Cell Tower Kernel Density Comparer Technical Specifications Document

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Type of Software

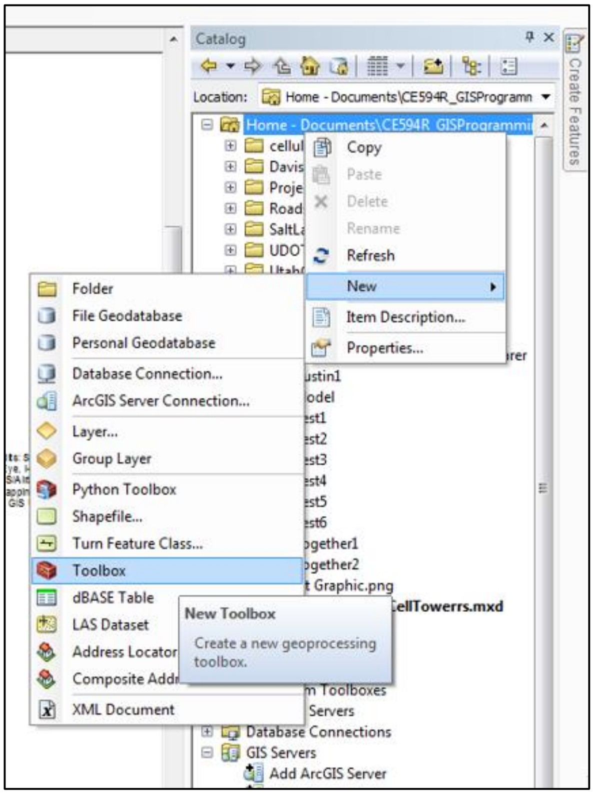
This ArcMap tool for comparing different kernel densities for cell towers was made using the Python coding language.

License Information

This code was created at Brigham Young University for the CE 594R “GIS Programming” class under the direction of Dr. Daniel P. Ames. We have chosen to use the MIT License for sharing and distributing this code:

Installation of This Python Script in ArcMap

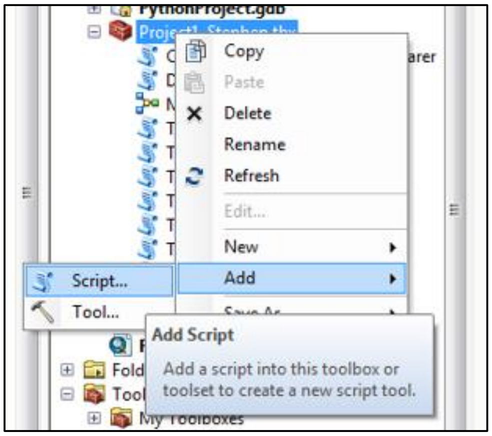
Inside the ArcMap Catalog, this software needs to be installed as a new "Script." First, inside the "Home" folder (or any connected folder inside ArcMap) a new "Toolbox" needs to be created. This can be done by right clicking on the desired folder you want it to be in and select "New" → "Toolbox" (as shown below).



New Toolbox

Create a new geoprocessing toolbox.

A similar process can be used to add this script to the Map Document. This can be done by right clicking the desired Toolbox, and select "Add" → "Script" (as shown below).



Add Script

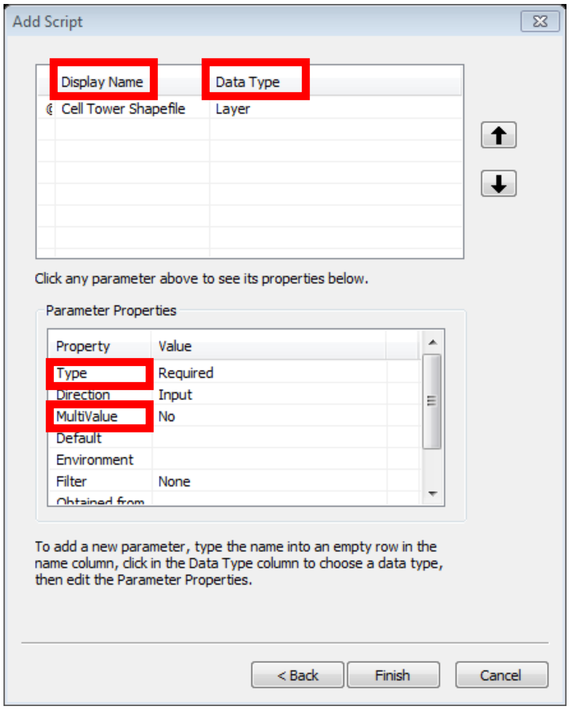
Add a script into this toolbox or toolset to create a new script tool.

The next step is to fill out the required information about this script. It is recommended to use the following descriptions in each field. However, any description the user desires to use is also fine. It is also recommended to turn on the "Store relative path names (instead of absolute paths)" and "Always run in foreground" options on this page. After filling this page out, select the "Next >" button.

Field Name	**Suggested Description**
Name:	CellTowerKernelDensityComparer
Label:	Cell Tower Kernel Density Comparer
Description:	This script compares different kernel densities of Cell Towers for the different Polygons in a shapefile, suggest possible locations (if any), and produce an Atlas with the final results. This was used to compare the different densities of cell towers in Utah County, although it could be used for any shapefile.
Stylesheet:	<leave blank>

The next page should ask you for the location of the script file. This can be found by either typing in the path and name of the script (wherever you downloaded and saved it too) or by clicking the 📂 button next to the text box. After searching for this script, click add in the window browser and the path and script name should appear in the textbox. If you are satisfied with your connection to the script's location, then select the "Next >" button.

The last page should look like the figure shown below. The three required fields that need to be checked for each parameter in the script are the "Display Name" and "Data Type," and in the properties field "Type" and "MultiValue."



Display Name	Data Type
Cell Tower Shapefile	Layer

Click any parameter above to see its properties below.

Parameter Properties

Property	Value
Type	Required
Direction	Input
MultiValue	No
Default	
Environment	
Filter	None
Obtained from	

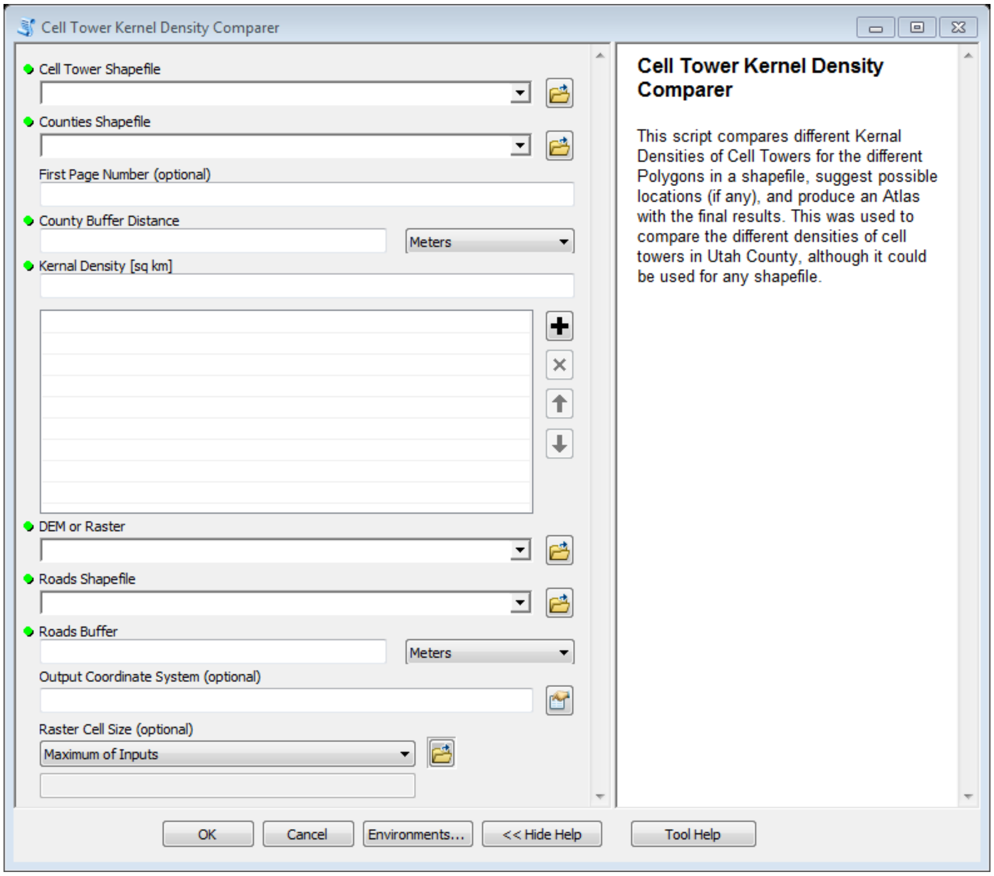
To add a new parameter, type the name into an empty row in the name column, click in the Data Type column to choose a data type, then edit the Parameter Properties.

The order of the parameters is requisite for this script to work. The order of the following table should be followed, with the appropriate properties associated with it.

Display Name	Data Type	Type	MultiValue
Cell Tower Shapefile	Layer	Required	No
Counties Shapefile	Layer	Required	No
First Page Number	Double	Optional	No
County Buffer Distance	Linear Unit	Required	No
Kernel Density [sq km]	Double	Required	Yes
DEM or Raster	Layer	Required	No
Roads Shapefile	Layer	Required	No
Roads Buffer Distance	Linear Unit	Required	No
Output Coordinate System	Coordinate System	Optional	No
Raster Cell Size	Cell Size	Optional	No

**NOTE: The order of these parameters is VERY important, or else the script will not work.*

If set up correctly, when double clicking the newly imported script it should look like any other toolbox tool. The following figure is an example if the instructions were followed in this document.



Cell Tower Kernel Density Comparer

● Cell Tower Shapefile

● Counties Shapefile

First Page Number (optional)

● County Buffer Distance — Meters

● Kernal Density [sq km]

● DEM or Raster

● Roads Shapefile

● Roads Buffer — Meters

Output Coordinate System (optional)

Raster Cell Size (optional) — Maximum of Inputs

Cell Tower Kernel Density Comparer

This script compares different Kernal Densities of Cell Towers for the different Polygons in a shapefile, suggest possible locations (if any), and produce an Atlas with the final results. This was used to compare the different densities of cell towers in Utah County, although it could be used for any shapefile.

If you have a final prompt looking like the example above, your installation is complete.

Hardware and Software Limitations or Requirements

There are several limitations to this project that one should be aware of. For making this code easier to use, the default environment setting for the Workspace was not added as a parameter for the tool to make the programming easier for the script's writers. Before using, it will be necessary to change the workspace to a default geodatabase on the personal computer. The workspace string should be changed to something like:

"C:\\Users\\Stephen\\Documents\\CE594R_GISProgramming\\PythonProject.gdb"

If no coordinate system is specified (since it is an optional parameter), the default coordinate system of:

"NAD_1983_UTM_Zone_12N"

will be used. This was used because the writers currently (as of 2015) live in this zone and used geographical information about the region.

Only the script and documentation are provided by the authors any data, shapefile, rasters, or other information need to be provided or searched by the user.

Another limitation that might affect the user is that this python script was prepared for ArcMap version 10.1 and 10.2. This may work with earlier and later version, but there may be a need to update the script for the other versions of ArcMap.

How to get code

This script along with its documentation can be obtained by emailing the authors directly or any other person that has these files. Alternatively the code and its documentation are available by going to the following URL:

https://github.com/sduncan4/Cell-Tower-Kernel-Density-Comparing-Tool

Software Design

Purpose of Design

The purpose of the Cell Tower Kernel Density Comparer tool is to provide an easy to use function that allows ArcMap users to generate several maps of possible cell phone tower locations within a spatial area. This tool can be used by communication companies and planners in determining options for best placement of new cellular tower within a region.

Efforts were made to include parameters that would best determine locations for cell tower placement. These parameters include:

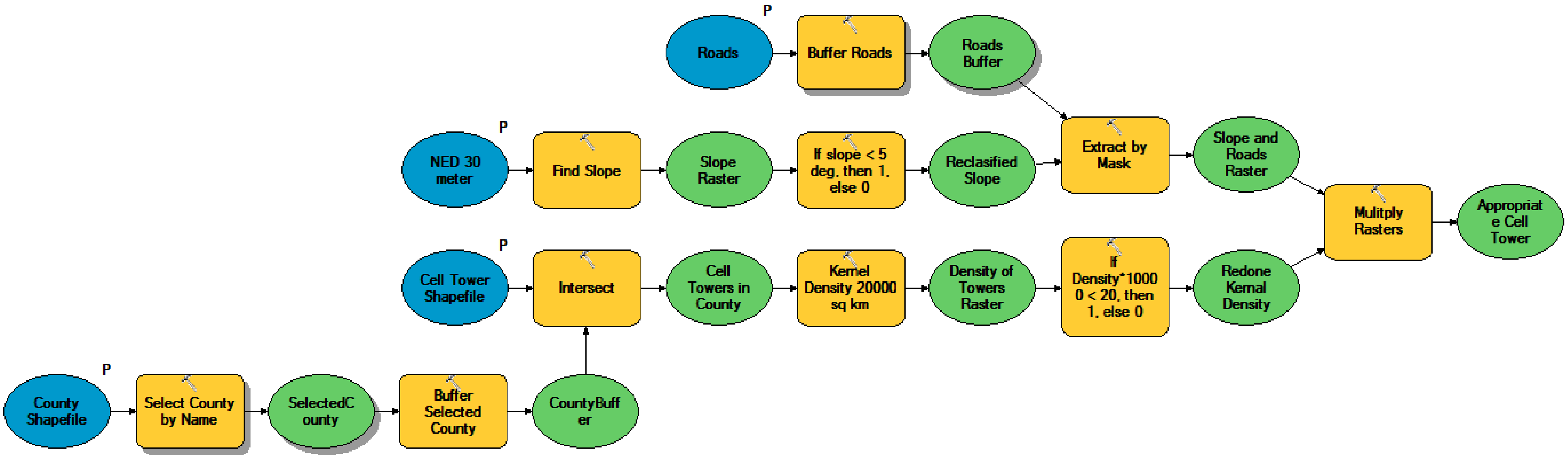
- Slope of terrain (towers cannot be placed on excessively steep hillsides)
- Proximity to access roads
- Distance from other towers (ensuring operational and cost efficiency in placement)

The tool generates a collection of maps (an atlas). The user load any number of spatial areas of interest and the tool returns four maps of possible tower placements for each area. Each of the four maps returned to the user represent a different kernel density. The maps can then be compared and a best scenario is selected by the user.

This software was created at Brigham Young University for the CE 594R “GIS Programming” class under the direction of Dr. Daniel Ames.

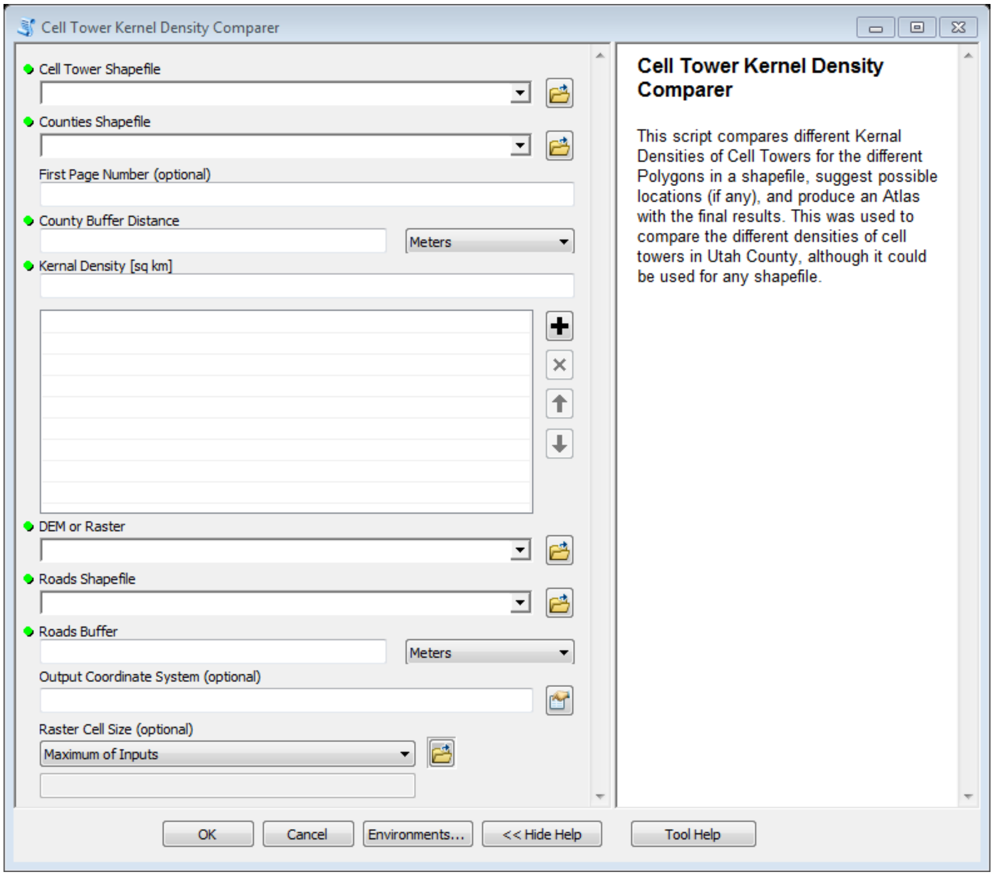
Software Structure

The basic structure of the code is shown in the flowchart below. This model was exported from ArcMap Model Builder. The rectangular boxes represents functions in the code, the blue ovals are input files, and the green ovals are function outputs. Our software flow chart can be seen on the next page.


P
Roads
Buffer Roads
Roads Buffer
P
NED 30 meter
Find Slope
Slope Raster
If slope < 5 deg, then 1, else 0
Reclasified Slope
Extract by Mask
Slope and Roads Raster
P
Cell Tower Shapefile
Intersect
Cell Towers in County
Kernel Density 20000 sq km
Density of Towers Raster
If Density*1000 0 < 20, then 1, else 0
Redone Kernal Density
Mulitply Rasters
Appropriate Cell Tower
P
County Shapefile
Select County by Name
SelectedCounty
Buffer Selected County
CountyBuffer

Menu and Interface Elements

The tool is integrated into the ArcMap system of tools. As such its formatting follows the same design as other tools in ArcMap. This design is intuitive and easy to use. Below is a screen shot of what will appear when the tool is opened.



County Buffer Distance: Meters

Roads Buffer: Meters

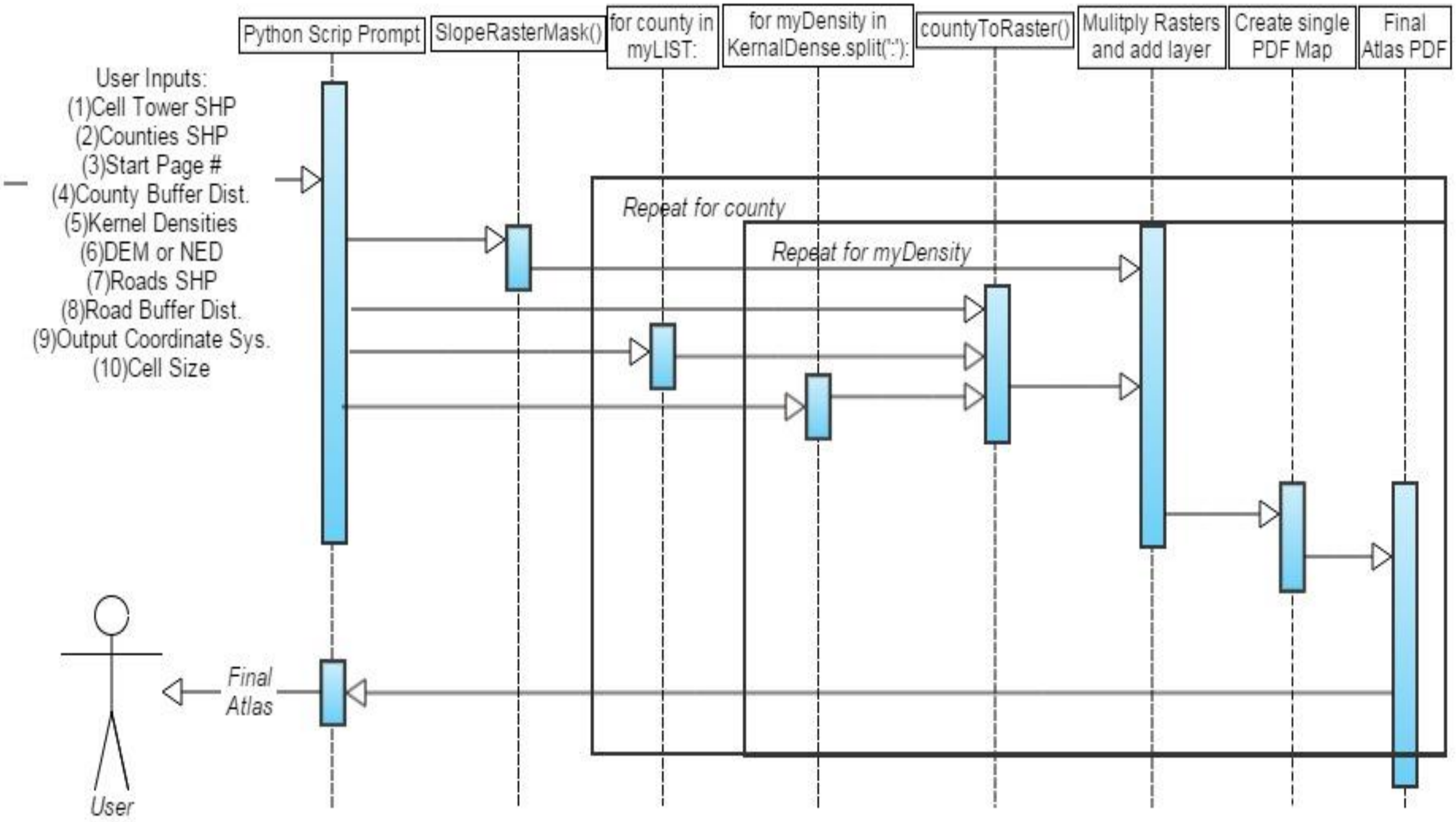
Raster Cell Size (optional): Maximum of Inputs

Cell Tower Kernel Density Comparer

This script compares different Kernal Densities of Cell Towers for the different Polygons in a shapefile, suggest possible locations (if any), and produce an Atlas with the final results. This was used to compare the different densities of cell towers in Utah County, although it could be used for any shapefile.

Users direct the tool the desired files to be used. Numerous parameters can also be specified by the user such as the county buffer distance, the units, and the kernel density.

The following page shows a diagram of the function of the software once run. The user enters a series of inputs (as shown above), the various functions are called to process the data, and the atlas is returned to the user as the end result.


Python Scrip Prompt
SlopeRasterMask()
for county in myLIST:
for myDensity in KernalDense.split(':'):
countyToRaster()
Mulitply Rasters and add layer
Create single PDF Map
Final Atlas PDF
User Inputs:
(1)Cell Tower SHP
(2)Counties SHP
(3)Start Page #
(4)County Buffer Dist.
(5)Kernel Densities
(6)DEM or NED
(7)Roads SHP
(8)Road Buffer Dist.
(9)Output Coordinate Sys.
(10)Cell Size
Repeat for county
Repeat for myDensity
Final Atlas
User

Main Files

The tool requires several files to run and are provided by the users. These input files include several types of shapefiles and a raster. The types of input files required as well as example sources where some might be obtained are given below:

- Cell Tower Shapefile (Point)
  http://wireless.fcc.gov/geographic/index.htm?job=licensing_database_extracts
- Main Highways Shapefile (Polyline)
  http://gis.utah.gov/data/sgid-transportation/roads-system/
- Shapefile of Area of Interest (Polygon)
  http://gis.utah.gov/data/boundaries/citycountystate/
- DEM of Area of Interest (Raster)
  http://gis.utah.gov/data/elevation-terrain-data/10-30-meter-elevation-models-usgs-ned
- Background Image
  server.arcgisonline.com

Key Functions

The following table contains the functions used in the Python code. These functions are presented in the order they appear in the code.

Function Name	**Comments**
SlopeRasterMask()	Using a function to analyze the slope, buffer the roads, and extract by mask all the different inputs and output a masked raster of good areas that fit both places. The input parameters are: (1) Elevation DEM or NED you plan to use (2) The roads shapefile you plan to use and buffer from (3) The number you will use to buffer from the roads (4) The output raster name
FinishMapLayout()	This function is to help set the layout view. The input parameters are: (1) The County Name you are looking at (2) The Page Number you will start from (3) The Kernel Density used to produce the map
PDFstuff()	This function is to help set the PDF documents. The input parameters are: (1) The County Name you will name the map for (2) The Atlas Path you will save everything too
countyToRaster()	Function to select counties, buffer counties, clip with cellular and create raster. The input parameters are: (1) The county shapefile (2) The County Name you will name the map for (3) The county buffer (4) The specified kernel Density