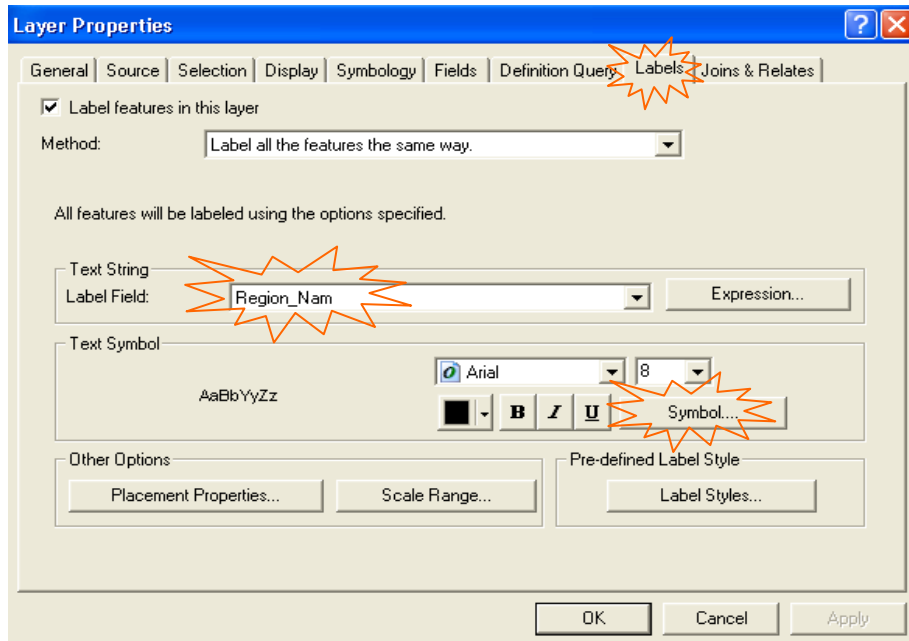
Again, choose your color preference. On the map, the Cities should display with your new symbol.

34. Choose a new color for the “River” layer also by double clicking on the line symbol underneath the layer in the Table of contents, as you did for the “Zones” and “Cities”.

35. Experiment with the colors and options for the various layers. You are not tied to those suggested by this lab.

→ **Labeling:** All maps contain textual information. Features in ArcMap are identified with labels that make use of information from fields in the Attribute table to identify a particular set of features.

36. For the moment, turn off your “Cities” and your “Rivers” layer.
37. Double left click on the “Regions” layer, The pop-up window you now see is called the “Layer Properties” dialog. The mapmaker controls many properties of an individual layer from this dialog, and we will work with this quite regularly in the future, but for the moment, click on the “Labels” tab. (see below)
38. Click on the arrow for the drop down menu on the Label Field option, and choose “Region_Nam”.



39. Using the text tools, change the label to bold size 8. For more advanced options, click on the button “Symbol”, then the button “Properties”, and finally the tab “Mask”.

This will allow you to put a halo on your text. Choose a white halo, of 1.5 points.

Click OK repeatedly to accept these changes and exit out of the Layer Properties dialog.

You are encouraged to explore the other tabs within the labeling function at your leisure. For example, you can explore the “Label Styles” under Pre-defined Label Style to see different sizes of text and shadowing styles.

Saving your progress

At this point, you have changed and customized quite a few features of this map. In order to preserve these changes, we will now save your progress as a “Project file”.

A project file in ArcMap carries the file extension .mxd. An .mxd file saves each component of a working map, from the files you have opened, to the colors you have chosen. This allows you to edit and return to a particular map, repeatedly.

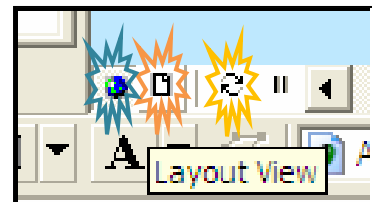
40. From the “File” menu in the top left corner of your screen, choose “Save As”. Navigate to the GIS folder on the C: drive; C:/Student/GIS_Lab/Lab01, and save as “Lab01_”Yourname”.mxd. It is always a good idea to save your map repeatedly while working.

The Layout View

41. You now have a basic GIS map of Ethiopia. The next step is to prepare this map for printing.
42. First, make sure that your “Regions”, “Cities”, and “Rivers” shapefiles are all turned on by checking the checkmark box next to the layer name in the table of contents. Also, go to the “Add Data” button, and add the “Lakes” shapefile to your datascreen.
43. The map window that you have been working in up to now is called the “Data View”.

We will now move to a different map window called the “Layout View” to prepare the map for printing. The “Data View” is where you perform the majority of your GIS editing work, while the “Layout View” is where you arrange your map(s) along with preferred graphics for printing or export. To navigate between these two views, there are two small tabs located on the bottom left-hand corner of the main map window.

44. The “Layout View” is represented by the white sheet of paper, and the “Data View” by the little globe. Click over and back between these tabs, and observe the changes.

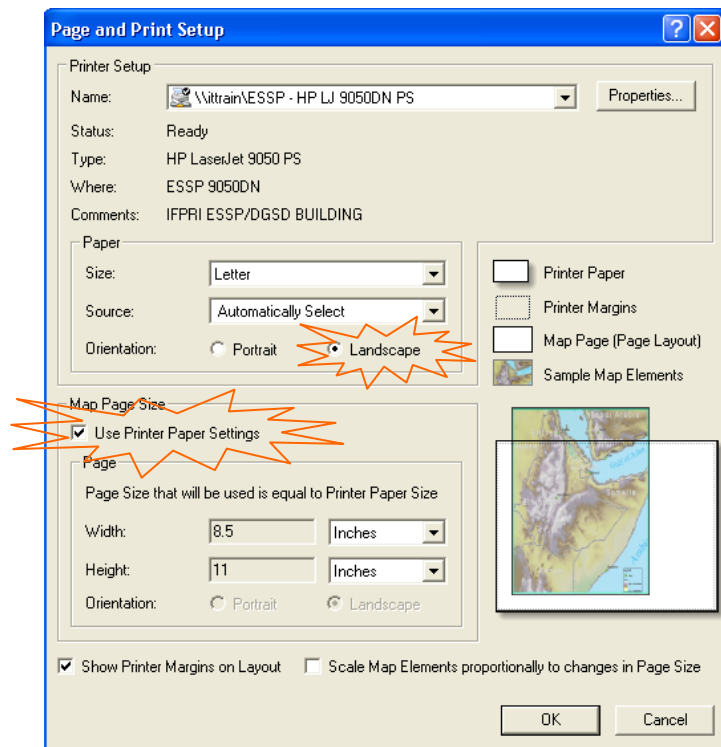


45. The third little icon, represented by the double arrows, is the “Redraw/Refresh” button. Use this button at any time, if you feel your map has not redrawn fully after opening or editing.

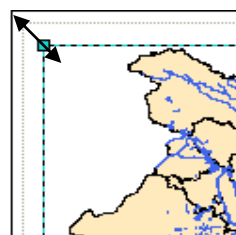
46. When you have finished experimenting with the alternative map views, select the layout view.

47. We want to select a paper setup that best fits the geographical nature of Ethiopia in order to use the most space on our page for our map.

Click on the File tab in the upper left of your screen and scroll to “Page and Print Setup”. Make sure you select Landscape for the Orientation. Also click the checkmark to “Use Printer Paper Settings”. This will give you a dotted outline of how far you are able to expand your map. (see next step)



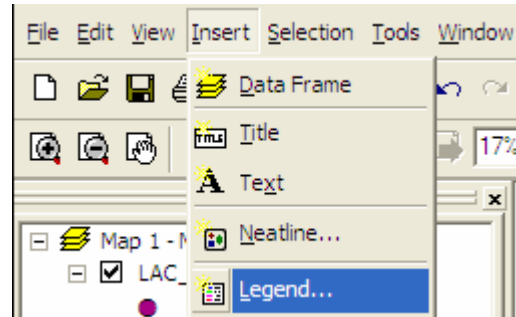
48. Now, resize the window around your map of Ethiopia, so that it fits within the printable area.



49. Using the “Insert” menu, add a Title, Scale Bar, and North Arrow to your map. Using the insert title option, name your map “Ethiopia: Regions and Cities” (or something similar).

There are many Scale Bars, and North Arrows styles to choose from. Pick your favorite.

50. Return to the menu option “Insert” and click on “Legend”.



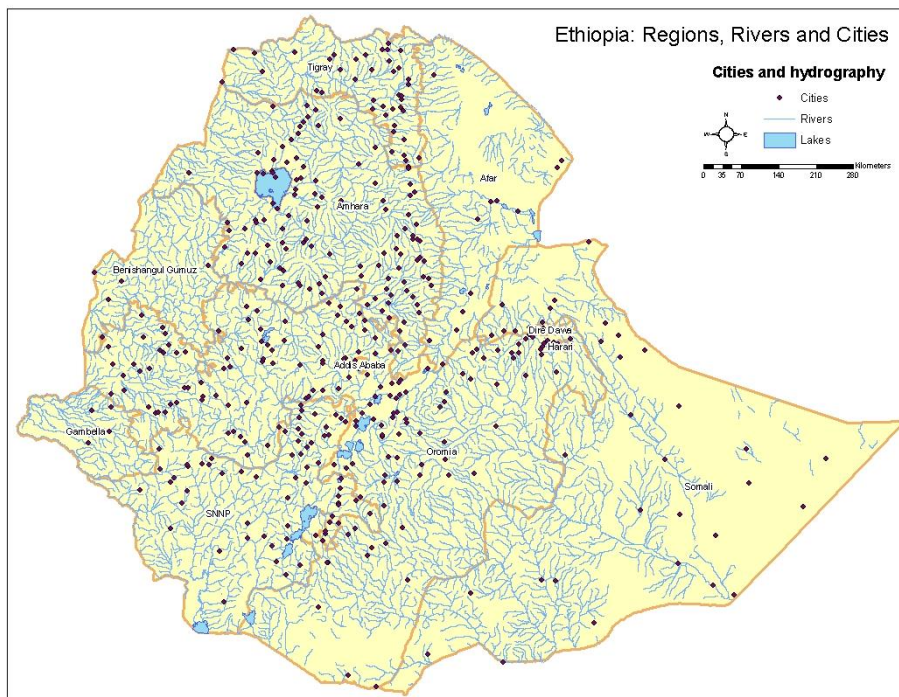
51. In the Legend Wizard dialog that pops up, accept all the default options by Clicking “Next” repeatedly, and finally “Finish”.

52. You will notice a small legend appear somewhere in the middle of your layout window. Position it correctly.

53. If you wish to change the name of your layers in the legend, edit the corresponding text in the table of contents, and it will also change in the legend. Just click twice on the text in the table of contents to edit it, (as you would to rename a file in Windows Explorer).


54. When you are happy with the appearance of your map, you can export this map as a .jpeg, by choosing the menu option “File”, scroll to “Export”, then save with as (Lab01_YOURNAME.jpeg) in your Lab01 folder following the instructions.

➔ **PLEASE MAKE SURE that you save the changes to your map before you continue.** Your map should look similar to the one below (featuring your own color and style preferences of course).

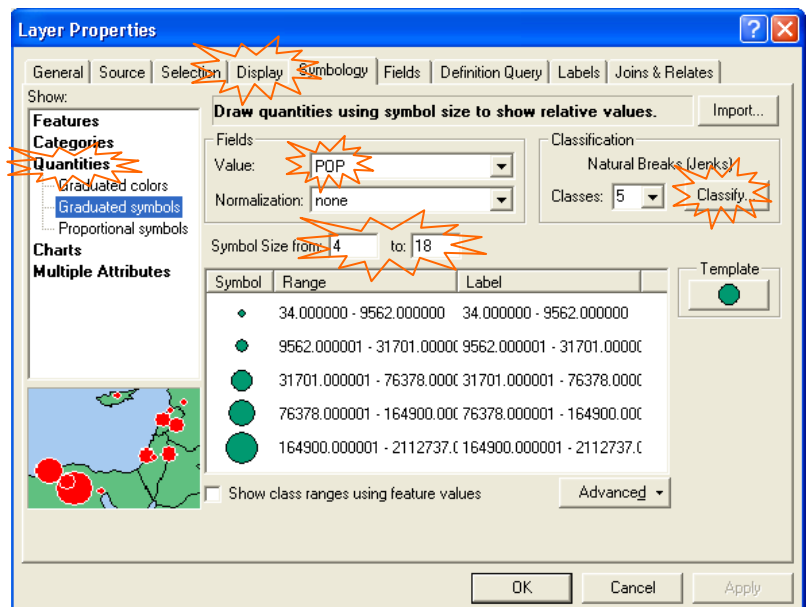


Lab 02: Advanced symbology

In the previous exercise, Rivers had the same line symbol regardless of their level of importance. This is sufficient for a basic navigational map, but most GIS maps are used as a visual interpretation of tabular data, therefore we will learn how to visualize such data in this lab.

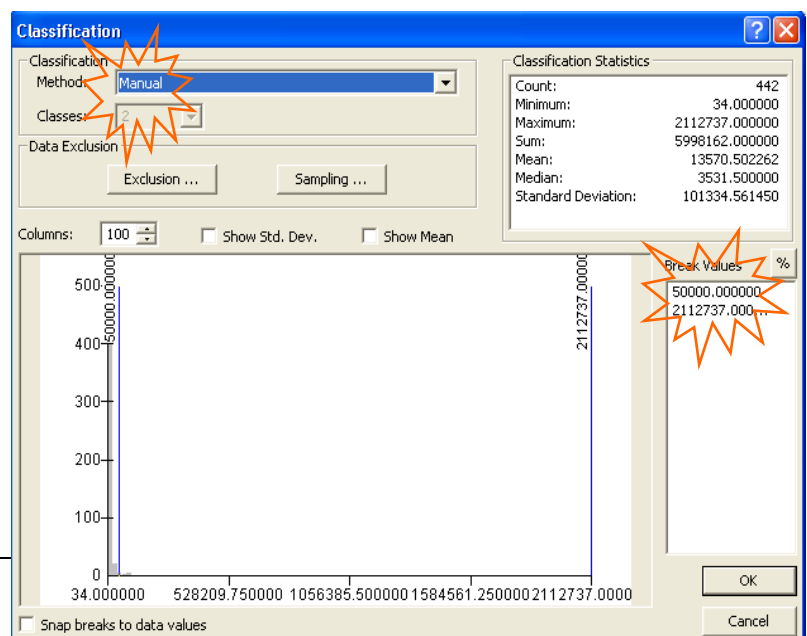
1. Open a new, blank map by clicking on the “New Map” button  in the upper left corner of your screen below the “File” button.
2. From your Lab01 folder, add the file “Regions”, “Cities”, “Lakes” and “Rivers”. Reorder these files in the table of contents so that “Cities” are on top, “Rivers” are next, then “Lakes” and “Regions” is at the bottom. Remember: Your table of contents must be in the Display mode, look at the bottom of the table of contents and make sure that the Display tab is selected.
3. From your Lab02 folder, add the “Roads” shapefile. Uncheck the roads layer for now so you don’t see it in your map frame; we will work on that later. When you uncheck it, the roads layer should disappear from the Data Frame.
4. Choose an appropriate color for the “Regions” layer, and then SAVE your project file as Lab02_YOURNAME to the Lab02 folder.
5. Double-click on the layer name “Cities”; this will take you directly to the “Layer Properties” for the layer. Select the tab “Symbology”.

6. In the “Show” box (see graphic), click on the option “Quantities”, and the sub-option “Graduated symbols”. In the “Value Field” dropdown list, select the Field name “POP”.



7. Click “Apply”, but not OK. If you move your dialog slightly you will see that the city symbols have changed. The map is still a little too busy. Change the “Symbol size” to “from: 4 to: 12”.
8. Next, click on the “Classify” tab. This will take you to the “Classification” drop down menu (see graphic).

9. Click on the arrow to the right of “Classes” and choose 2. Click on the arrow to the right of “Method” and choose “Manual”.

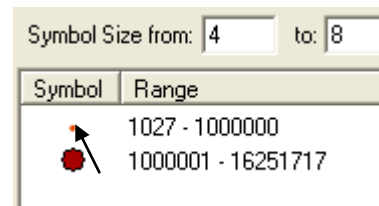


10. Choose your “Break Values” to be 50,000 and the second the same as it displays the maximum value of population of a city. (See right)


11. Press OK once you have finished step 10.

- Now you are back to the Layer Properties Window. Double-click on the largest circle and chose a bright color to represent the cities that are greater than 50,000 people. Press OK.

Double-click on the other circle and chose the symbol "Circle 1" in the left box, change the size to 4 and choose a color for these cities that display population under 50,000.



- Press OK repeatedly until you see the mapping screen again.

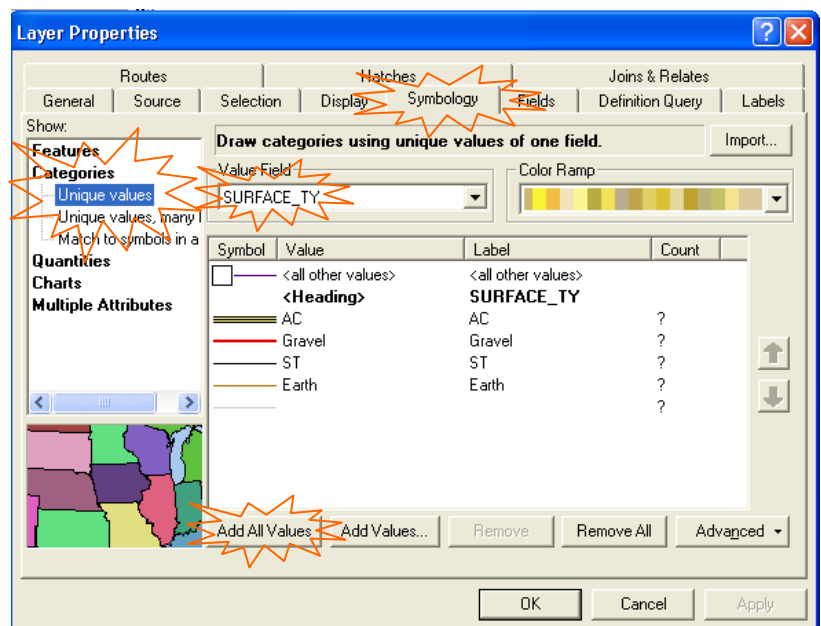
- Now it should be clearer where the cities of 50,000 are. Switch to your identify tool , click on one of the large circles. Scroll up and down in the "Identify" window that appears in order to read the attribute information. What is the city's name (SCHNM)? What is its population (POP)? What is the population calculated for the year 2000 (ES00POP)?

→ Now, **SAVE YOUR WORK** again as **Lab02_YOURNAME!!**

- Okay, now we are ready to add our roads. Check the box next to your roads layer so it appears in your Data Frame.
- Wow! There are a lot of roads in Ethiopia, this is not very helpful. Double click on the roads layer (double-click on the word 'Roads') in order to enter into the "Layer Properties" window. Click on the Symbology tab like you did when you were working on the cities.
- Click on "Unique Values" under the "Categories" option to the left of the Layer Properties window. (see below)

- Next, in the drop down menu on the Value Field, choose "SURFACE_TY" and then click on the tab "Add all Values".

- Let's first see how the Primary roads connect to major cities (The primary roads here are labeled as AC or Asphalted Concrete).

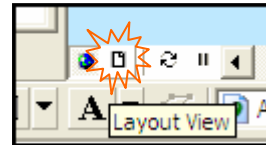


- Double click to the left of the "AC" on the line symbol, this will take you to the "Symbol Selector" window, choose the "ExpressWay" symbol and press OK. You are now back at the "Layer Properties" window.

- Now, press "Apply" and move the "Layer Properties" window to the side so you can see your map. Now you are able to see the primary roads more clearly.

- Now let's label the other roads more clearly. Double click on the line next to the "Gravel" roads in order to the "Symbol Selector" again. Choose "Major Roads" symbol and press okay. Do the same for the roads labeled "ST" and "Earth in order to display them in a different color. Press "Apply", and now all roads in your Data Frame should have the colors you chose to display.

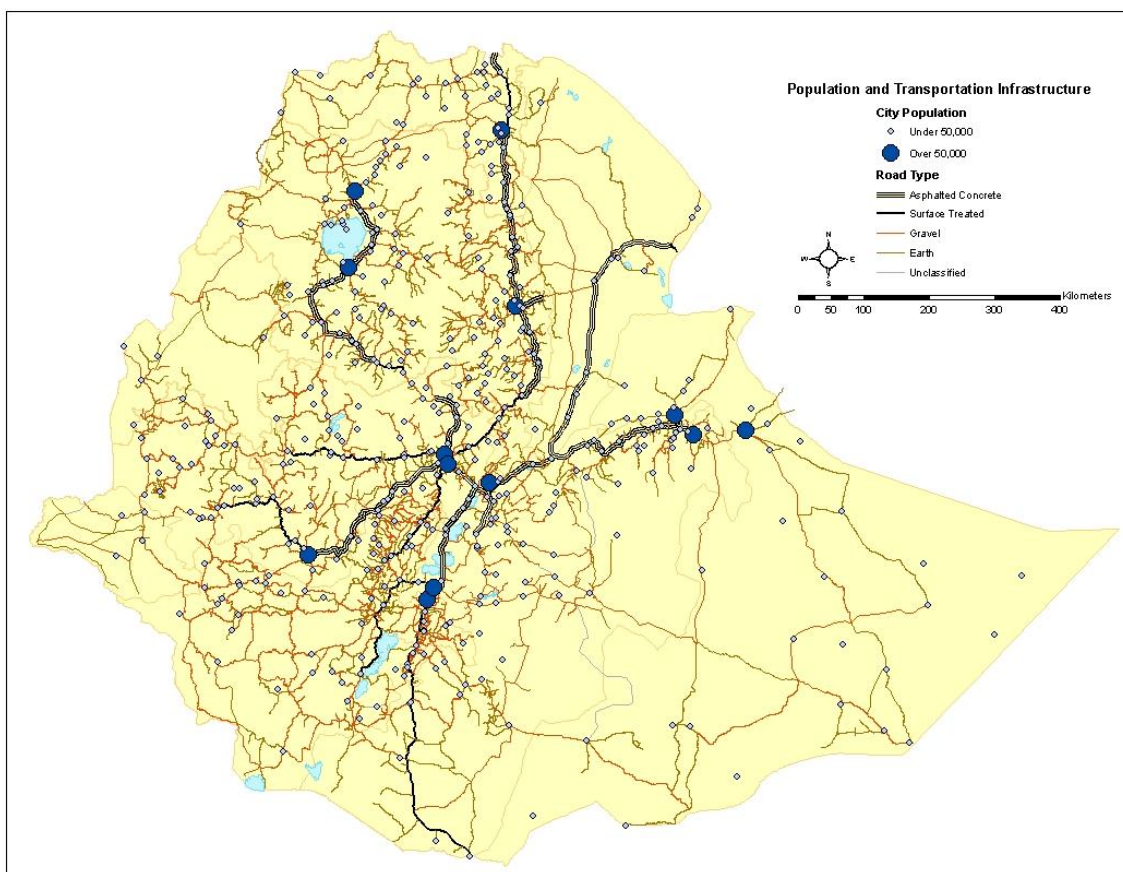
23. When you have finished experimenting with the alternative Roads views, select the **layout view** (see step 44 in previous exercise if you need help).




24. Using the “Insert” menu, add a Title, Scale Bar, and North Arrow to your map.
25. Return to the menu option “Insert” and click on “Legend”.
26. In the Legend Wizard dialog that pops up, except all the default options by Clicking “Next” repeatedly, and finally “Finish”.
27. You will notice a small legend appear somewhere in the middle of your layout window. Position it correctly.
28. If you wish to change the name of your layers in the legend, edit the corresponding text in the table of contents, and it will also change in the legend. Just click twice slowly on the text in the table of contents to edit it, (as you would to rename a file in Windows Explorer).
29. When you are happy with the appearance of your map, you can export this map as a .jpeg, by choosing the menu option “File”, scroll to “Export”, then save following the instructions.

Your map should look similar to the map below.

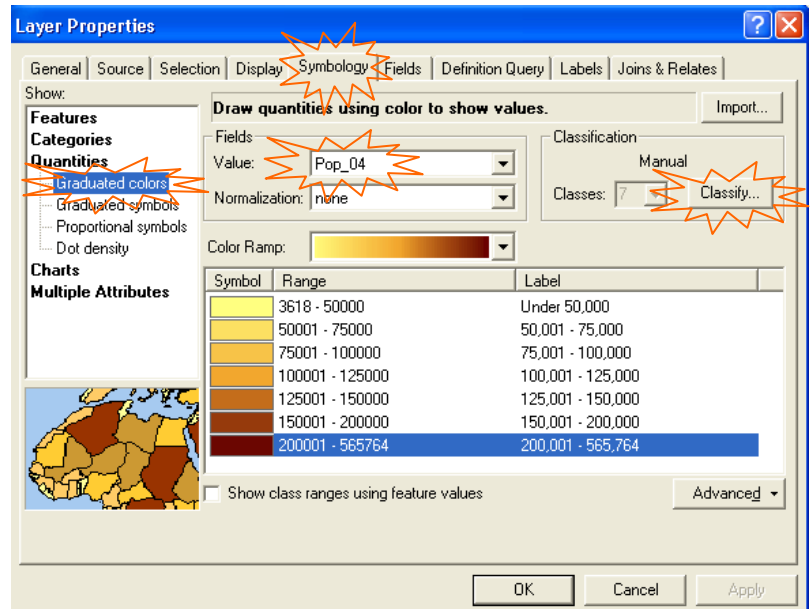
➔ PLEASE MAKE SURE that you save the changes to your map before you continue.



Lab 03: Chloropleth mapping in Arc-GIS

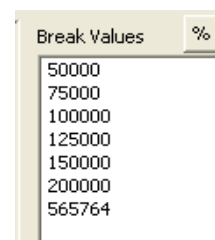
1. Open a new, blank map by clicking on the “New Map” button  in the upper left corner of your screen below the “File” button.
2. From your Lab01 folder, add the “Regions” and “Lakes” shapefile. From your Lab02 folder, add the “Roads” shapefile. From your Lab03 folder add the “Woreda” shapefile.
3. Double click on your “Woreda” layer in order to open up the “Layer Properties” window. And choose the “Symbology” tab.


4. Click on the “Graduated Colors” under the Quantities option on the left side of the Layer Properties window.



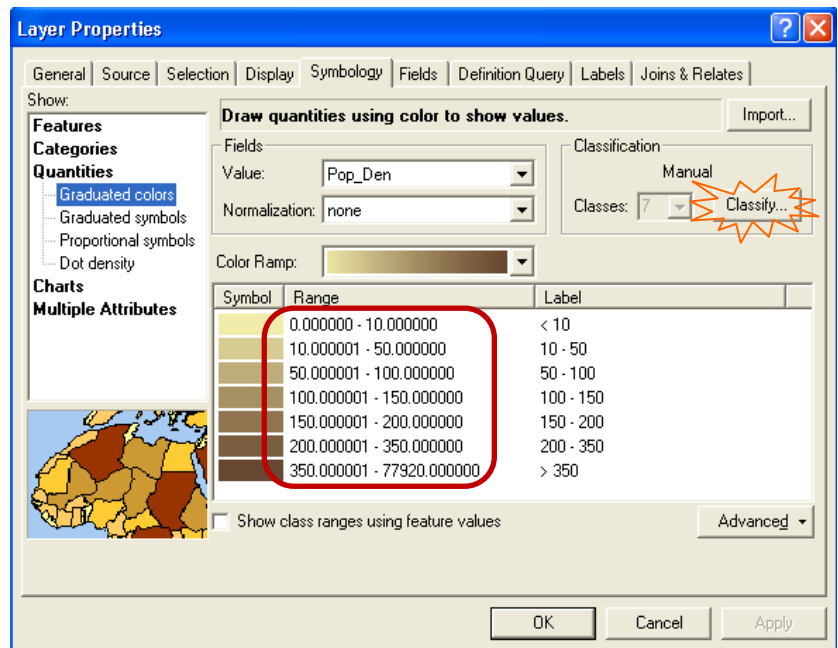
5. Choose Pop_04 in the Value Field, which is the population count per woreda in 2004.
6. Classify your data accordingly by clicking on the “Classify” button and choosing classifications for your values (see step 8 of the previous exercise for help in the specific steps of classifying your data). When finished, press Apply and Okay.

7. Now you are back to the Layer Properties Window. Left click on the numbers under the label column. Here you are able to change the labels of your data so when you make a map, the labels in the legend are clear (see right).

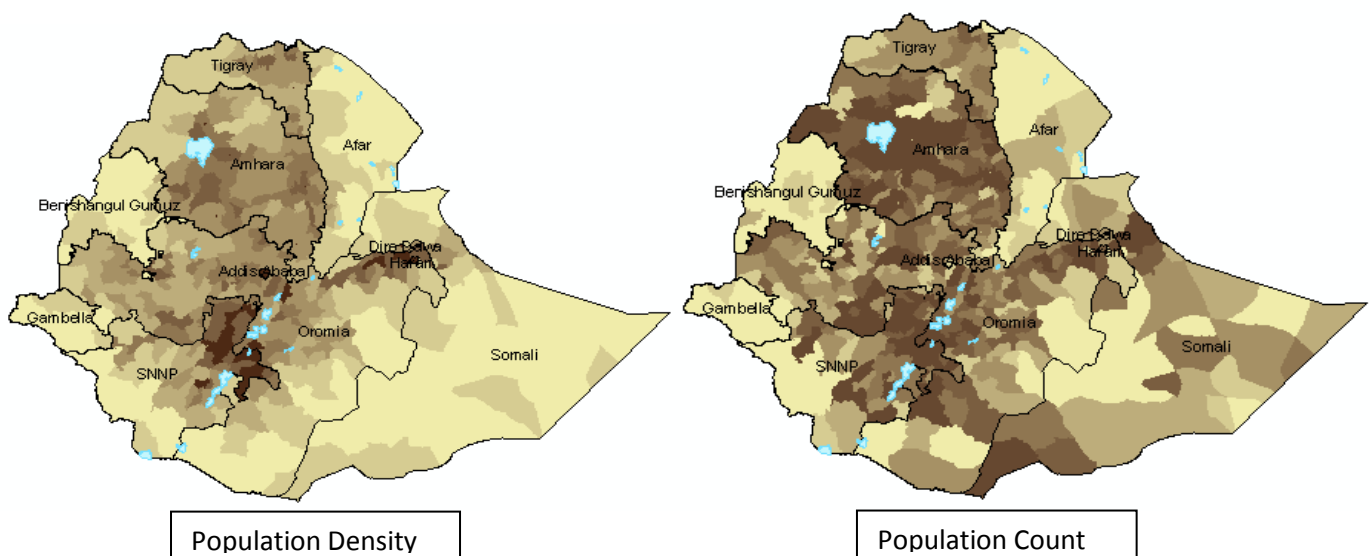


8. Change all of your labels following the graphic above. Then click out of the labels box and press Apply and OK to return to the mapping screen.
9. Make sure that your “Roads” layer is on and that you have classified your roads in hierarchical order.
10. It is interesting to note spatially how population follows critical road infrastructure. But, is population count an appropriate measure to understand relationships between infrastructure and demography? Let’s experiment with a different measurement to understand the differences and then create a map of both.
11. Right click on the “Woreda” shapefile name in the table of contents and press copy.
12. Scroll to the top of the Table of contents and right click on Layers tab  and choose “Paste Layers”. This will copy the same layer that you have already built on population count into the Table of Contents. You will now have two of the same “Woreda” layers in your table of contents.
13. Now, double click on the new “Woreda” layer that you just copied into your table of contents and click on the “Graduated Colors” under the Quantities option on the left side of the Layer Properties window.

14. Choose Pop_Dens (this is the population density: average people per square kilometer by woreda).
15. Classify your population density data by clicking on the “Classify” button and choosing classifications for your values. See the picture to the right under the label “Range” which shows how I classified my data. (look at step 6 above if you need help). When finished, press Apply and Okay.



16. Left click on the Symbol tab above the color squares and choose Properties for all Symbols. Under the Outline Color tab, choose No Color for your outline color and then press OK until you exit Layer Properties.
17. Notice how population density changes the further away one gets from the main infrastructure corridors in the highlands. Turn off and on the “Roads” layer in order to see the Density differences under the “Roads” corridors.
18. Now add your “Regions” shapefile from your Lab01 folder. Left click on the colored square underneath the layer in the table of contents in order to open the Symbol Selector window. Choose the “Hollow” option and press okay.
19. Turn off the “Roads” layer and just look at the differences between Population Density and Population Count. You can do this by turning off and on the Population Density “Woreda” layer. The layer beneath it is the Population Count layer.



Looking at the Population Density map, we can see that parts of SNNP and areas in the Northeast of Oromia have very high population density (see two maps below). In these high population density areas, what does the road infrastructure look like? Are they well connected?

Later in the course, we will use spatial analysis to calculate distance, access, and remoteness to specific targets such as cities and markets in order to quantify these relationships!

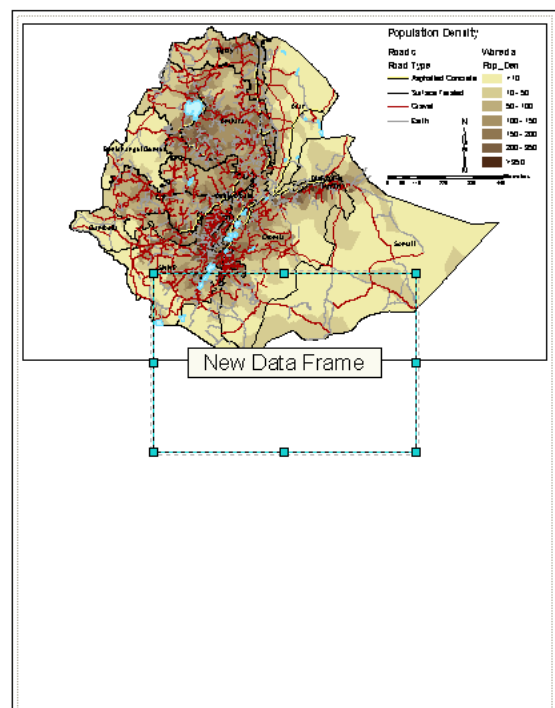
20. Now we will map both of the variables in the same layout window. Switch to the layout view, by

clicking on the layout symbol in the bottom left and corner of the map window. 

21. Using the “Insert” menu, add a legend, and other appropriate cartographic elements to your map (North Arrow, and simple scale bar) for the Population Density map.

➔ **Save your map if you haven’t recently!**

22. In the layout window, resize the map, so that it is roughly one-quarter the size of the page by clicking once on the map and then dragging one of the corner sizing squares to diminish the size of the map. (You will also have to resize the legend and other elements). Move them to the top right hand corner of your layout.

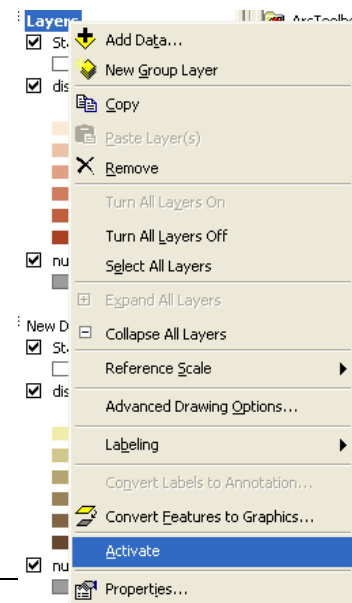



23. From the “Insert” drop down menu, choose the “New Data Frame” option. This will add a new empty map window to your layout. (see right)

24. Now to add data to your new map window. In the table of contents, right-click on the “Woreda: Pop_04” layer in your first Data Frame that you have been working with up until now and scroll to “Copy”.

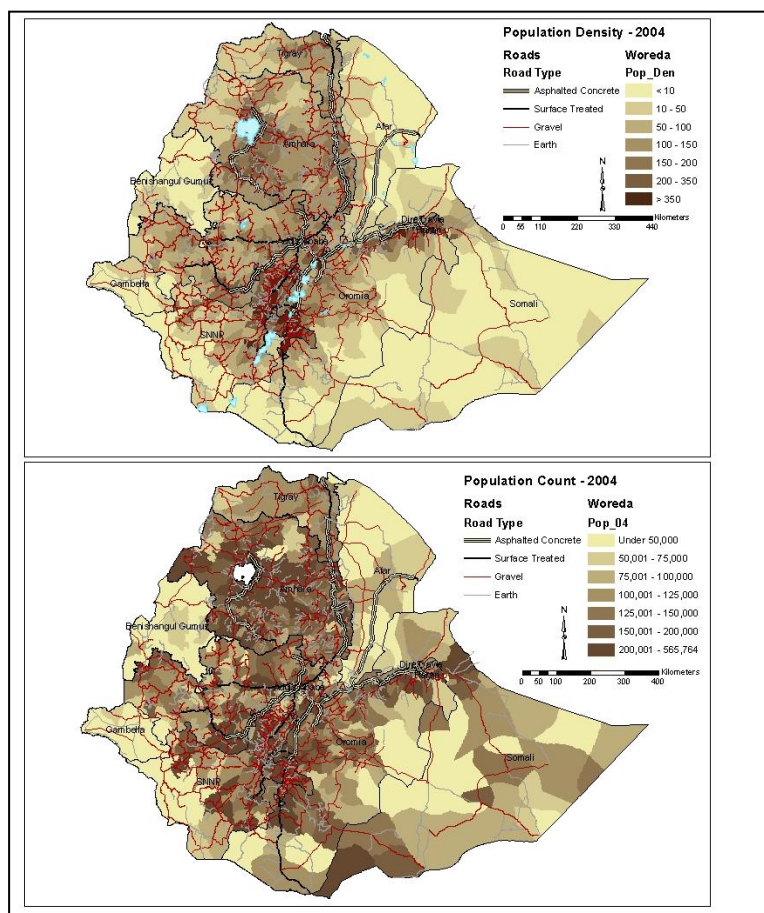
25. Now right-click on the “New Data Frame” listing, and scroll to “Paste”. Repeat the process to add the “Regions” and “Lakes” layer to your second map window.

26. In a multi-map set-up such as this. Only one map may be considered “Active” at any given time. This means that you can only work on the elements of one map at a time. To “Activate” a map, you can simply click on it in the layout view, or, you can right-click on the title of its corresponding set of layers in the table of contents, and scroll to “Activate”.




27. On switching to the “Data View” (remember, the little globe symbol),  you will notice that only the active map is shown.
28. Test this by switching to the “Data View” and activating (from the table of contents) each map in turn.
29. After understanding varying “Data View” interfaces, put the final touches on the maps (including adding another legend for the Population Count map) that you chose to make and export them as a .jpeg by going to the “File” button in the upper, left corner. Scroll to export and save as .jpeg in your Lab03 folder!

Your layout window should now look something like this, but may have different colors!

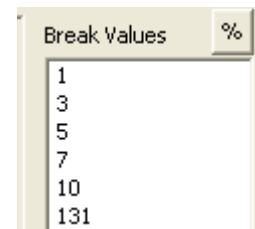


Lab 04: Working with Attribute Tables in ArcGIS

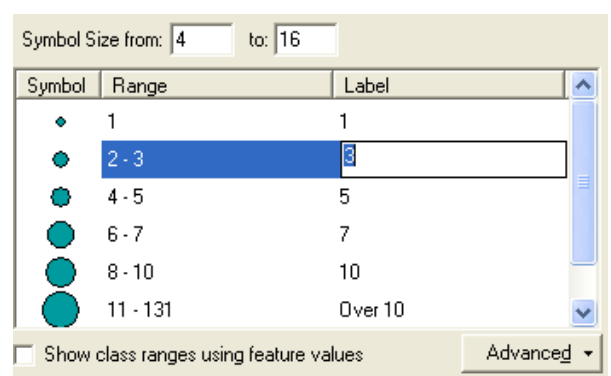
1. Open a new, blank map by clicking on the “New Map” button  in the upper left corner of your screen below the “File” button.
2. From your Lab01 folder, add the “Cities” and “Lakes” shapefiles.
3. From your Lab02 folder, add the “Roads” shapefile. From your Lab03 folder add the “Woreda”. From your Lab04 folder add the “Banks”, and “Microfinance” shapefiles. Reorder your shapefiles so that the point data are at the top of the table of contents, then the “roads”, and last the “woreda” shapefile.

➔ **Remember:** Your table of contents must be in the Display mode, look at the bottom of the table of contents and make sure that the Display tab is selected.

4. Choose an appropriate color for the “Woreda” layer, and then SAVE your project file as Lab04_YOURNAME to the Lab04 folder.
5. Double-click on the layer name “Banks”; this will take you directly to the “Layer Properties” for the layer. Select the tab “Symbology”.
6. In the “Show” box (see step 4 in the previous exercise), click on the option “Quantities”, and the sub-option “Graduated symbols”. In the “Value Field” dropdown list, select the Field name “TOT_Bank”. This value field represents the total number of banks in each town.
7. Change the “Symbol size” to “from: 4 to: 16”. Next, click on the “Classify” tab. This will take you to the “Classification” drop down menu (see graphic on step 7 in previous exercise if you need help).
8. Click on the arrow to the right of “Classes” and choose 6. Click on the arrow to the right of “Method” and choose “Manual”.
9. Choose your “Break Values” to be 1, 3, 5, 7, 10, and the last number displays the maximum value of banks in a town. (See right)
10. Press OK once you have finished step 9.








11. Now you are back to the Layer Properties Window. Left click on the numbers 2-3 under the label column. Here you are able to change the labels of your data so when you make a map, the labels in the legend are clear.
12. Change all of your labels following the graphic to the right. Then click out of the labels box and press Apply and OK to return to the mapping screen.



13. Now define thresholds for the “Microfinance layer following the same steps that you completed above. Use the variable “CLIENTS” in order to show how many people the microfinance project is serving

14. I used the thresholds shown to the right, but you can experiment using different classifications in order to emphasize microfinance projects that are serving over 50,000 people or emphasize small microfinance projects. The way in which you classify your data depends on what you hope to demonstrate and communicate to your audience.

Symbol	Range	Label
	0	<
	1 - 5000	> 5,000
	5001 - 10000	5,001 - 10,000
	10001 - 20000	10,001 - 20,000
	20001 - 389360	Over 20,000

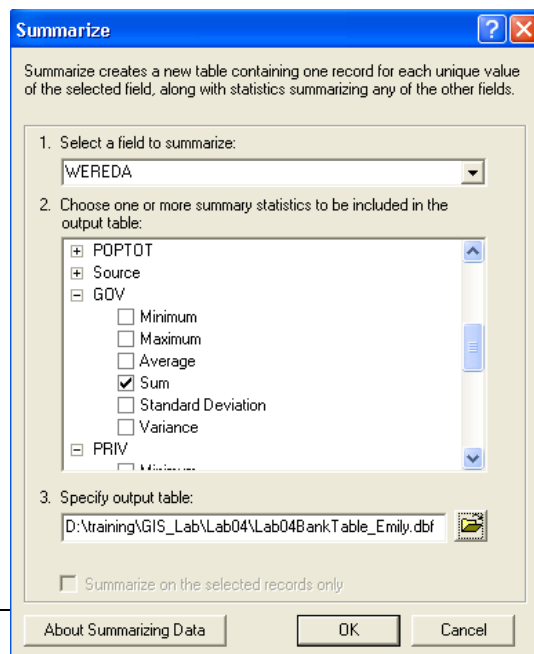
15. Although we are able to see where most of the Banks and Microfinance offices on a map, we should do a few calculations to understand how these banks and microfinance areas are represented spatially.

16. Right click on the “Banks” and open your attribute table (Remember, this is the table that holds all of the underlying data that connects to our specific map layer)

17. We have quite a bit of data in this file, such as:
- Town name
 - Town population
 - Wereda name
 - Region
 - Zones
 - Population urban
 - Population rural
 - Population total
 - Government owned banks
 - Private banks
 - Total banks (this is what we mapped at first)

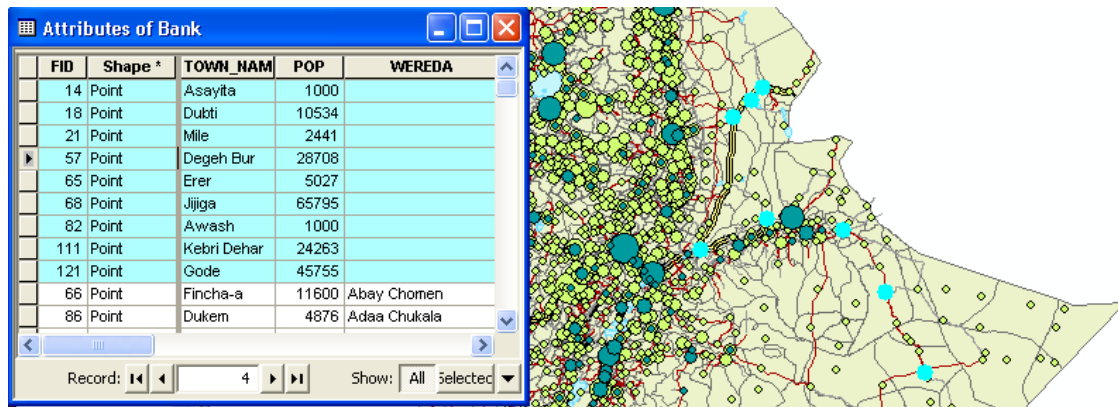
18. Let’s use our attribute table tools to summarize some of these data by administrative unit. Right click on the “Wereda” tab in your attribute and choose “Summarize”.

19. This will take you to the Summarize window (See below) which gives you a variety of options on how to summarize your data. You will see that each variable in your attribute table is listed. Click on the + box next to the variable name. This will give you a drop down list of various calculations you can perform. You have a choice to summarize data by “Wereda” including: Minimum, Maximum, Average, Sum, Standard Deviation, and Variance.

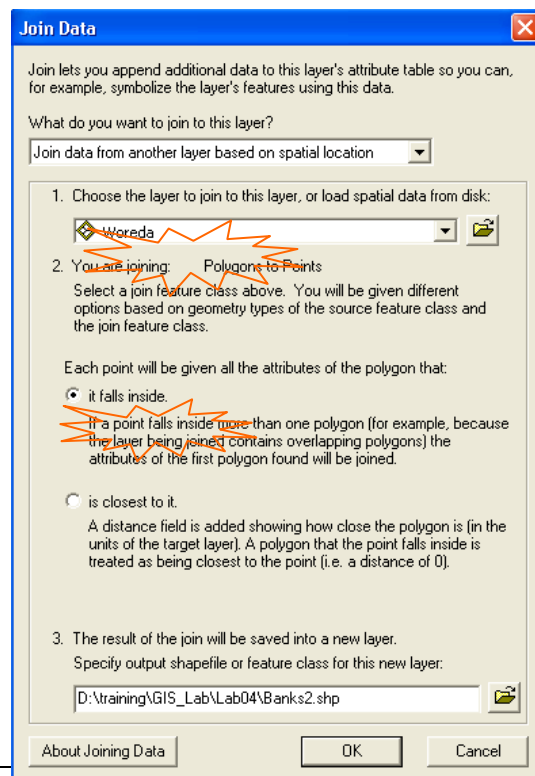



20. For now, let’s Sum “GOV”, “PRIV” , and “TOT_Bank” by clicking on the + box next to the variable name. Choose “Sum” for each of these variables by clicking on the box next to the Sum option.

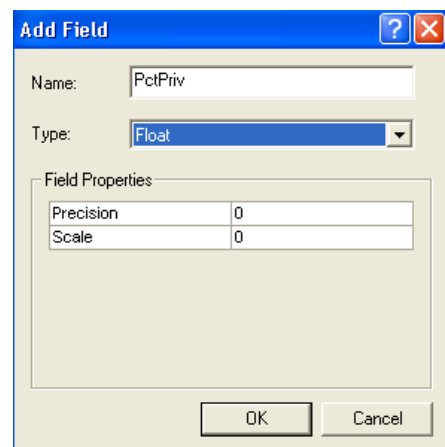
21. Last, save your table to your Lab04 folder: Lab04BankTable_YOURNAME and then press OK.
22. This may take a moment for the table to calculate. It will then ask you if you want to add the result table to the map. Click YES.
23. Close your attribute table and open the table that you have created by right clicking on the new table of contents and selecting "open". You will now see the variables that you selected in the "Banks" layer have been summarized by Woreda. This table also includes a variable called "Count_Wereda" this is an automatic field that is calculated in ArcGIS that tells you how many observations per Woreda were calculated to sum each statistic that you chose.
24. The bottom right of the table shows you the number of observations. Notice that there are 119 observations in this dataset. This means, that at the time these data were collected, there were 119 different Woredas that have a bank. BUT, note that the first observation in our table, there are 9 observations that didn't have a woreda name allocated to their bank location. Thus, there may be several other woredas that have banks, but were merely not labeled.
25. Let's see where these banks are that do not have a Woreda label. Open the "Banks" attribute table. Right click on the Wereda variable and choose "Sort Ascending". You will see the nine observations. Highlight these observations by dragging your arrow over the 9 observation tabs, or hold the shift button down and select each individually.
26. Now move your table to the left of the screen so you can see the points that are highlighted in the map. They are primarily in the east part of the country. (See below)



27. Let's populate the missing Wereda labels by performing a spatial join on the "Bank" shapefile. Right click on the "Bank" layer and select "Join and Relate". This will open the Join Data window.
28. In the Join Data window. Select to "Join data from another layer based on spatial location". This will present you with several options. Follow the example to the right and populate the fields as such.
29. We choose that each point will be given the attributes from the polygon that it falls inside. This way, we will be able to population each bank point with the attributes from the Woreda file that we have.
30. Save this new shapefile in your Lab04 folder as Banks2.shp



31. This may take a moment to process, the shapefile should add automatically to your map.
32. Now, right click on your "Banks2.shp" file and open the attribute table. Notice that you have now merged the attributes from the "Banks" shapefile and the "Woreda" shapefile.
33. Right click on the W_name attribute. Notice that each "Bank" point now has a Woreda attributed to its location. There are no blank values.
34. Now, if you would like to create an improved table that has all of the information on Woreda name, you can summarize your "Banks2.shp" by W-name (as you did previously in steps 18-22 of this exercise).
35. Let's calculate another indicator in our attribute table. First, make sure that you do not have any observations selected/highlighted by clicking on the unselect tool  in the upper left of your screen.
36. Now, open your Banks2 attribute table if it is not already open. Click on the Options tab in the bottom left of the Attribute table window and choose "Add Field". We are going to create a new variable by calculating the percent of banks that are privately owned per town.
37. Name your variable PctPriv, and choose "Float" as the type of value. Then press OK



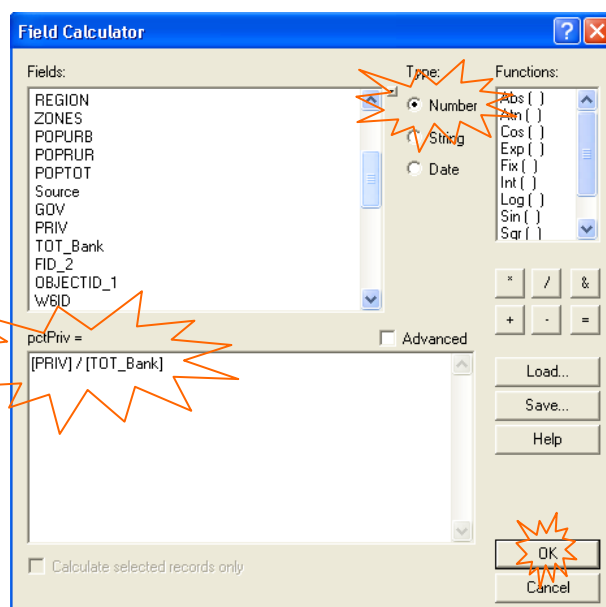
38. You should now see that the field that you have created has been added to the attribute to the far right of the table.
39. Now we will populate this field using the data that we already have in our attribute table.
40. Right click on the label of the new variable you created "PctPriv" and select "Field Calculator".

41. When you open your Field Calculator window, you want to create the following formula

$$[\text{PRIV}] / [\text{TOT_Bank}]$$

by choosing from the Fields drop down menu.

42. When you have created the same formula as you see to the right, press OK.



43. After a few moments, you will see that the field you created is populated with your calculation

Sum_PRIV	Sum_TOT_Ba	pctPriv
0	1	0
0	0	0.5
0	0	0.666667
0	0	0
0	1	0
1	3	0.333333
0	0	0.5
0	0	0.555556
0	1	0
0	1	0
0	0	0

44. Now, if you want, you can follow the same steps as above to calculate the percent of Banks that are government owned per town.
45. Remember, you can always collapse any of these data by using the summarize tool that we used at the beginning of the exercise to understand values by a larger aggregation (Woreda, Zone, or Region) and recalculate percentages if needed.
46. Now that we have calculated percent of Banks that are privately owned, let's map these to see where the largest share of private banks are located.
47. Double click on the "Banks2" shapefile, in order to go to the Layer Properties window. Under the Quantities option under the Show field, choose "Graduated Symbols". Under the Value field, choose your new variable "PctPriv". And then press Apply and OK.
48. Drag your "Cities" layer above the "Banks2" layer in your table of contents, and classify your cities by Cities under 50,000 and Cities over 50,000. Notice how the larger share of private banks tend to be near larger cities.
49. Classify your "Roads" data. Notice how most "Banks" follow the Road infrastructure of the country, and the larger proportion of private banks are on major roads.
50. When you are finished, your output should look something like the map below. Remember though, you can create many tabular statistics using the attribute table in ArcGIS that may be better represented in a Table format instead of a Map format. This depends on what you are trying to communicate.

Usually a mixture of tables, graphs and maps are the best way to communicate data

