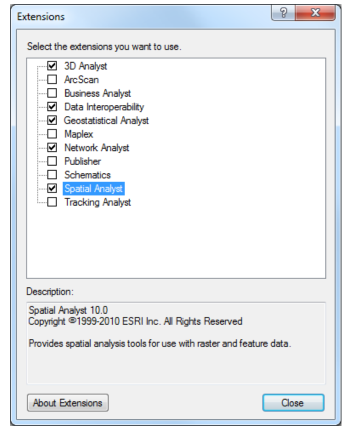
Geographical Information Systems Institute

Center for Geographic Analysis, Harvard University

LAB EXERCISE 9: Raster data manipulation



Terrain elevation surfaces are common enough to have their own acronyms (DEM for Digital Elevation Model or DTM for Digital Terrain Model). Continuous (field) spatial data is stored in **rasters** or **grids**. Each cell holds a numeric value that measures a geographic attribute (like elevation in a DEM) for that unit of space.

1. To make extensions active go to the main menu Customize and then select Extensions, check against Spatial Analyst and 3D Analyst

1.1 Downloading DEM and Extracting the files

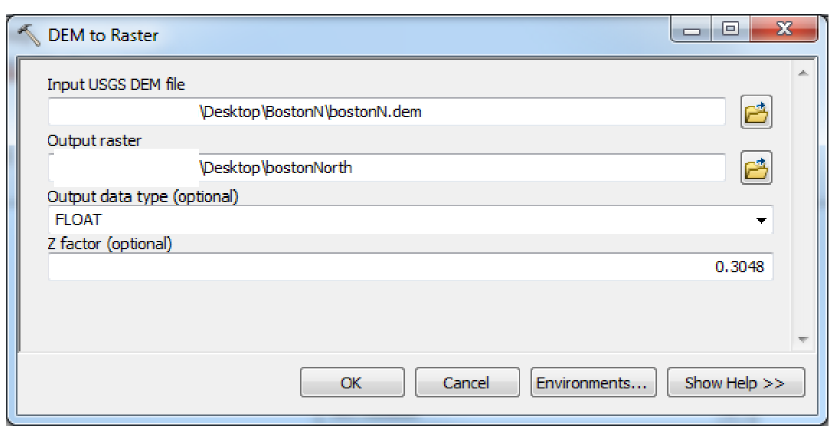
The DEM data files for Boston North and South are in the **Massgis** folder and called **BostonN and BostonS.**

2. Make sure that you have these folders on your desktop (and not in the T: drive).

You will convert this file to an ArcGIS readable raster (or grid) format in the next section. The DEM contain data on elevation, attributed to each individual cell (or pixel).

1.2. Processing DEMs (Optional)

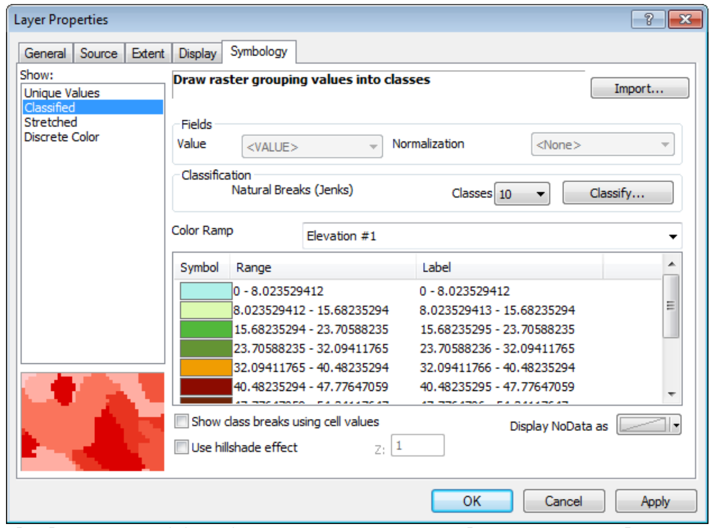
3. Open ArcToolbox in ArcMap, then expand the **Conversion Tools**, **To Raster**, then double-click "**DEM to Raster**."
4. In the dialog box click on the empty space under "**Input USGS DEM file**," click on the folder icon to the right of USGS DEM entry box, and select bostonN.dem (or whichever DEM you decided to use) from the DEM folder that you copied.
5. Then click on the folder icon in output raster entry box. A dialog box entitled "**Specify an output raster**" appears. Select your folder, and enter the name "**BostonNorth**" (or whichever DEM you decided to convert). Click "**Save**." This is the name of the output raster data file showing elevations for the location of your choice. Let the **Z-factor** be 0.3048 (see note below). Select Output data type as Integer. Click OK.



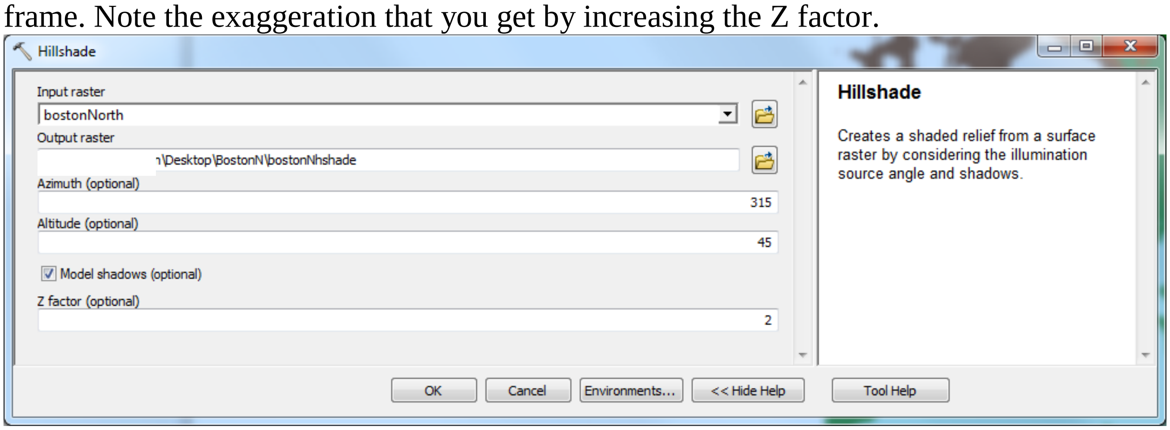
Note: The Z-factor adjusts the units of measure for the Z-units when they are different from the x, y units of the input surface. The Z-values of the input surface are multiplied by the Z-factor when calculating the final output surface. If the x, y units and Z-units are in the same units of measure, the Z-factor is 1. This is the default. If the x, y units and Z-units are in different units of measure, the Z-factor must be set to the appropriate factor, or the results will be incorrect. For example, if your Z-units are feet, and your x, y units are meters, you would use a Z-factor of 0.3048 to convert your Z-units from feet to meters (1 foot = 0.3048 meters).

When ArcToolbox is finished with processing the data, the dialogue box will close. The new raster(s) will appear on ArcMap automatically (if not, add them).

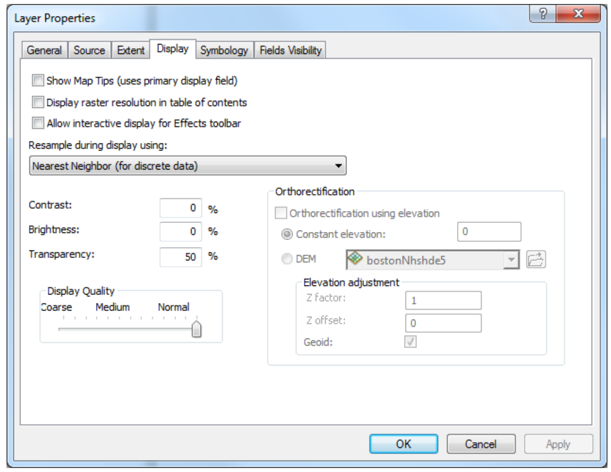
1.3. Processing rasters: Symbology and Hillshade



6. Add the raster you created in the last section (not the *.dem file) if it is not already automatically added. You should get an automatic classification using the default **stretched** classification. You might want to **change** the classification type for the layers.
   7. Right click on the raster in the TOC to get to Properties and then Symbology. Show classified instead of stretched which is the default.
   8. Right-click on the dropdown menu next to **Color Ramp** uncheck the “Graphic view” to a non-graphic view. Select Elevation #1 as shown in the screenshot. You can increase the number of classes from the default 5.
   9. In **ArcToolbox** expand Spatial Analyst tools, and choose “Surface” and then select **Hillshade** to get a new window. Select the raster as the input surface, Z-factor = 2, and the output raster location, and click OK. A hillshade model will appear in your data frame. Note the exaggeration that you get by increasing the Z factor.



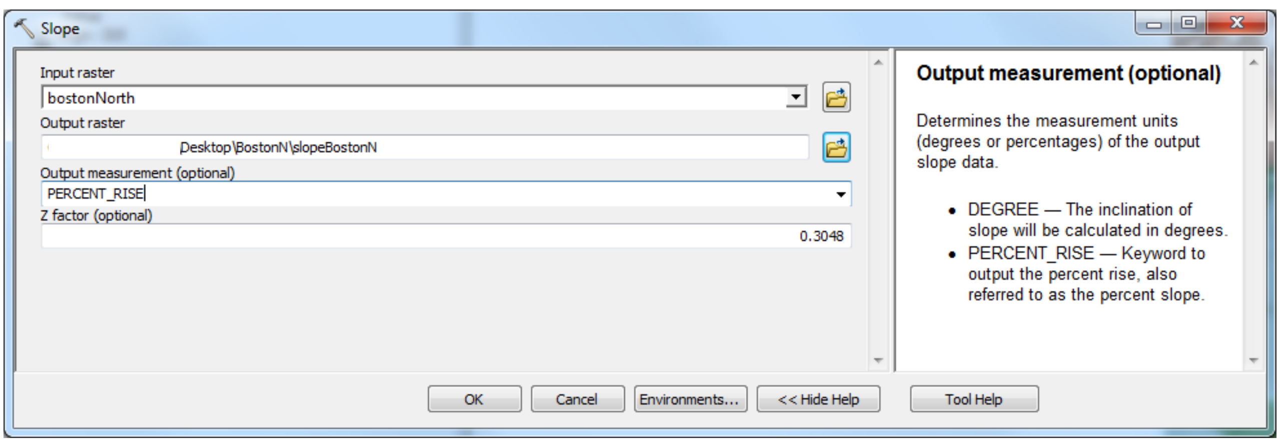
Note: Azimuth is the direction from where the sun is shining. 0 means north, 180 south and **315 (default)** north-west. The default is most suitable for graphical representations. The "Altitude" of the sun is measured in degrees above the horizon. The higher the altitude the shorter the resulting shadows. 0 degrees is when the sun is at the horizon, 90 degrees is when it is overhead.



10. Right click on the DEM layer in the TOC and select **Properties** and then **Display** to make it 50% transparent. (see below). Move it in the TOC so that it displays over the hillshade.
11. Run Hillshade again with a z factor = 5. Notice the difference in the way elevation is exaggerated when z=5.

1.4. Slope

12. Again, in spatial analyst select Surface, and then **Slope** to generate a slope model. Choose "PERCENT_RISE", and save it as shown in the screenshot.



Note: The slope for each pixel is approximated by identifying the maximum rate of change in value of the processed cell to its 8 surrounding neighbors. The algorithm moves a 3 x 3 window or kernel over the surface of the grid. For example for a set of pixels:

A	B	C
D	E	F
G	H	I

and calculates the rate of change in the x - and y - direction with the following formulas:

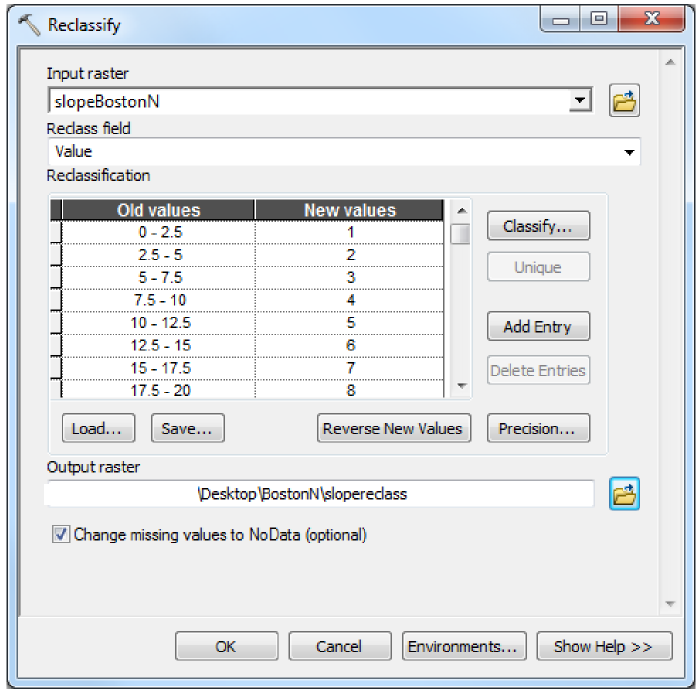
$(dz/dx) = ((A + 2D+ G) - (C + 2F + I)) / (8 * x\_mesh\_spacing)$ for the x-direction, and

$(dy/dz) = ((A + 2B + C) - (G + 2H + I)) / (8 * y\_mesh\_spacing)$ for the y-direction

The gradient of three rows is calculated and the average of those three values is taken. This is done to minimize the error in the output grid. The slope is calculated by putting these values into the slope formula:

tan(slope) = SQRT(SQR(dz/dx) + SQRT(dz/dy))

1.5 Reclassifying slope



ArcGIS classifies every continuous grid automatically for display. You can create "classes" with a group of cell values in each class. The goal is to lose as little information as possible during classification.
To reclassify the slope grid make it active and select "**Reclassify**" from the Spatial Analyst tool **Reclass**.

13. Input raster is the slope raster, Reclass field is Value. Then click "Classify" to bring up a dialog box, and change Classification Method to Defined Interval, and the interval size to 2.5. (You can experiment with your own classification schemes). Click OK.
14. Specify the location you want to save it to on the Desktop. Click "OK" button when done.

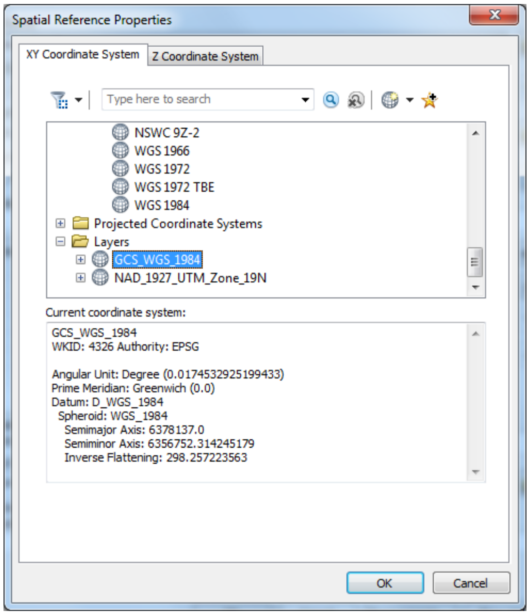
A new grid called "Reclass of Slope" is added to the view.

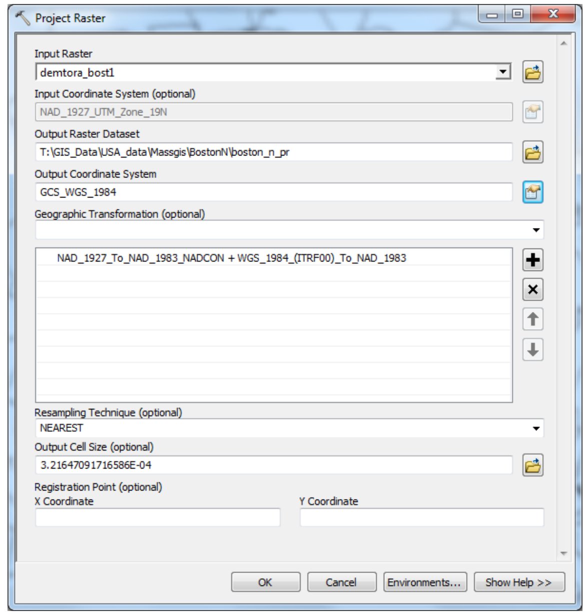
1.6 Combining rasters with polygons (Optional)

To combine (overlay) data from your rasters in another feature (polygon) dataset use **zonal statistics as table**. For example, to get the mean elevation in each census tract would require overlay of the elevation raster with the census tract polygon vector. However for all zonal operations, first make sure that both the datasets have the same projection, coordinate system, datum etc. To do this project the DEM raster to share the same coordinate system as the tracts.

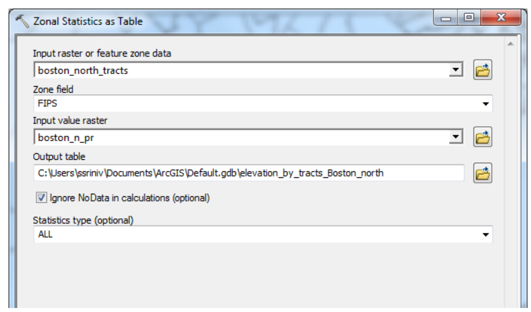
15. In **ArcToolbox**, expand **Data Management, Projections and Transformations**, **Raster** and finally, **Project Raster** to get a window which you should update as shown below. The input raster is the one you created in section 1.2

16. The output coordinate system could be imported from the tract layer by clicking first on  to get a new window where you should expand **Layers** and specify the coordinate system and projection of the tracts layer (WGS 1984). See the screenshots that follow.

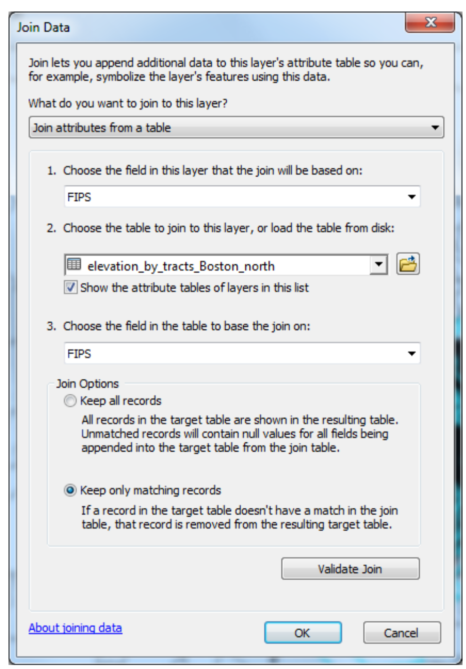




17. Next manually select only the tracts that overlap the DEM using the select button . Right click on the block groups layer in the TOC and select Data, export data to create a new shapefile.



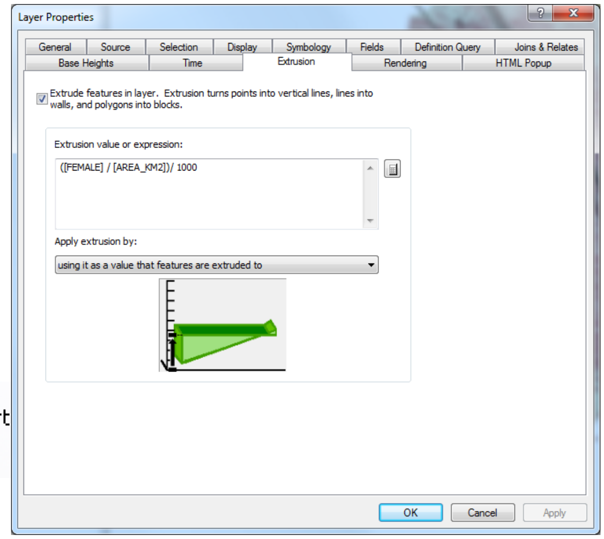
18. Next, in the Spatial Analyst tools of ArcToolbox expand **Zonal** and then select **Zonal Statistics as a Table**. I used the zone data set to be shapefile created in the previous step, the unique zone field is the FIPS and the raster is the projected elevation raster.



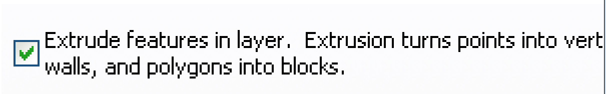
19. The results can be **joined** to the tracts shapefile using the attribute FIPS as the key. (Right click on the tracts layer in the TOC and then Joins and Relates).

2.0 Navigating ArcGIS 3D Analyst

To display surfaces in 3D, you can use the application ArcScene . Start **ArcScene** by from the start  menu. Adding data into ArcScene is the same as adding data into a view in ArcMap. You can add raster layers like the DEM and other rasters in the previous section, or feature themes (points, lines and polygons).

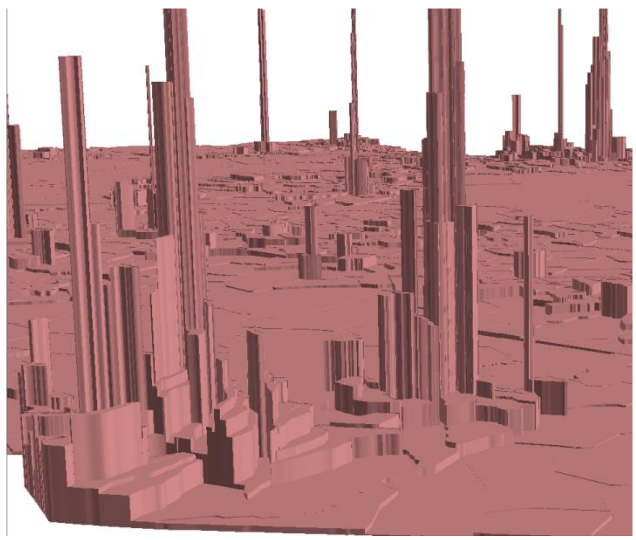


20. Add any polygon shapefile which has some continuous variable. For example, I added Tz_wards_2002_Project shapefile from the **Introduction**/ **Tanzania** folder or any layer from the Introduction/India fodler. Right click the layer in the TOC to get "**Properties**" and then make sure to check on the **Extrusion** box. and then make sure you check against the box that says

    "Extrude features in layer."

21. Then click on the calculator symbol , build the expression ([FEMALE] / [AREA_KM2])/ 1000" – or some other variables of your choice and click "OK".



The wards are now extruded according to the density of females the tract per sq km divided by a factor of 1000 to reduce the visual impact.

3D scenes are used like an ArcMap view to display and query spatial data. Adding a third dimension enables viewing 3 dimensional datasets from different angles. Rotate the data set by using the "Navigate" button  and move the mouse (right button down) in any direction in the ArcScene window. With the left button you have a zoom in/ out tool.