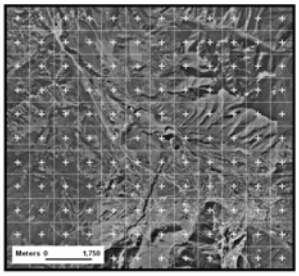
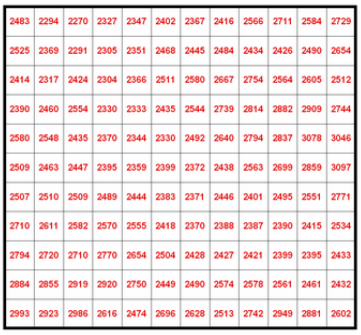
Raster: The 'Other' GIS Data

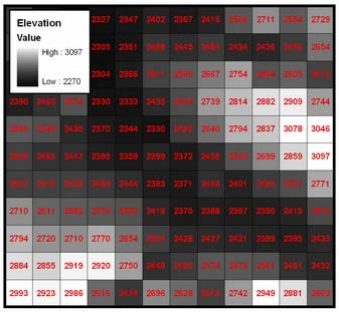
Surfaces are continuous geographic phenomena that cannot be described as discrete 'Features.' Surfaces are generally modeled as 'Raster' data, of which the most familiar type is the digital photograph. Things like elevation, temperature, slope and precipitation have measurable values for any particular location on the earth's surface.





2483	2294	2270	2327	2347	2402	2367	2416	2566	2711	2584	2729
2525	2369	2291	2305	2351	2468	2445	2484	2434	2426	2490	2654
2414	2317	2424	2304	2366	2511	2580	2667	2754	2564	2605	2512
2390	2460	2554	2330	2333	2435	2544	2739	2814	2882	2909	2744
2580	2548	2435	2370	2344	2330	2492	2640	2794	2837	3078	3046
2509	2463	2447	2395	2359	2399	2372	2438	2563	2699	2859	3097
2507	2510	2509	2489	2444	2383	2371	2446	2401	2495	2551	2771
2710	2611	2582	2570	2555	2418	2370	2388	2387	2390	2415	2534
2794	2720	2710	2770	2654	2504	2428	2427	2421	2399	2395	2433
2884	2855	2919	2920	2750	2449	2490	2574	2578	2561	2461	2432
2993	2923	2986	2616	2474	2696	2628	2513	2742	2949	2881	2602

To model these phenomena, an area of interest is divided into an array of identically sized squares. The centers of these squares then become the 'sample points.' The values of the variable of interest are recorded, or estimated, at each of the sample points. These values can then be assigned colors, or shades of gray, in order for them to be visualized.



This tutorial will introduce you to some of the basic skills necessary to have when using raster data in your analysis. This tutorial is in no way comprehensive, rather it is intended to provide you with a base

Getting Ready for the Tutorial

First, make a folder in your **C:\Temp** folder and name it using your initials (for example, if you name is John Jacob Jingleheimer-Smith, your new folder will be **C:\Temp\JJJ**).

Next, you need to download the dataset for this tutorial from the Workshop Materials website at **http://www.library.yale.edu/MapColl/beta/gis_workshop_materials.html**. Look for the **Data** link next to the "**Raster: The 'Other' GIS Data**" Workshop item.

Download the **zipfile (.zip)** to your computer and save it to your **C:\Temp*intials*** folder. Browse to your **C:\Temp*intials*** folder and extract the contents of the **zipfile** there.

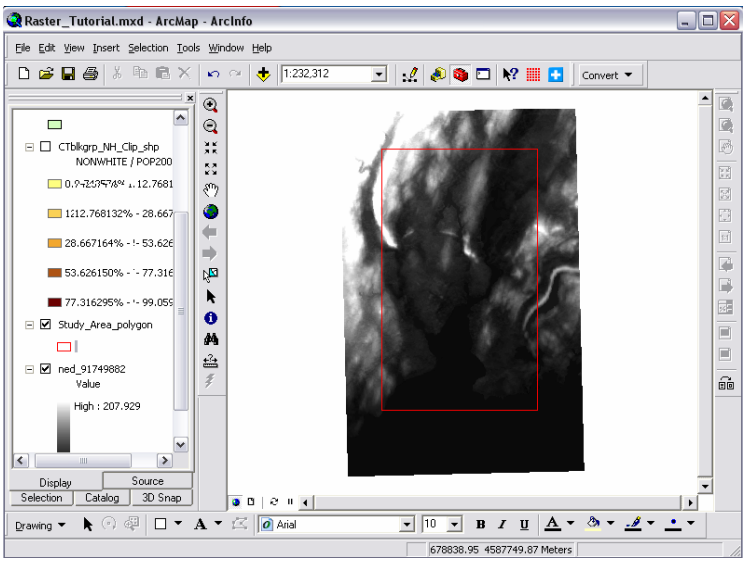
The resulting dataset contains the following folders & files:

- **Using Raster Data** (Folder)
  - **Raster_Tutorial.mxd** (Map Document)
  - **Data** (Folder)
    - **Raster** (Folder)
      - **NED_91749882** (Folder) – This folder contains various folders & files that make up a 'raster layer.' The data

storage model used for raster layers is tricky, in that it locates several essential components of a single raster layer across many folders & files. To further complicate matters, if you have more than one raster layer in a folder, there will be a single 'info' folder for all of the layers. This essentially makes it impossible to copy, paste, move and delete raster layers outside of ArcCatalog.

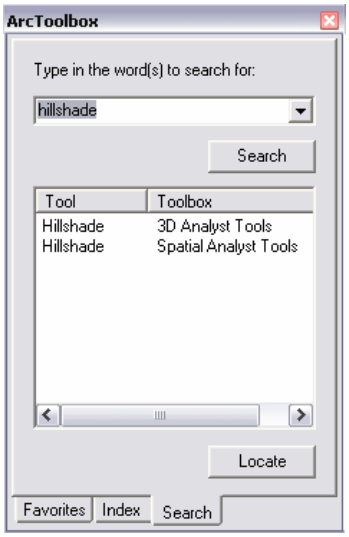
- **ned_91749882** (Folder) – Contains some of the files that make up the Digital Elevation Model for the tutorial.
- **ned_91749882.aux** (File) – part of the Digital Elevation Model for the Tutorial.
- info (Folder) – contains more information essential to the Digital Elevation Model for the tutorial.
- **metadata.shp** (Various Files) – A shapefile containing the metadata for the ned_91749882 raster layer, as well a a rectangular polygon that is the footprint of the layer.

- **Shapefile** (Folder)
  - **New_Haven_Air_Release_2002_D.shp** (Various Files) – A shapefile of the Toxic Air Release sites for 2002 in New Haven, CT.
  - **New_Haven_Schools_with_SF1.shp** (Various Files) – A shapefile of school locations in New Haven, CT.
  - **Study_Area_polygon.shp** (Various Files) – A shapefile of the rectangular area to which all other shapefiles have been clipped.
- **Work** (Folder) – Empty folder to place layers produced during the tutorial.

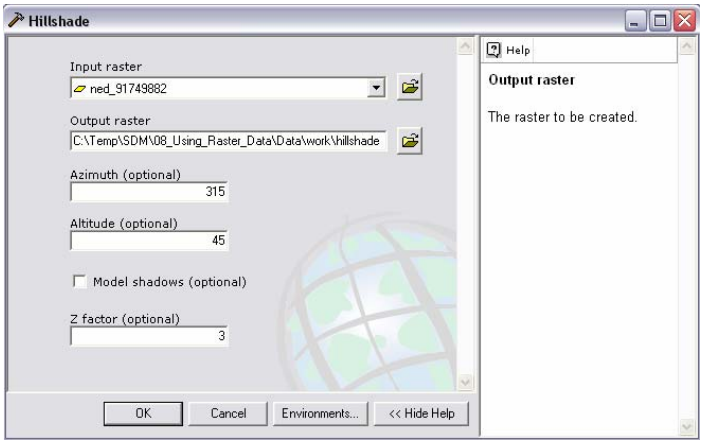


Projecting Raster Data & Why It Is Important

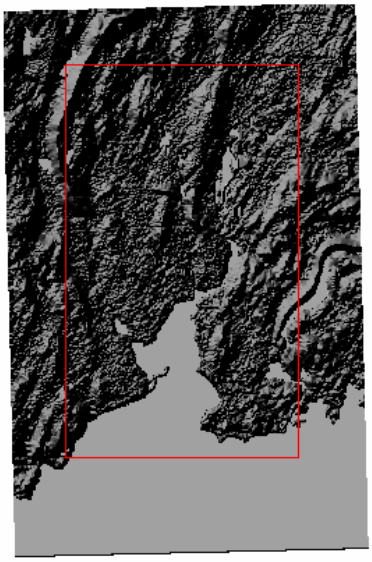
First, you will perform a process called "**Hillshading**." Hillshading takes a DEM and calculates (based upon parameters you provide) a shaded relief image that mimics the look of a naked (without geographic features) aerial view of the topography you are working with. You will actually do this twice. The first time, you will see what happens when you run particular processes on ***unprojected*** raster data. Then you will ***project*** your data, and re-run the Hillshade Tool to see the difference.



1. Open the **Raster_Tutorial.mxd** file to begin the tutorial.
2. Open the **ArcToolbox** and click on the **Search Tab** at the bottom of the panel.
3. Enter "**hillshade**" as the search term and click the **Search Button**.



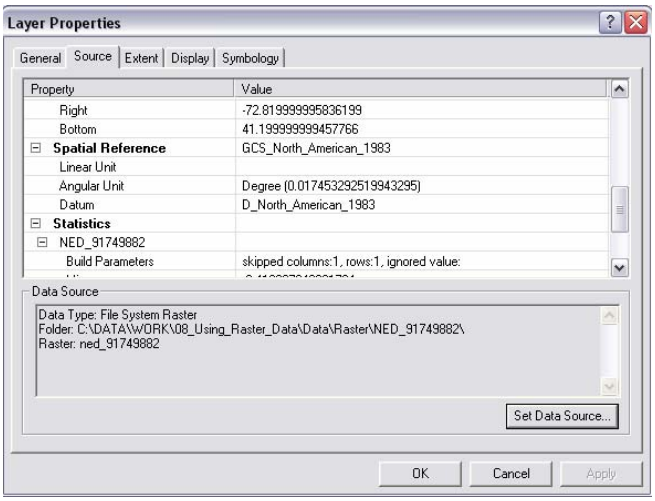
4. Double-click on the **Hillshade Tool** under Spatial Analyst Tools to open its dialog box.
5. If the **Show Help>> Button** is visible, click on it to open the **Help Panel.**
6. ect the **ned_91749882** layer as the **Input Raster**, using the drop-down menu.



7. Name the **Output Raster 'hillshade1'** and save it to the **..\work** folder that was created when you extracted the data for this tutorial.
8. Assign a **Z Factor** of 3. This is the amount of exaggeration applied to the elevation values to provide a more visually pleasant result.
9. **Leave the remaining settings at their default**

values (note that you could change these setting to mimic the particular position of the sun at any given time of day), and click **OK**.

Note that the results of the process are less than realistic. The resulting raster layer should look something like an aerial photo. In this case, the layer is very dark and very irregular.

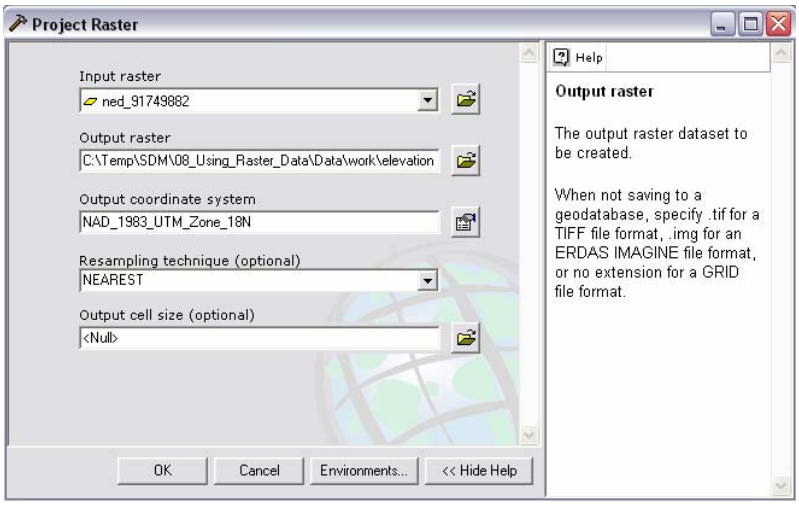


10. Right-click on the **ned_91749882** layer and open the **Properties Dialog Box**.

11. Click on the **Source Tab** and scroll down the **Properties List** to the **Spatial Reference** item.

Note that the layer does not have a linear unit. This is why you got such a terrible result from the Hillshade Tool. The Hillshade Tool requires a linear measurement to make its calculations. The tool assumes that the elevation units (the values of each raster cell) are in the same units as the linear units (horizontal X,Y measurements) of the file. The NED Elevation models are provided from the USGS in Latitude & Longitude coordinates. These are angular units and the Hillshade Tool is unable to resolve the difference in measurement. You will now *Project* the **ned_91749882** layer to a projection that has a linear unit, measures in meters, which is the same unit of measurement that the elevation values in the dataset are recorded in.

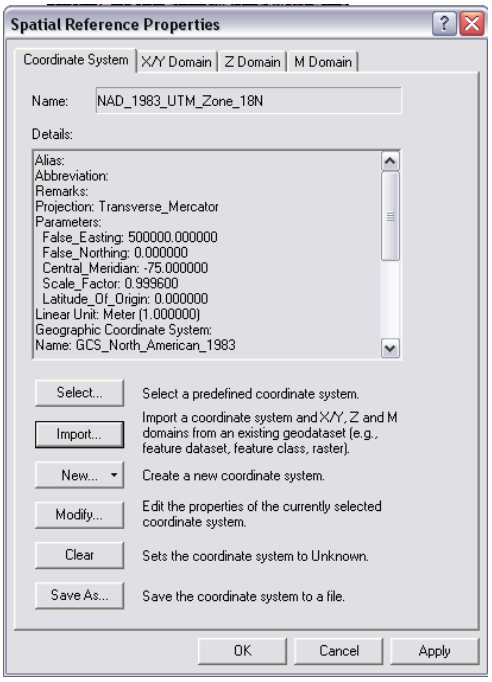
1. Close the **Properties Dialog Box** for the **ned_91749882.**



2. Right-click on the **hillshade1** layer and **Remove** it.

3. Return to the **Search Tab** in **ArcToolbox** and enter **'project raster'** as the search term.

4. Double-click on the **Project Raster Tool** to open its **Dialog Box.**



5. Select the **ned_91749882** layer as the **Input Raster** from the drop-down menu.

6. Name the **Output Raster 'elevation'** and save it to your **..\work** folder.

7. Click on the **Spatial Reference Properties Button** to open the **Dialog Box.**

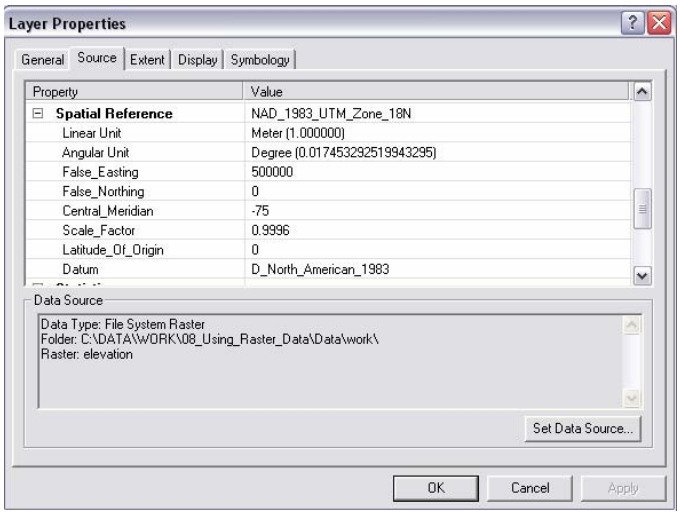
8. Since the rest of your data layers are already projected to an appropriate coordinate system, you will "**Import**" the **Coordinate System** from one of those layers. Click on the **Import Button**  and browse to the **..\Data\Shapefile** folder with in the tutorial dataset and select any of the shapefiles in that folder. Click Add.

9. Click **OK** to accept the **Imported Coordinate System**. Note that you will be using the **UTM Coordinate System**, and the **NAD 1983 Datum**. Click **OK** to apply the projection.

10. Right-click on the **ned_91749882** layer and remove it.

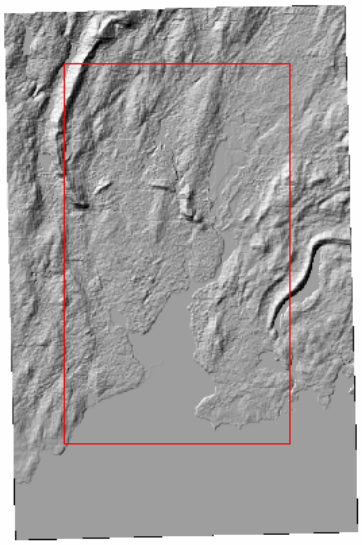
11. Right-click on the new **elevation** layer and open the **Properties Dialog Box**.

12. Scroll down to the **Spatial Reference Item** and note that the layer now has a **linear unit** (meters). Close the **Properties Dialog.**



13. Return to the **ArcToolbox** and open the **Hillshade Tool** again. This time, use the new **elevation** layer as the **Input Raster**, name the Output Raster '**hillshade2'**, assign a **Z Factor of 3** and accept the default values for the other setting. Click **OK**.

Note the difference between this Hillshade result and the first. This result should look far more realistic (if the world were flat grey, with no geographic features). It is important to know how projection effects calculations of this type. When using an improperly projected DEM, other calculations (such as slope, aspect, visibility and any processing tasks that depend upon both vertical and horizontal linear units of measurement) can output wildly inaccurate results.



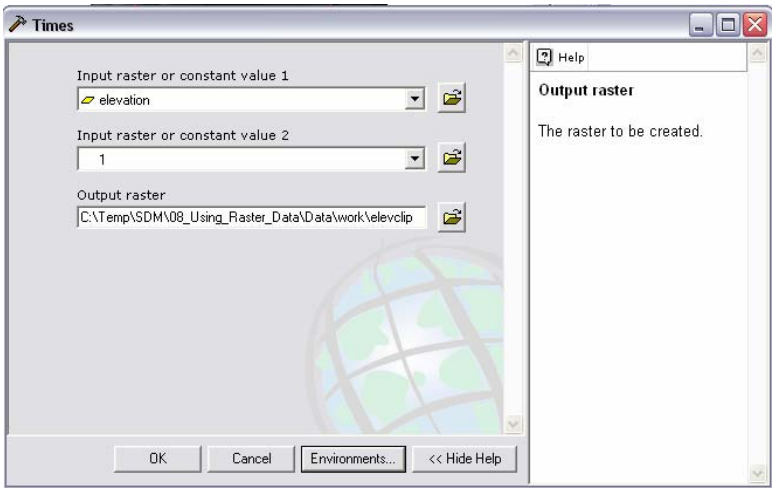
14. Save your work.

"Clipping" a Raster Dataset to a Vector Layer

See that red box that has been sitting on top of the raster layer? That is the study extent that all but the raster layers have been clipped to in the tutorial data. In many cases, you would like to *subset* your raster data to an area defined by one of your vector data layers. In this case, you would like to subset the elevation layer to the **Study_Area_polygon** layer. That is a problem because, for some reason, there is no tool for doing that seemingly simple task in ArcMap. So, you have to "trick" ArcMap into clipping rasters to vector layers.

1. Uncheck the box next to the **hillshade2** layer to turn off its visibility.

2. Return to the **ArcToolbox Search Tab** and enter "**times**" as your search term. Double-click on the **Times Tool** in the **Spatial Analyst Tools,** to open the **Times Tool Dialog Box.**

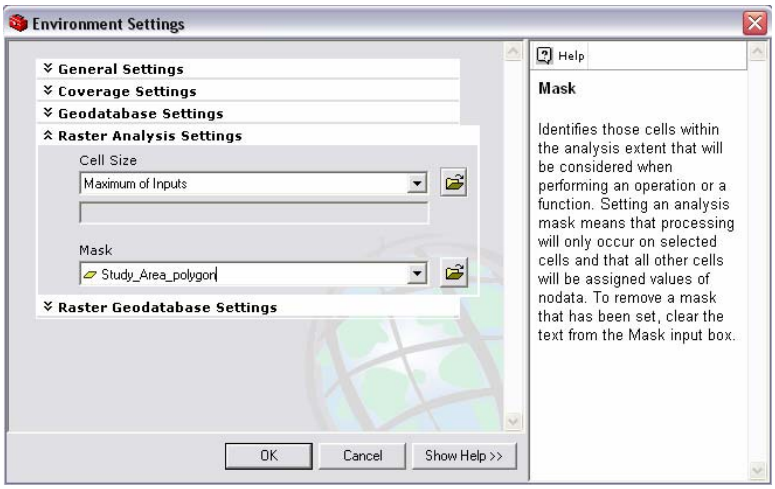


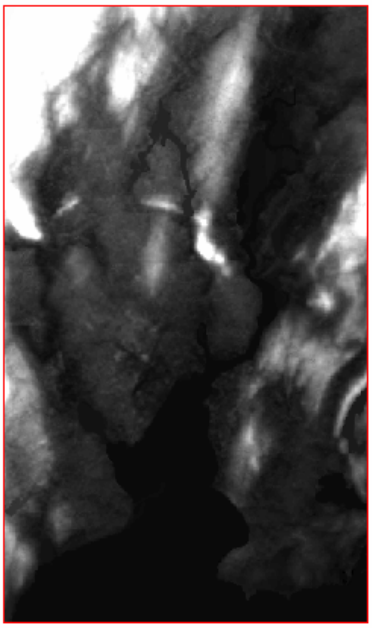
3. Select the **elevation** layer as the **Input Raster** using the **Drop-Down** menu.

4. Under the **Input Raster or constant value 2** item, enter the value **1**.

5. Name the Output Raster **'elevclip'** and place it in your **..\Data\work** folder.

6. Click on the **Environments…** Button at the bottom of the Times Tool Dialog Box.





7. Click on the **Raster Analysis Settings** item to expand it.

8. Select the **Study_Area_polygon** layer in the Drop-down menu for the **Mask** item. Click **OK**.

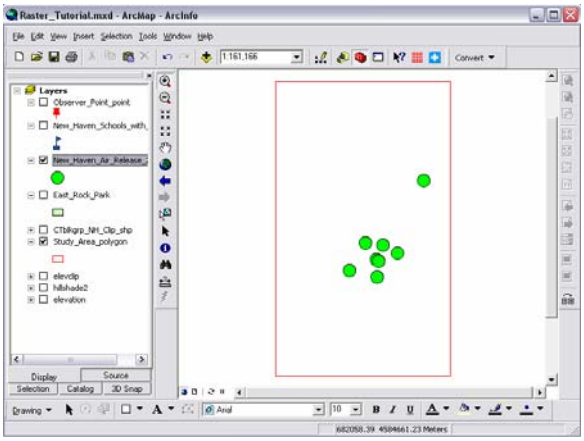
9. Turn off the visibility of the **elevation** layer by unchecking its **checkbox**.

If all went well, you should now have an elevation layer clipped to the **Study_Extent_polygon** layer. The **Mask setting** identifies those cells within the analysis extent that will be considered when processing. Setting an **analysis mask** means that processing will only occur on cells that fall within the **Mask layer** and that all other cells will be assigned values of **NODATA**.

10. Save your work.

Creating a Distance Raster from Vector Data

So far, you have learned how to *use* raster data, in the form of a Digital Elevation Model. Next, you will learn to *create* a raster layer. The raster data model is a convenient way of modeling other geographic relationships, as well. In this part of the tutorial, you will create a *distance map* that models the distance from the nearest Toxic Air Release Site in New Haven, CT. Later, you will learn how to further alter this distance map and extract the

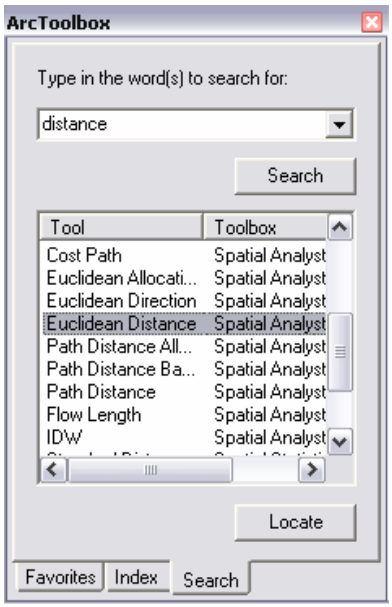


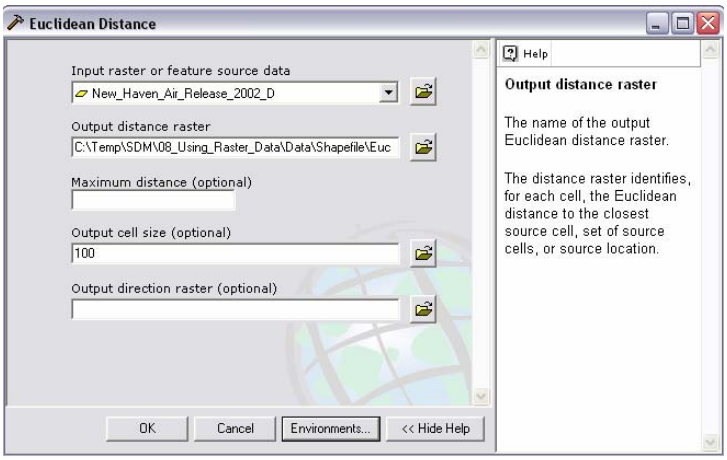
distance values from this layer to another layer.

1. Turn off the **visibility** of all layers except for the **Study_Area_polygons**, and the **New_Haven_Air_Release_2002_D** layer.

2. Return to the **ArcToolbox Search Tab** and use "**distance**" as your search term. Scroll down in the list to find the **Euclidean Distance Tool** in the **Spatial Analyst Tools.** Double-click on the **Euclidean Distance Tool** to open its **Dialog Box**.

3. Select the **New_Haven_Air_Release_2002_D** layer as the **Input Raster or feature source data** from the Drop-down menu. This is the layer that contains the features you are measuring distance ***from***.





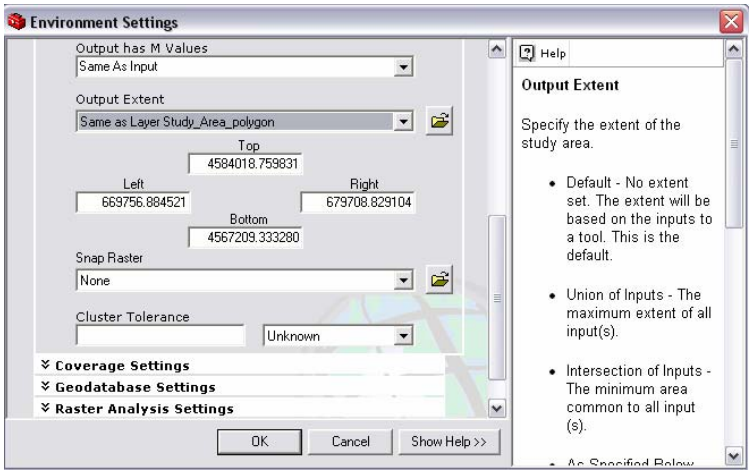
4. Name the **Output Distance Raster** "**dist2tox**" and save it to your **..\work** folder.

5. Leave the **Maximum Distance** blank, but change the **Output Cell Size** to **100**. This will result in a raster with cells that are 100 meters square.

6. Leave the **Output Direction** raster blank.

7. Click on the **Environments…** Button at the bottom of the Times Tool Dialog Box.

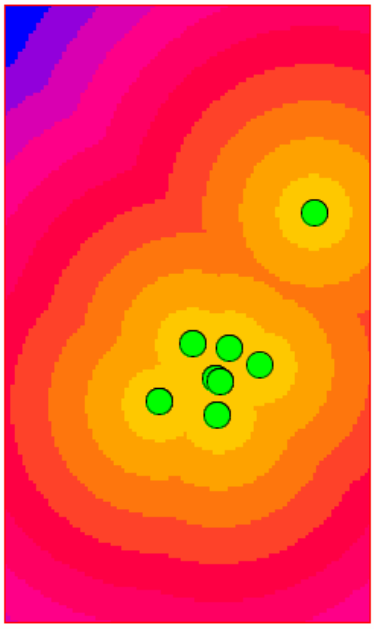
8. Click on the **General Settings item** to expand it. Scroll down to the **Output Extent setting** and change it to **Same as Study_Area_polygon**.



This tells the **Euclidean Distance Tool** to calculate distance for the full extent of the study area. If you do not change this setting, the default setting for extent is the *intersection* of the input layers, which will result in a smaller extent than we are interested in (since the New_Haven_Air_Release_2002_D layer has a smaller extent than our study area).

9. Click on the **Raster Analysis Settings** item to expand it.

10. Select the **Study_Area_polygon** layer in the Drop-down menu for the **Mask** item. This will limit the resulting distance raster to the study area. Click **OK**.



11. Click **OK** to create the distance raster.

In the resulting raster layer, each cell value provides the distance, in meters (the linear unit of the **Map Document**) from the nearest feature in the **New_Haven_Air_Release_2002_D** layer to every other point in the study area. You could extract the values of this layer to another layer now, but first you will use the **Map Algebra** features in **ArcToolbox** to convert the measurement to whole feet. **Map Algebra** is a special set of functions designed specifically for using raster layers as variables in mathematical calculations. You can add, subtract, multiply, divide and perform many more complex mathematical operation on raster datasets using **Map Algebra**.

12. Save your work.

Using Map Algebra from ArcToolbox

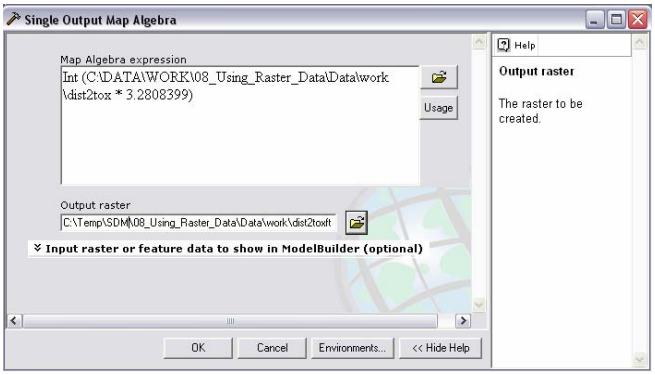
As noted above, **Map Algebra** allows you to perform mathematical operations on and betweens raster layers, using the raster layer as a whole, as the variable in the mathematical operation. You used **Map Algebra** earlier when you used the **Times Tool** to clip your **NED** layer, although by multiplying by 1, you made no mathematical change to the layer. Here, you will use a **mathematical operator** (again, **multiplication**) and a **Map Algebra function** (the **Int() function**), to transform your distance layer from meters to whole feet.

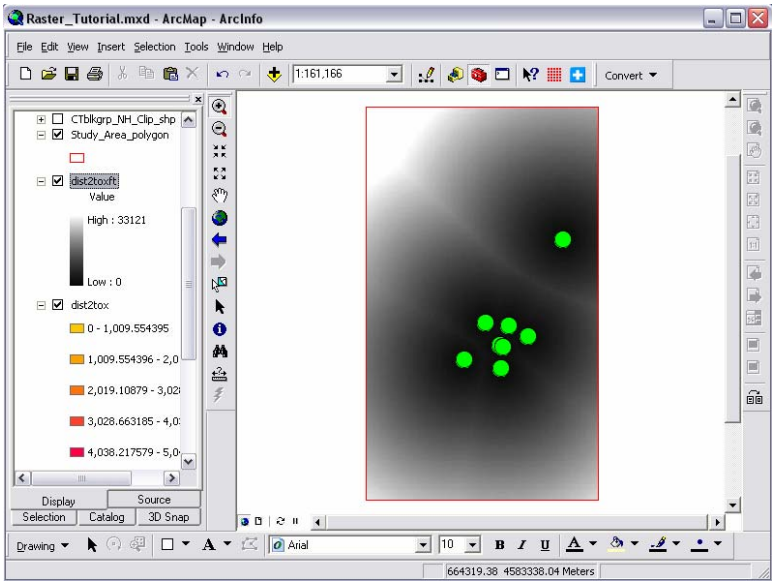
1. Return to the **ArcToolBox Search Tab** and enter "**Map Algebra**" as the search term. Double-click on the **Single Output Map Algebra Tool** to open its **Dialog Box**.

2. In the **Map Algebra Expression** window, enter the following expression:

   Int (* 3.2808399)

3. Now, **place your cursor in front of the * operator in the expression** and click on the **Browse Button** , to the right of the expression window. **Browse** to the location of your **dist2tox** layer that you created in the last section of the tutorial and select it. Click **Open** to add the path for the **dist2tox** layer to your **Map Algebra expression.**





4. Under the **Output Raster** item, browse to your **..\work** folder and name the new layer "**dist2toxft**."

5. Click **OK** to create the **dist2toxft** layer using your **Map Algebra Expression.**

You should now have a raster layer that provides the distance, in whole feet, from the nearest feature in **New_Haven_Air_Release_2002_D** to every other point in the study area.

6. Save your work.

Extracting Raster Values to Points

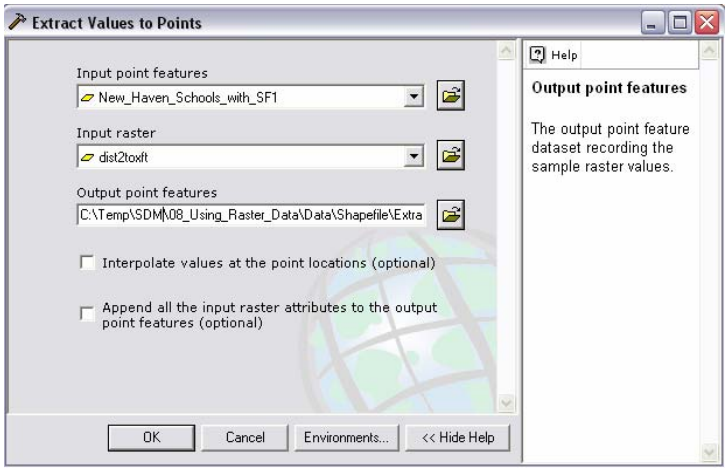
You have created a distance layer that describes how far every point in your study area is from toxic air release sites in New Haven, CT. However, what you are really interested in is not how far *every* point in your study area is from these sites, but how far your features of interest are from this site. In this tutorial, you will use the location of schools

in the study area as your feature of interest. This part of the tutorial will show you how to extract values from a raster layer to a point layer.

1. Make the **New_Haven_Schools_with_SF1** layer visible.

2. Return to the **ArcToolbox Search Tab** and use "**Extract**" as your search term. Double-click on the **Extract Values to Points Tool** to open its **Dialog Box.**

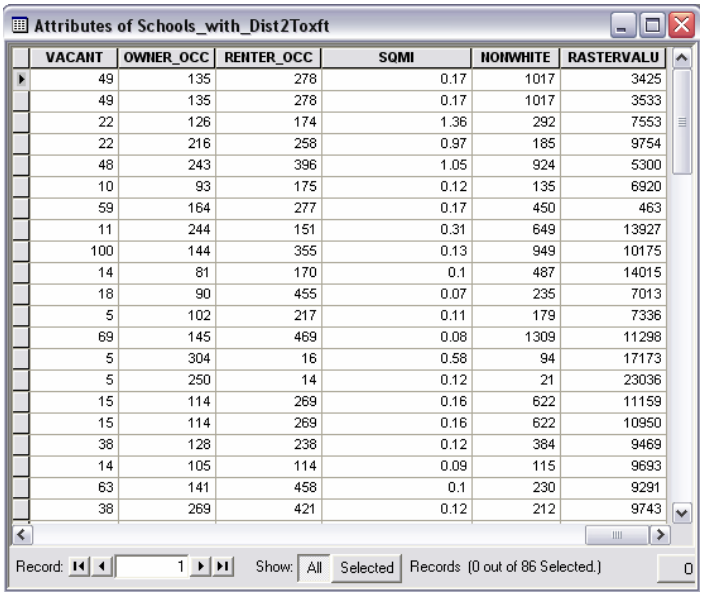
3. Select **New_Haven_Schools_with_SF1** as the **Input Point Features** layer from the Drop-down menu.



4. Select the **dist2toxft** layer as the **Input Raster** from the Drop-down menu.

5. Under the **Output point features** item, name the ouput layer **Schools_with_Dist2Toxft** and save it to the **..\Data\Shapefile** folder for this tutorial.

Note that if all goes well, a new **Schools_with_Dist2Toxft** layer will be added to your Map Document.



VACANT	OWNER_OCC	RENTER_OCC	SQMI	NONWHITE	RASTERVALU
49	135	278	0.17	1017	3425
49	135	278	0.17	1017	3533
22	126	174	1.36	292	7553
22	216	258	0.97	185	9754
48	243	396	1.05	924	5300
10	93	175	0.12	135	6920
59	164	277	0.17	450	463
11	244	151	0.31	649	13927
100	144	355	0.13	949	10175
14	81	170	0.1	487	14015
18	90	455	0.07	235	7013
5	102	217	0.11	179	7336
69	145	469	0.08	1309	11298
5	304	16	0.58	94	17173
5	250	14	0.12	21	23036
15	114	269	0.16	622	11159
15	114	269	0.16	622	10950
38	128	238	0.12	384	9469
14	105	114	0.09	115	9693
63	141	458	0.1	230	9291
38	269	421	0.12	212	9743

6. Right-click on the **Schools_with_Dist2Toxft** layer in the **Table of Contents** and Open the Attribute Table.

7. Scroll to the far right of the attribute table and note that there is a field called **RASTERVALU.** This is the value of your **dist2toxft** raster layer that lies beneath each of the points in the **New_Haven_Schools_with_SF1 ,** or the distance from every school in the study area to the nearest Toxic Release Site.

8. Save your work.