The Terrestrial Ecological Unit Inventory (TEUI)

Geospatial Toolkit

User Guide v5.8

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GTAC FS Internet website: https://www.fs.fed.us/gstc/

What is the purpose of this User Guide?

The TEUI Geospatial Toolkit is an ArcGIS Add-In for visualizing, mapping, and analyzing landscapes. This User Guide explains how to use the Toolkit to generate and visualize descriptive statistics for feature classes or discrete raster zones using environmental raster data. Users can also aggregate statistics by map units or features with a common identifying symbol. While the Toolkit was developed for the mapping and analysis of Terrestrial Ecological Units, the Toolkit can be used to analyze and/or map any polygon-based data. Non-TEUI projects have included range analysis, watershed analysis, Terrestrial Eco Site analysis, vegetation mapping, wildlife habitat, scenic areas, and soil mapping.

Note: TEUI stands for "Terrestrial Ecological Unit Inventory." The TEUI Toolkit is intended to support the TEUI Technical Guide (GTR_WO-68).

Who should read this User Guide?

This User Guide is written for U.S. Forest Service staff and others interested in mapping or evaluating landscapes and individual delineations using underlying geospatial raster data.

Where can I get more information?

https://www.fs.usda.gov/about-agency/gtac/teui

How is this User Guide organized?

This User Guide is organized in a task-oriented fashion. Each section in the User Guide explains how to perform the following tasks in a step-by-step fashion.

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SECTION 1. Installing the Toolkit

The Toolkit is an ArcGIS Add-in that is compatible with ArcGIS 10.X. Please see the Toolkit website (https://www.fs.usda.gov/about-agency/gtac/teui) for previous versions compatible with ArcGIS 9.3 and below. (Toolkit versions 3.2 and 4.1 are no longer recommended.)

What are the computing requirements to install and use the TEUI Geospatial Toolkit?

- Windows XP or Windows 7 operating system
- ArcGIS 10.X
- ArcGIS Spatial Analyst extension
- At least 4 GB RAM space to run the TEUI Geospatial Toolkit Statistics (more memory may be needed depending on project size).

How do I download the Toolkit ArcGIS Add-In?

The TEUI Toolkit ArcGIS Add-In for ArcGIS 10.X can be downloaded from the following web address:

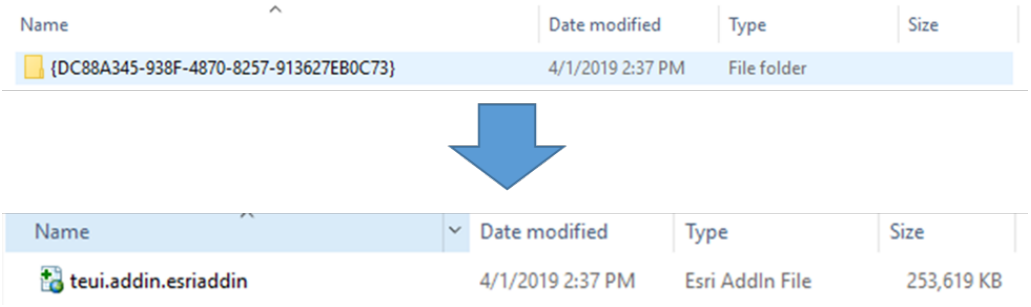
https://www.fs.usda.gov/about-agency/gtac/teui

Installing the Toolkit ArcGIS Add-In

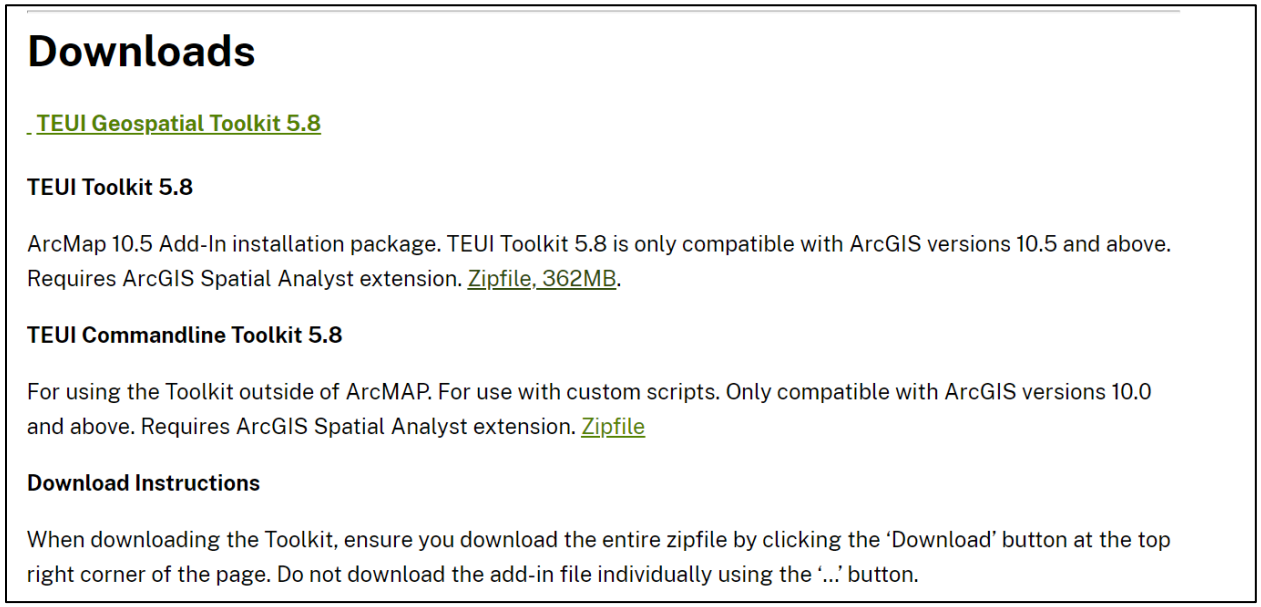
1. First, be sure that ArcMap is **not** open or running. Also, remove any previous versions of the TEUI Toolkit installed on your PC by using the Add-In manager in ArcMap (**Customize | Add-In Manager)**. Under **My Add-Ins** click **TEUI.Addin** then click **Delete this Add-In.**

2. In **File Explorer** navigate to **Documents -> ArcGIS -> AddIns** and browse through the **Desktop 10.x** folders to ensure that an old TEUI Toolit version doesn't exist. You will have to open each folder to verify whether it contains the **teui.addin.esriaddin** file (below). If it is present, delete it. Only delete files with the name **teui.addin.esriaddin**, as esri addin files with a different name are other addins you

have previously installed.



3. On the TEUI Toolkit website scroll down to the **Downloads** section (see below), click the **Zipfile, 362MB** link for TEUI Toolkit 5.8 and save it to a location of your choice.



Downloads

TEUI Geospatial Toolkit 5.8

TEUI Toolkit 5.8

ArcMap 10.5 Add-In installation package. TEUI Toolkit 5.8 is only compatible with ArcGIS versions 10.5 and above. Requires ArcGIS Spatial Analyst extension. Zipfile, 362MB.

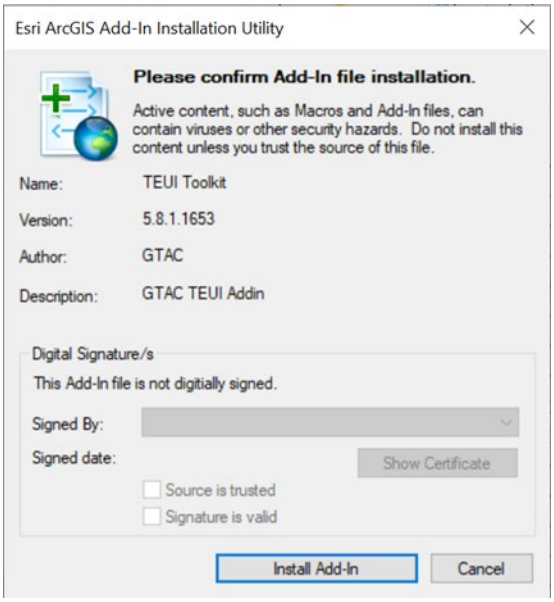
TEUI Commandline Toolkit 5.8

For using the Toolkit outside of ArcMAP. For use with custom scripts. Only compatible with ArcGIS versions 10.0 and above. Requires ArcGIS Spatial Analyst extension. Zipfile

Download Instructions

When downloading the Toolkit, ensure you download the entire zipfile by clicking the 'Download' button at the top right corner of the page. Do not download the add-in file individually using the '...' button.

4. Once the download is complete, navigate to the location of the saved Add-In, double click on the compressed folder (**DO NOT** unzip the folder), and then double click on the Toolkit Add-In.



5. When prompted, select **Install Add-In** (see above)**.**

6. Click **OK** once the installation has succeeded.

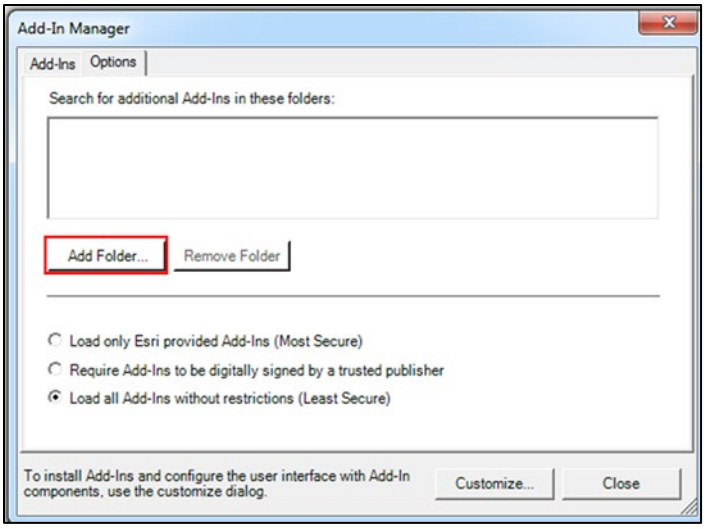
If you double-click the Add-In and the computer tries to open it with Adobe or a program besides ArcGIS that means you don't have ArcGIS installed on your local desktop computer. If so, follow the instructions below about how to load the Toolkit in Citrix.

How to load the Toolkit in Citrix

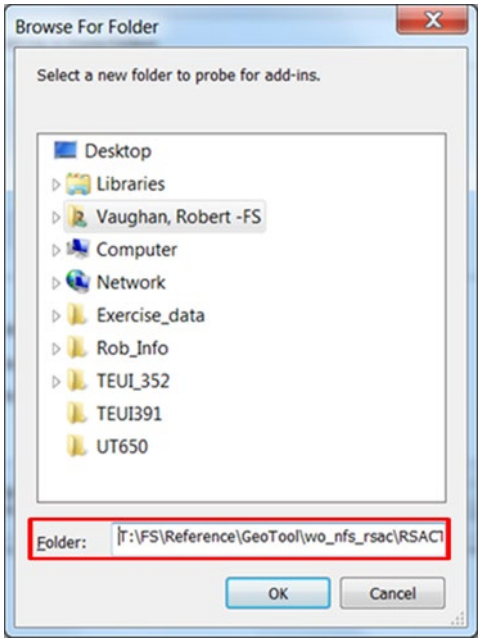
1. In ArcMap, select **Customize | Add-In Manager** from the top menu bar.

2. Select the **Options** tab in the Add-In Manager dialog.

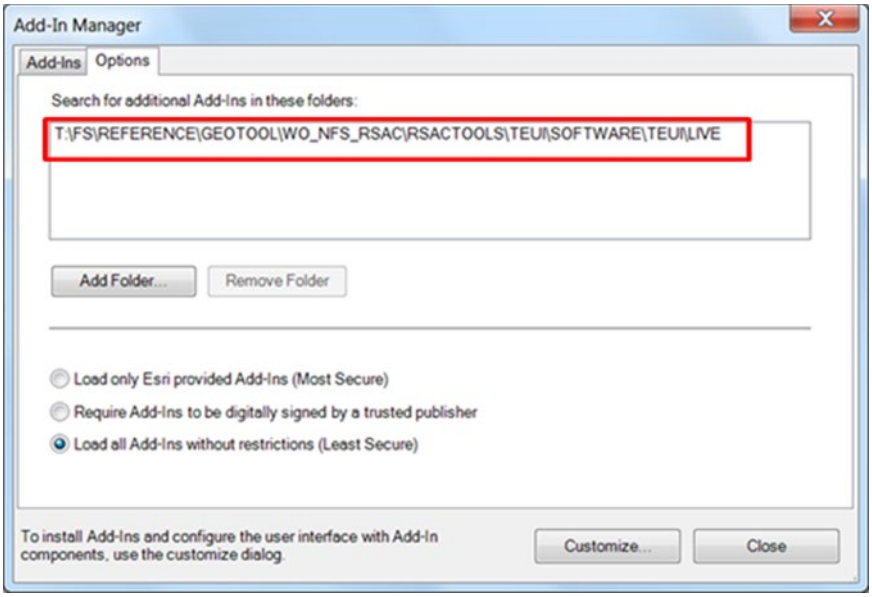
3. In the Options window, select **Add Folder**….(see below)



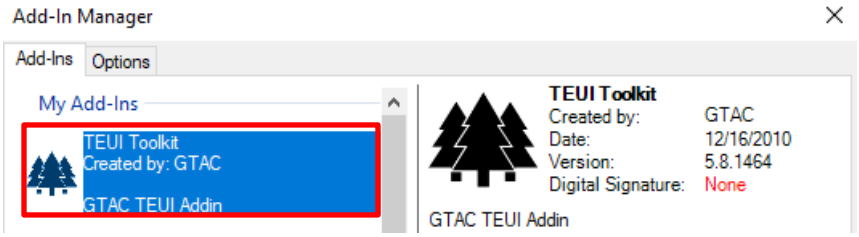
4. In the Browse For Folder dialog, enter: **T:\FS\Reference\GeoTool\wo_nfs_rsac\RSACTools\TEUI\Software\TEUI\live** in the bottom Folder space and click **OK**. (see below).



5. You should now see the address listed in the "**Search for additional Add-Ins**" window (see below).



6. Click once on the TEUI Add-In (see below).



7. Click **Close** when finished.

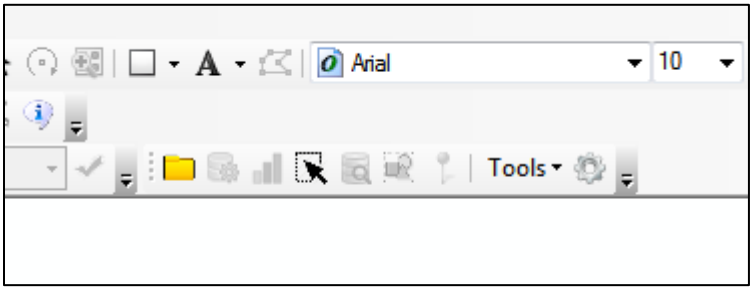
Loading the Toolkit toolbar in ArcMap

Once you have installed the Toolkit, you may have to activate it for it to appear on your screen in ArcMap.

1. Start ArcMap.

2. Click on **Customize | Toolbars** and click on **TEUI**. The Toolkit toolbar should appear on your screen.

3. Drag and drop the toolbar to a location of your choice.



Setting directories for the Toolkit in Citrix

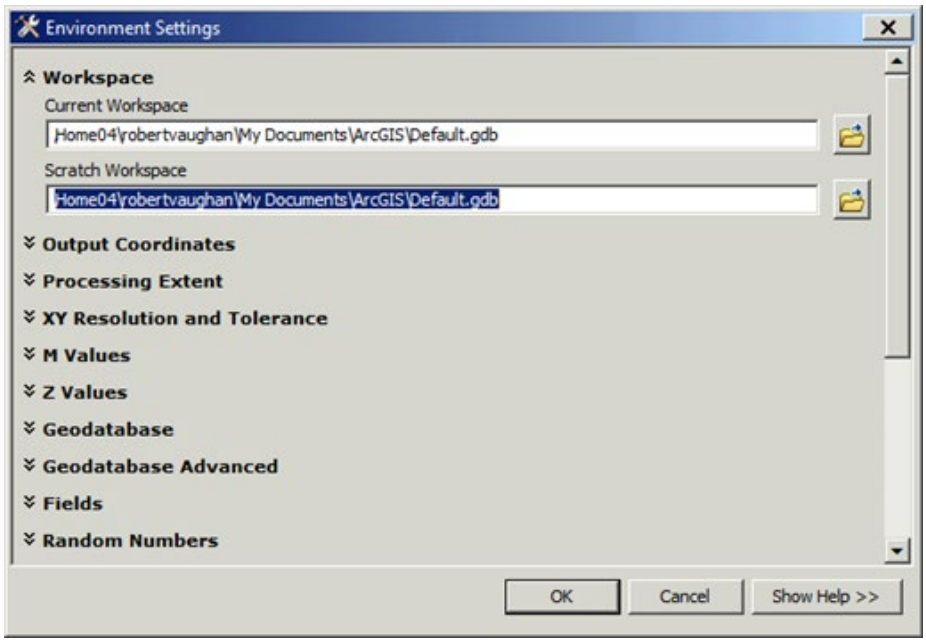
Ignore this section if you have ArcGIS on your desktop.

1. Make sure the Workspace paths in ArcGIS **do not have any spaces between characters**.

   i. On the ArcGIS main menu, click **Geoprocessing** | **Environments | Workspace.**

   ii. Notice default location example below which has a space in the path section “My Documents”.

   iii. If the **Current** and **Scratch Workspace** path has any spaces between characters, change the path to one that doesn’t. The paths should also go to a directory where the disk space quota is large enough for what you are working on.

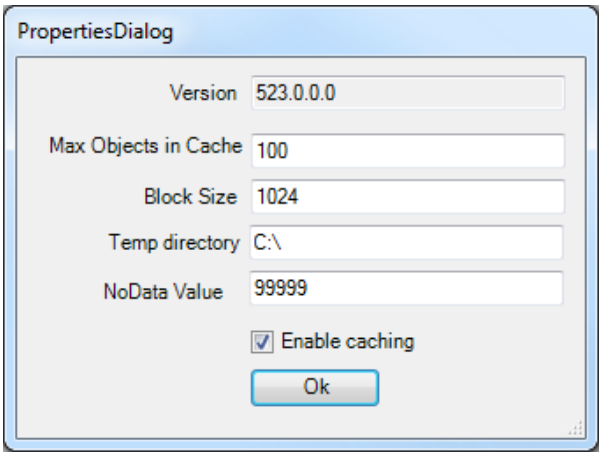


2. Using ArcCatalog or Windows Explorer within Citrix, make a **project folder** for toolkit statistics in a preferably a **local** forest\region project folder or in **T:\datacenter\citrix\AppDataXX\<username>** directory

3. Using ArcCatalog or Windows Explorer within Citrix, make a **temporary processing folder** (**must be separate from project folder, and not within the project folder**) preferably a **local** forest\region project folder or in **T:\datacenter\citrix\AppDataXX\<username>** directory.

4. Click on the sprocket (**TEUI Properties** button) on the right end of the Toolkit Toolbar.

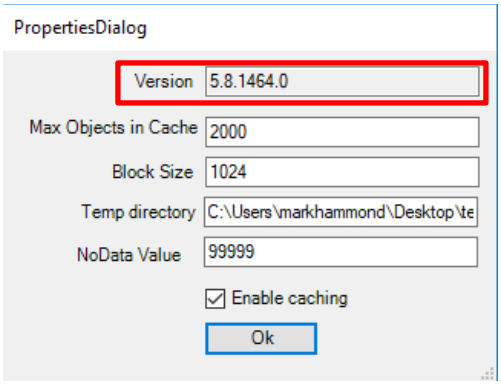
5. In the TEUI Properties dialog, click on the blank **Temp Directory** field. Set this folder location to the temp directory created in Step 3 above. Note: Temp directory is initially blank because it isn't automatically set by the program in Citrix.



Checking the Toolkit version

1. Click on the **sprocket** icon at the far right of the Toolkit toolbar to open the Properties Dialog.

2. The Toolkit version that is currently installed is shown at the very top of the dialog box.



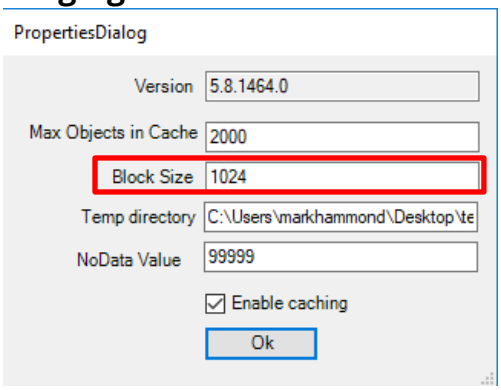
*If the toolkit doesn't seem to be updating, try clearing the add-in cache on your local machine. Go to **C:\Users\user name\AppData\Local\ESRI\Desktop10.x\AssemblyCache**. In the AssemblyCache folder will be a folder for each add-in ArcMap has loaded. The folders are named with a long alpha-numeric that won't make any sense, but if you click into these folders you will see .dll, .pdb, and .xml files that have the same name as the add in. Delete the folder within the AssemblyCache folder that holds the add-in you want to be updated properly, and restart ArcMap. Note that a few of these folders you need to click through are hidden, so you'll have to make sure you can see hidden folders.*

Setting tool processing and memory parameters

1. Open the Properties Dialog if it isn't already (click on the sprocket icon at the end of the Toolkit toolbar).

2. Users can modify the **Max Objects in Cache** parameter, which is a dynamically scaled value that depends on how much memory the Toolkit application is using. Users can use this value to limit the amount of memory the application uses. (**Changing this value is not recommended.**)

3. Users can also modify the Block Size parameter to control how much memory can be used by the program (see below). A larger block size speeds up processing, but requires more memory. (**Changing this value is not recommended.**)

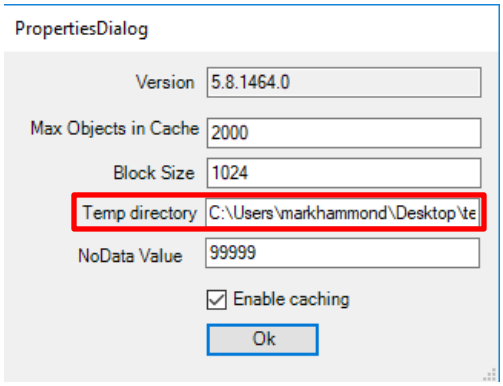


4. By selecting “Enable caching,” users can speed up the statistics process. This is the default.

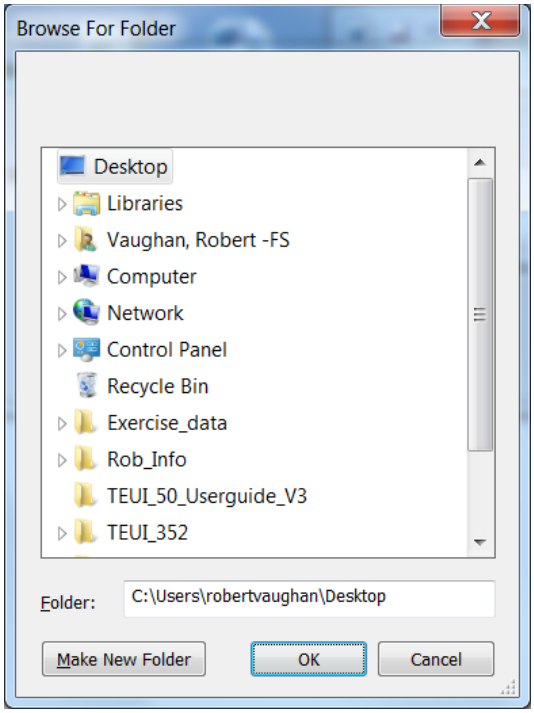
Setting the temporary working directory

1. Open the Properties Dialog if it isn’t already (click on the sprocket icon at the end of the Toolkit toolbar).

2. Users can modify the temporary working directory. This may be needed in cases where users do not have permission to modify particular directories on a computer. This may be helpful when working over network connections.



3. Click anywhere in the Temp directory entry space and a navigation pane will open. Navigate to the directory (folder) of your choice and click **Ok**. NOTE: **DO NOT** set your Temp directory to your training data folder or you will get an error message.



SECTION 2. Creating a new project and opening an existing project

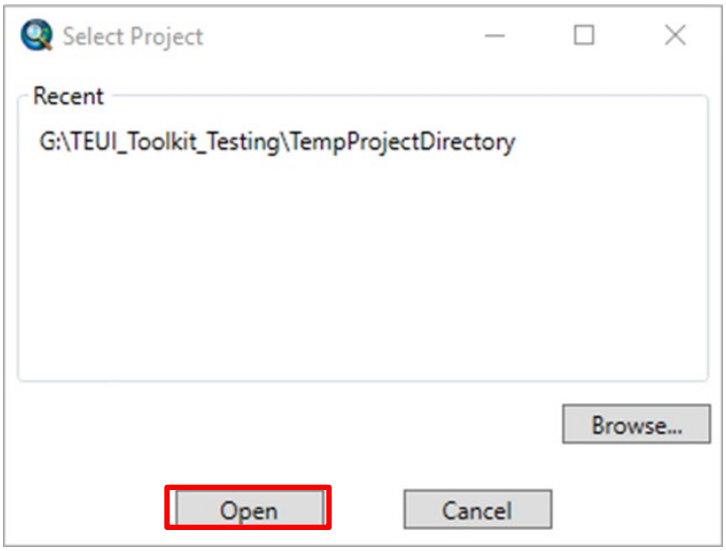
The Toolkit requires the user to specify a folder to store the database that contains project statistics and the location of the data used to create them. This folder can be an existing project folder, but it is recommended that a new folder be created and used to reduce the number of extraneous files in the project folder.

Create a new Toolkit project

1. On the toolbar, click the **Folder** button.

2. In the Select Project dialog, click **Browse….**
3. In the Browse for Folder dialog, navigate to a location of your choice and select **Make New Folder**. **NOTE: It is best practice to not have any spaces in the file path name.**

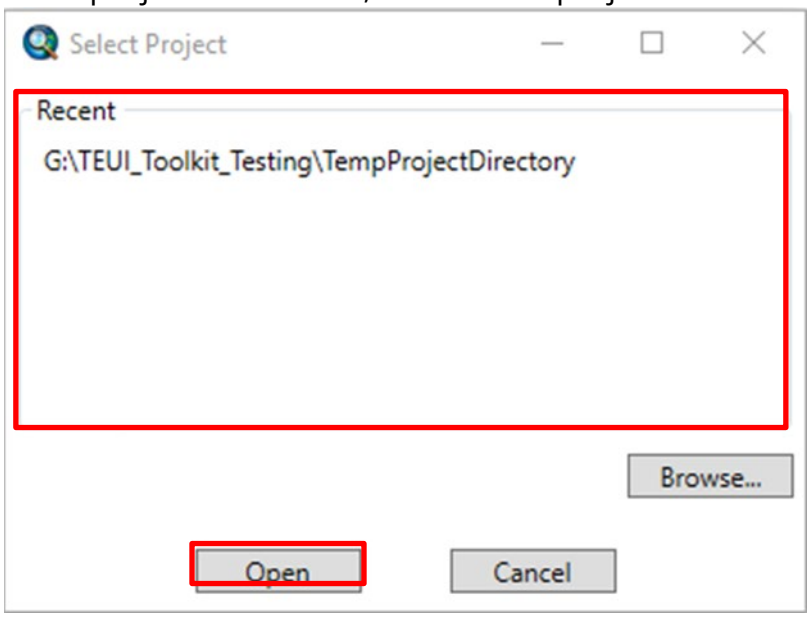
4. Type in an appropriate name for your project and click **OK**.



Open an existing Toolkit project

If you want to work with an existing Toolkit project, you can connect to the associated project folder.

1. On the TEUI toolbar, click the **Folder** icon to open the Select Project dialog.
2. If the project was recent, click on the project in the **Recent** window and click **Open**.



3. If it is older and does not appear in the dialog box, select **Browse...** and navigate to the project folder location.

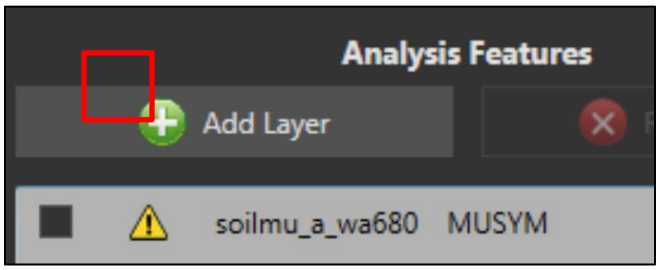
4. Select the project and click **OK**.

5. Use the instructions in the next section to see which data files are included in the project database.

SECTION 3. Managing geospatial data and calculating statistics

Managing project data is very simple. The user simply points the program to the location of the data on your computer that is to be used in the analysis.

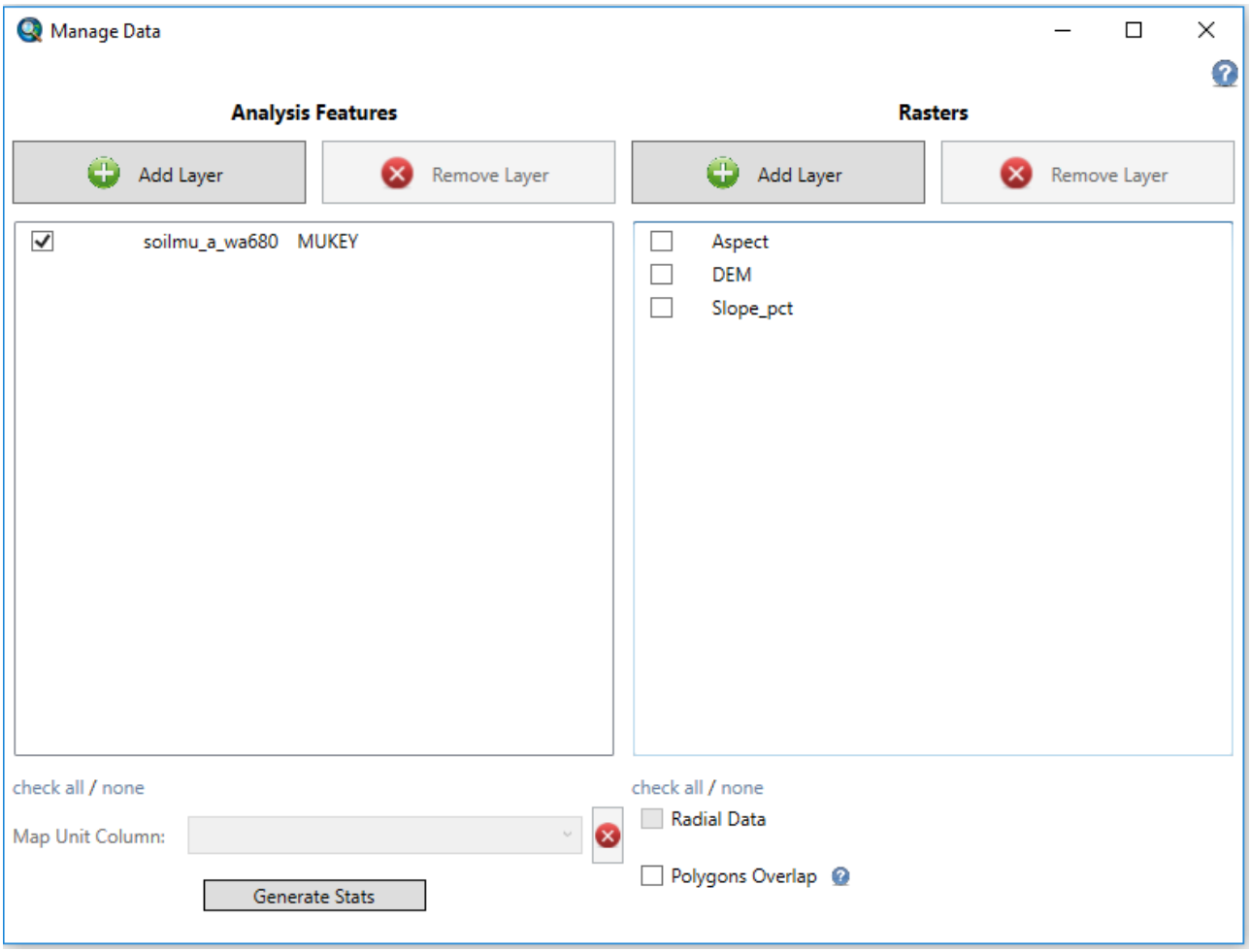
Note: If you move the geospatial data used in an existing Toolkit project, you will see a yellow triangle next to the layer name in the TEUI Data dialog. Click the triangle to open a file browse dialog and navigate to the layer's location.



Add analysis features to a Toolkit project

1. On the toolbar, click the **Manage Data** button.

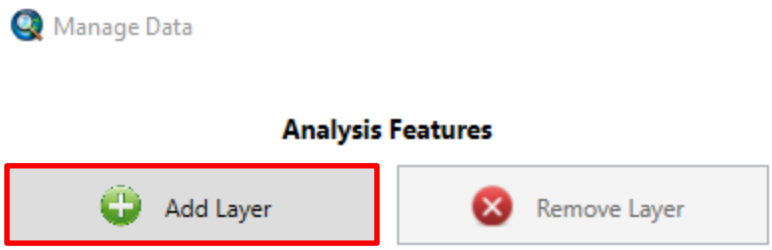
2. The Data Manager dialog window will appear. The tool uses two types of data layers: **Analysis Features** and **Rasters**.



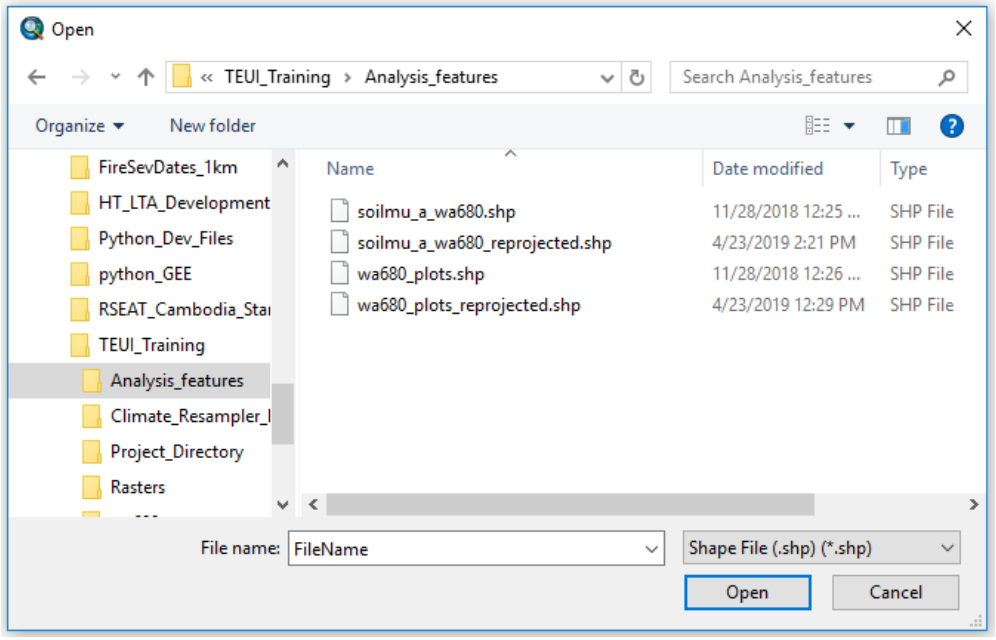
Analysis Features are vector or raster data layers that define zones within which you would like to generate statistics. These layers can be polygons, points, or lines in the form of a shapefile (.shp), or a feature class within a file geodatabase. Analysis features can also be a in the form of a discrete raster, with the value field as the identifier.

Rasters are the raster data that are to be used to generate the descriptive statistics. An example would be a digital elevation model (DEM), percent slope, aspect, or land use as raster layers. Raster data can be continuous or discrete.

3. In the **Analysis Features** area, click on the **Add Layer** button.



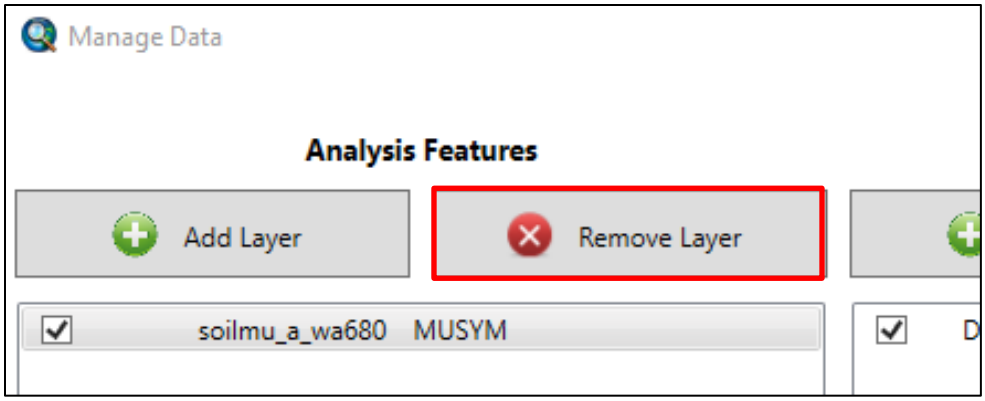
4. A data navigation window will appear. Navigate to the analysis layer you wish to use and select **Add**. You can add as many data layers as you wish to analyze.



Note: *All data layers to be analyzed (analysis features and raster data) must have the same geographic coordinate system and projection. You will receive a warning if they are different. You can continue to run statistics, but the results may not be accurate.*

Remove data layers from a Toolkit project

To remove an analysis layer from the Data Manager, click on the layer you wish to remove in the grey layer list, and click **Remove Layer**. Click **OK** when prompted to confirm your action.

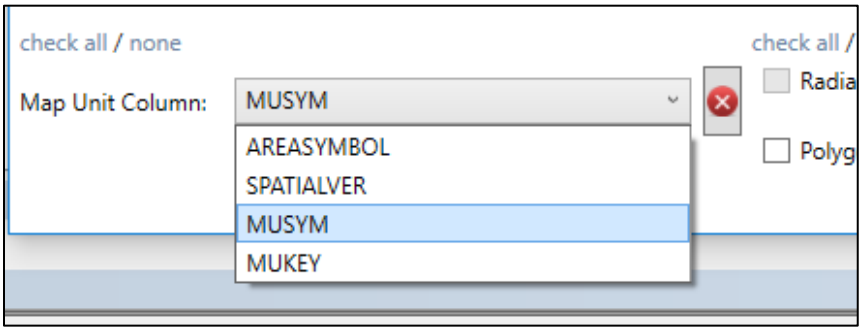


Choose a map unit

In some instances, such as TEUI mapping or Soil Survey, you may wish to identify individual polygon features as belonging to a specific ***map unit.*** *This is simply a repeating identifying symbol or value that will be used to aggregate the statistics of the polygons belonging to that group. You* ***do not*** *need to select a map unit column in order to run the Toolkit. If you wish to use a map unit, the symbol must be present as an attribute in the feature class layer or in the VAT table of the discrete raster.* ***NOTE: the map unit symbol field must not contain any special characters (e.g., !, $, #, %, *, ^, etc.).***

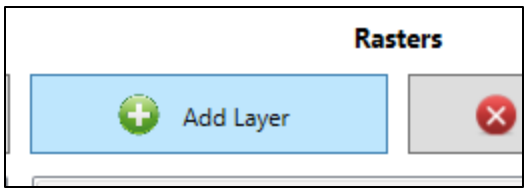
1. Select the **Analysis Feature** layer that you wish to add a Map Unit symbol for by clicking on the layer of interest.

2. Select the appropriate **Map Unit Column attribute name** for your map unit symbol in the drop down menu.

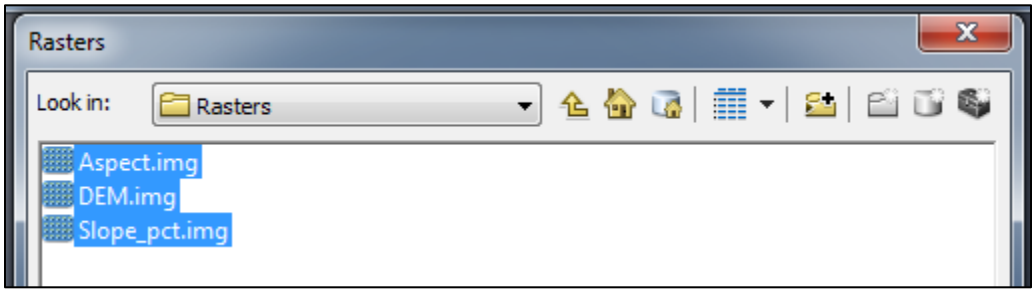


Add raster data to the Toolkit project

1. To add raster data to your Toolkit project, select the **Add Layer** button under the **Rasters** heading.



2. In the **Rasters** dialog window, navigate to the location of the raster data you wish to add to the Toolkit project.



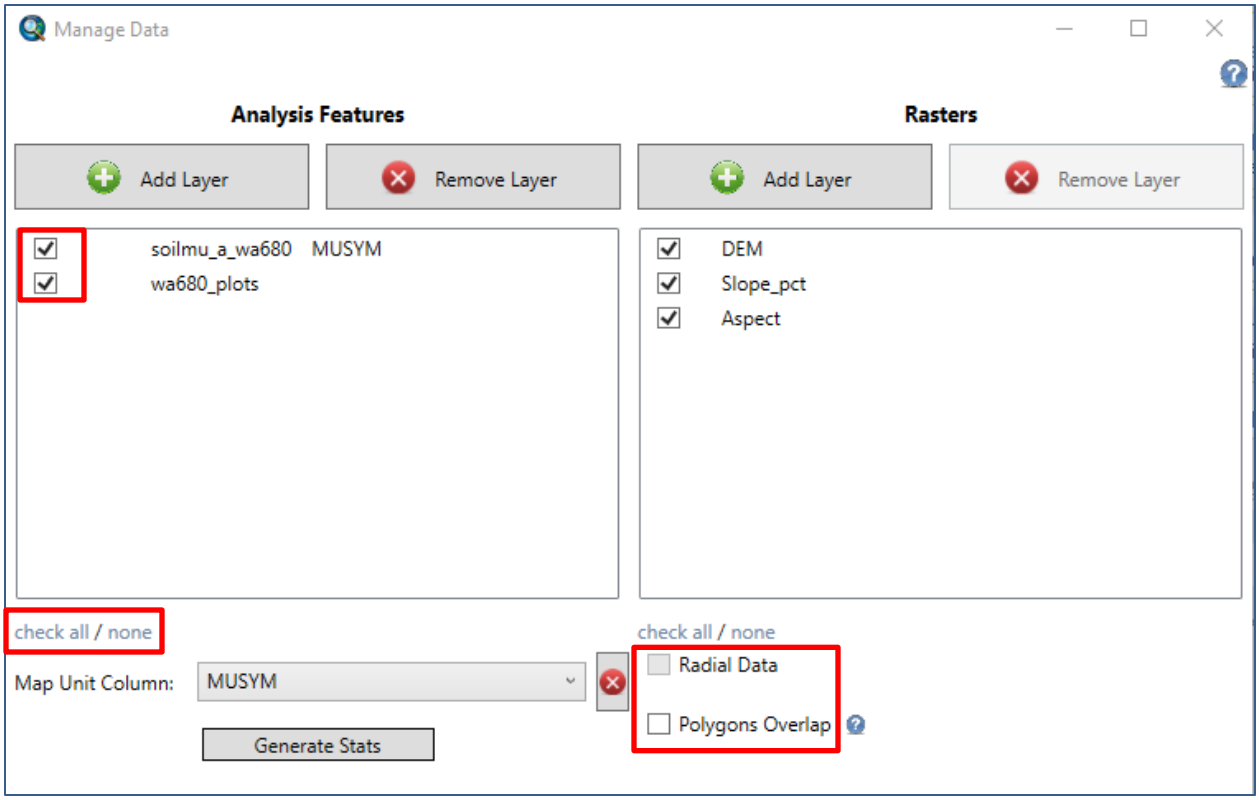
3. Select the layer you wish to add and select the **Add** button.

Calculate statistics

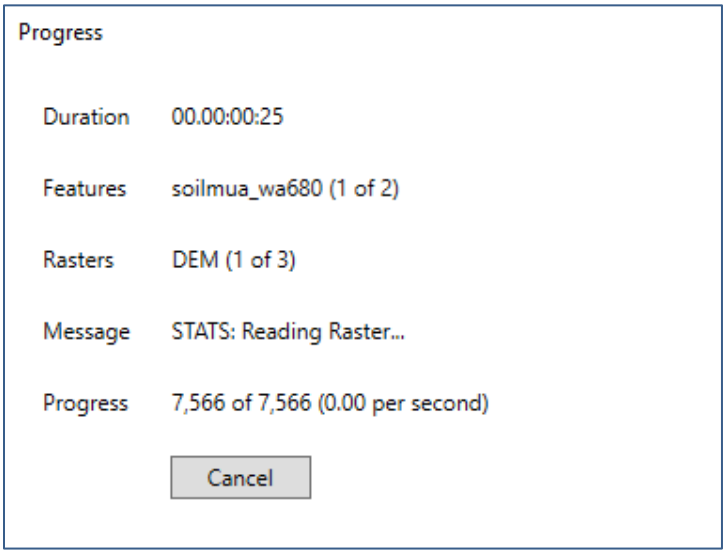
1. To calculate statistics, you must first select the analysis feature layers and raster data layers you wish to run statistics on by **checking the box next to each layer** (see next page).
2. You can check or uncheck every layer at once by clicking the **check all** or **none** buttons below the layer list.

If your polygons overlap then make sure to check the Polygons Overlap box at the bottom of the window. This method will significantly increase processing time but will ensure accurate statistics for overlapping polygons.

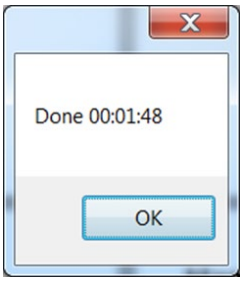
If a layer is radial data (such as aspect) click that layer to highlight it then check the Radial Data box at the bottom of the window.



3. Click on the **Generate Stats** button. Select **Yes** when prompted by the time warning that appears. This process may take a significant amount of time depending on the amount of data selected to be run (see next page).
4. A dialog will appear which informs the user of the process duration, features and rasters being used, and the progress. The tool can process more than 1 million cells per second.



5. Click **OK** when the statistics generation is complete.



Query Statistics with TeuiLite

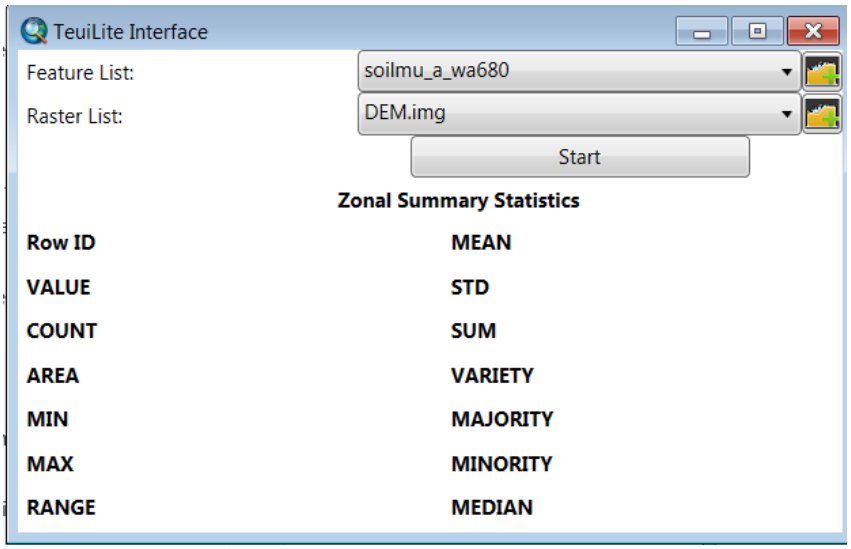
TeuiLite displays the zonal statistics of a polygon which you must select in ArcMap.

1. On the toolbar, click the **TeuiLite** button.

2. In the Feature List menu, select the **soilmu_a_wa680** layer (this tool must use a polygon feature layer).

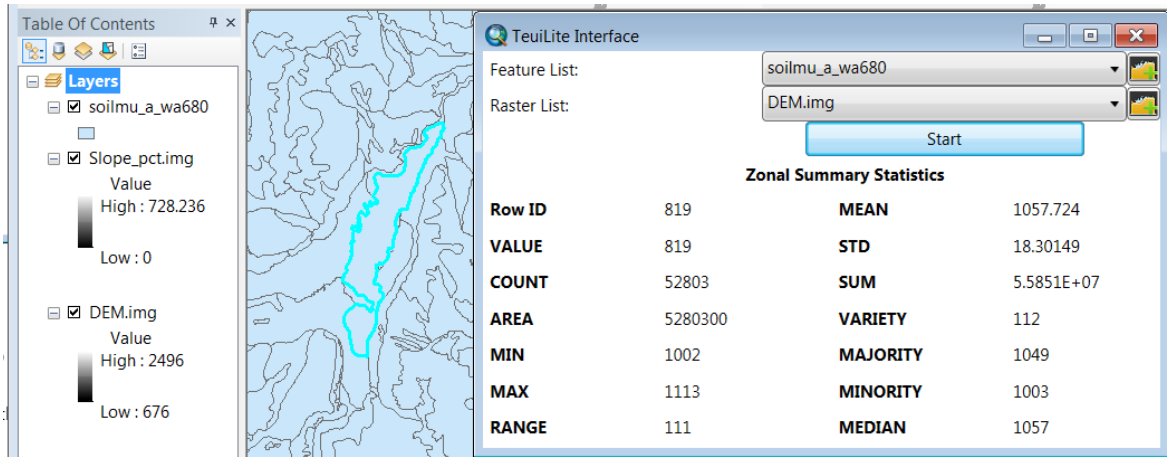
3. Select a **Raster** layer to query.

4. Click **Start**.



5. In the ArcMap viewer, make sure the **soilmu_a_wa680** layer is visible.

6. Select a polygon and you should then see its zonal stats displayed in the TeuiLite Interface.

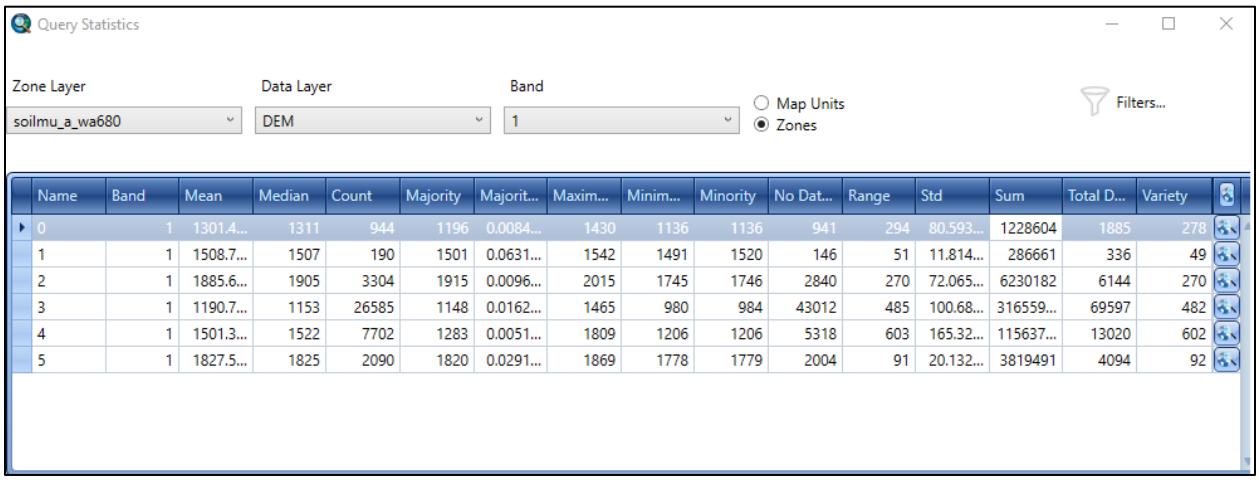


The Query Statistics Tool

The Query Statistics tool provides advanced filtering options for map unit and zonal statistics.

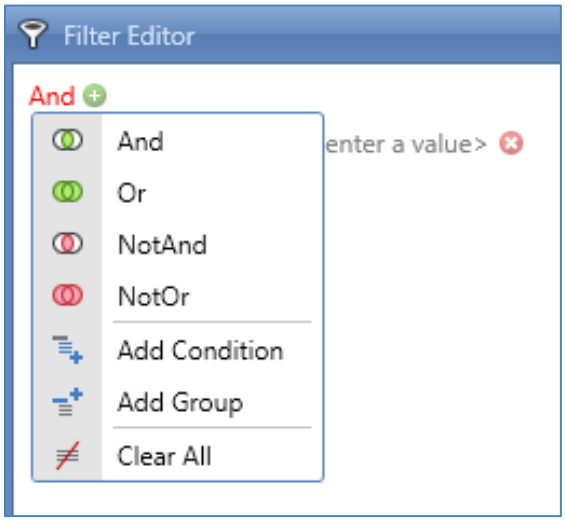
1. On the toolbar, click the **Query Statistics** button.

2. In the Query Statistics window select the Zone Layer, Data Layer, Band, and either Map Units or Zones.



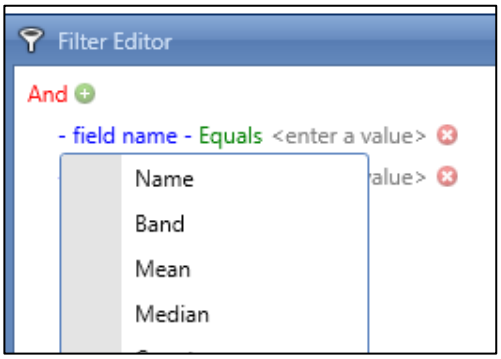
3. Click the Filters button in the upper right corner of the window to open the Filter Editor window.

4. In the Filter Editor window click **And** to open a menu of filter commands.

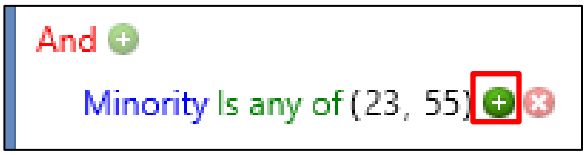


5. Clicking the green plus button next to **And** will add a row for filter commands.

6. In the filter command line click the green and blue words to adjust the command.

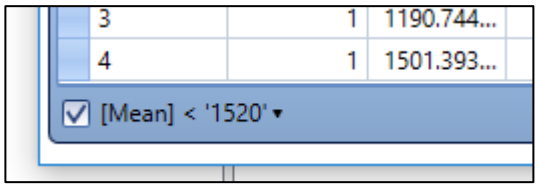


7. To enter multiple values in a command you must click the green **+** button to add more fields.



8. Enter value(s) then click **OK**.

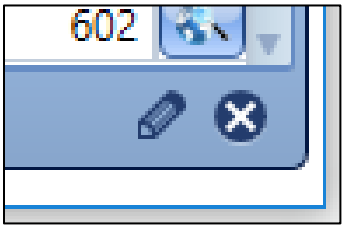
9. The bottom left of the Query Statistics window will display the current filter.



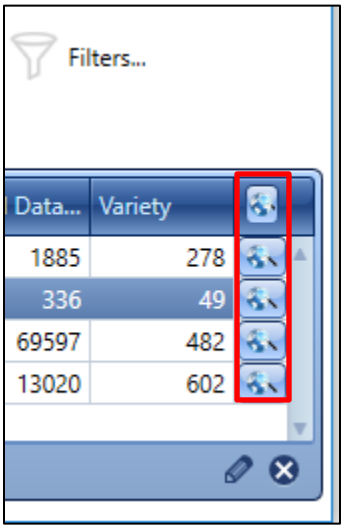
- Clicking checkbox on the left will turn the filter on/off.

- The dropdown menu on the right contains all the filter commands you have created.

10. On the bottom right of the Query Statistics window you can click the editing pencil button to edit the filter or the X button to erase the filter.



11. Click the globe button on the right side of a row to zoom to that map unit/zone in ArcMap.



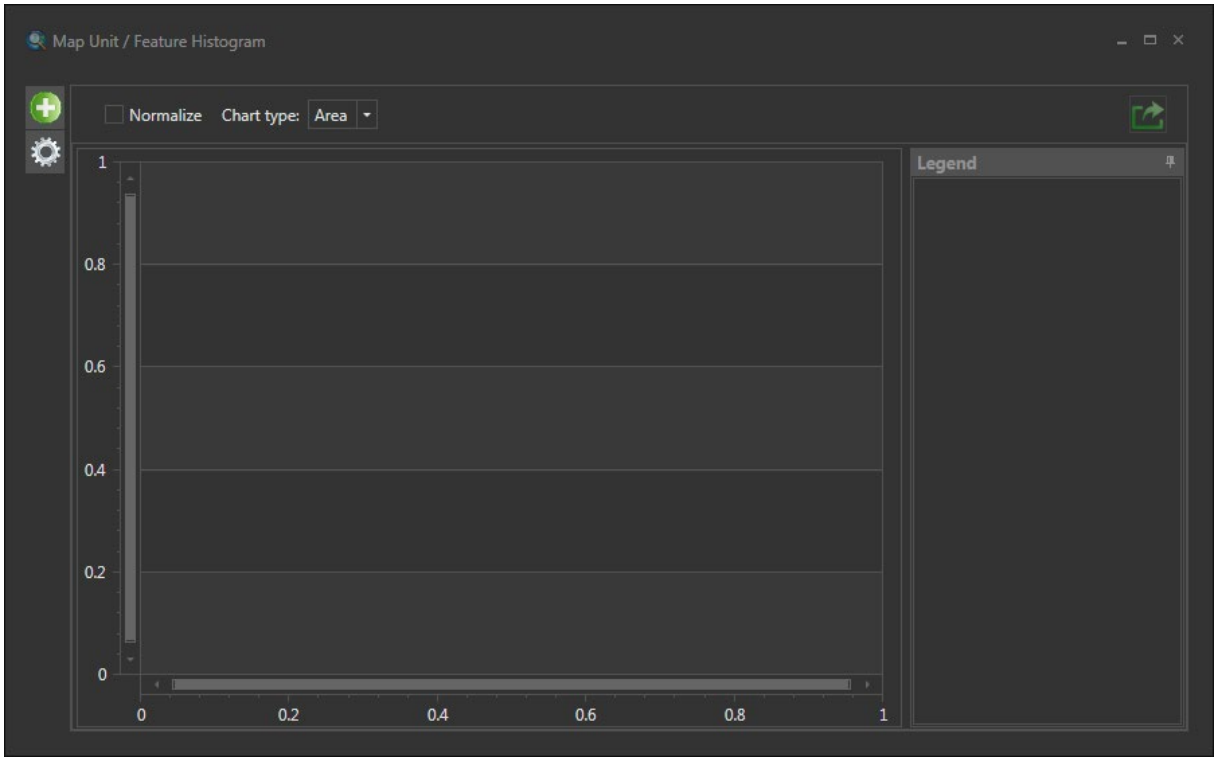
SECTION 4. Creating and visualizing graphs and tables

A primary Toolkit feature is to visualize the generated statistics in both a graph and table format. The Toolkit creates zonal statistics for the analysis features and raster data selected in the data manager. The results can be visualized in graph form or as summary table by individual feature or by map unit if one was chosen.

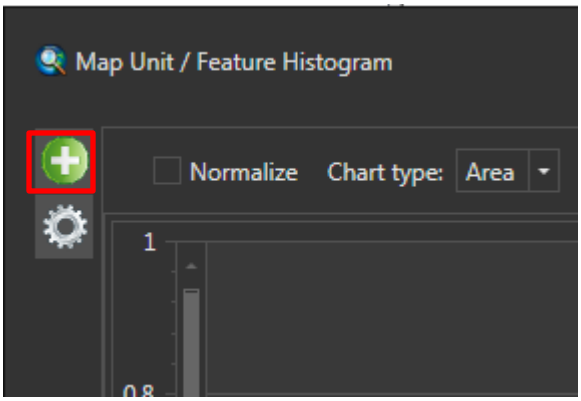
Open a graph window

1. To create a graph, click on the **Display Graph** button on the toolbar.

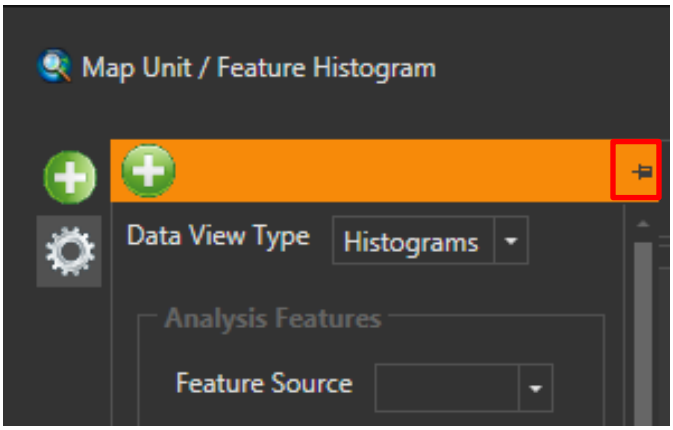
2. A blank graph window will appear. You can open as many individual graph windows as you want.



3. Click on the **green plus button** in the upper left corner of the graph window (see next page).



4. The Add Series window pane will open up. You can **pin the window open** by clicking on the sideways pin in the upper right hand of the Add Series window pane and close it again by clicking on the vertical pin.



Data View Types:

Histograms. This is the default option. This data view type allows the greatest flexibility for comparing individual polygons against other individual polygons, individual polygons against map units, or map units against map units (if chosen).

Map Units. This data view displays unique map unit graphs to compare map units or other aggregated statistics types. These graphs have the mean (solid line), range (darker colored area), and standard deviation (lighter colored area) on the same graph, for each polygon within a map unit (see next page).

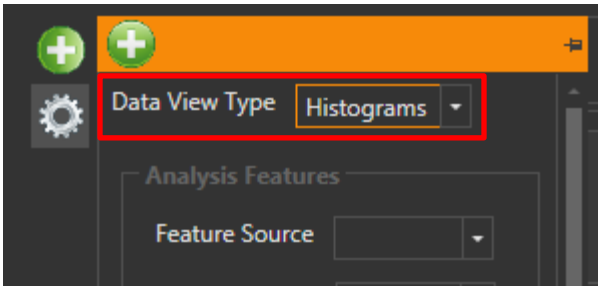
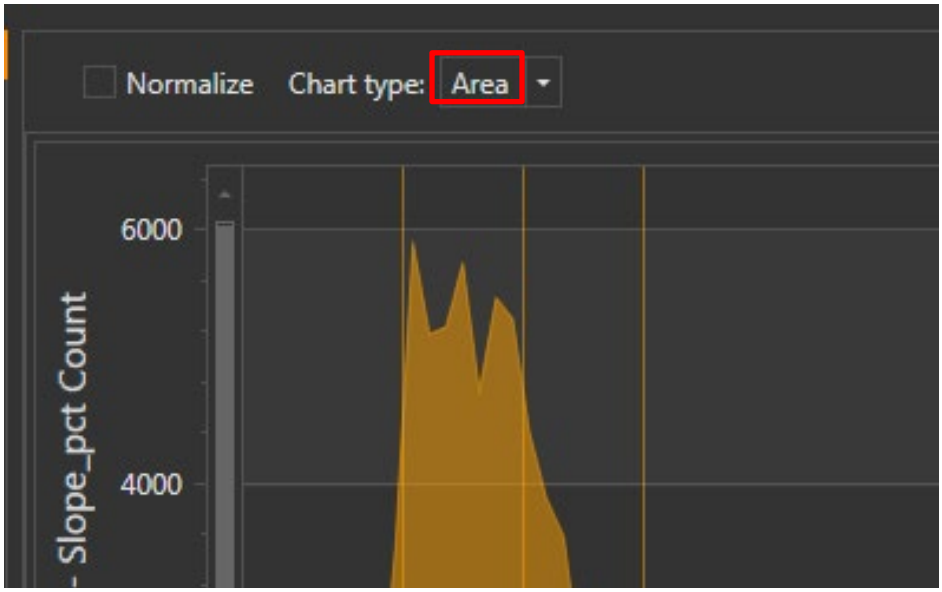


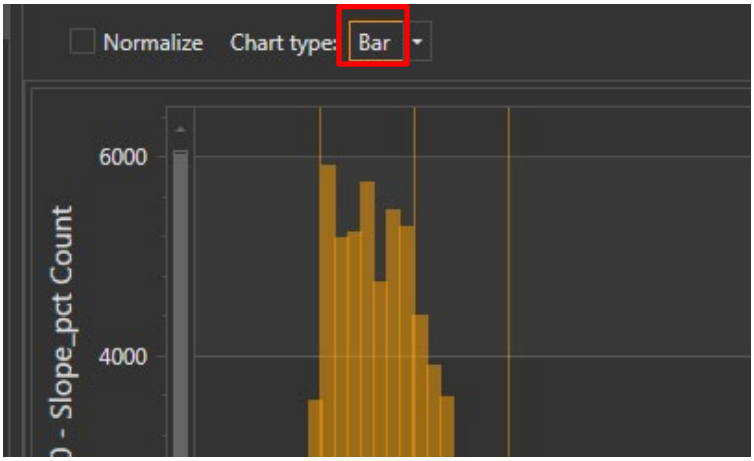
Chart types:

You can choose the type of graph that best represents your data. The default is the area chart. The Area, Bar, Point, and Line chart types display the data in standard x-y format. The Radial chart type is designed specifically for data measured in degrees, such as aspect.

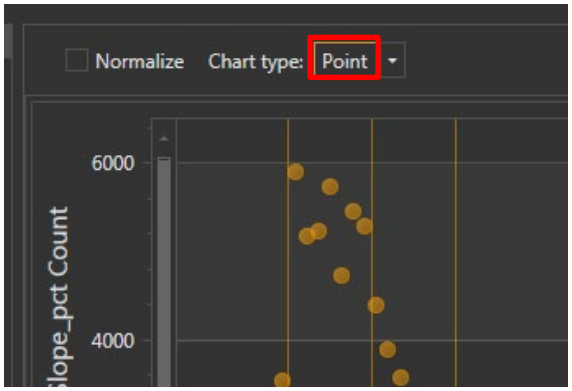
Area chart



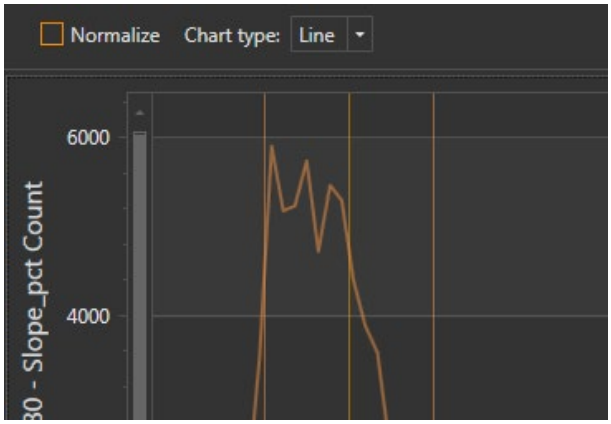
Bar chart



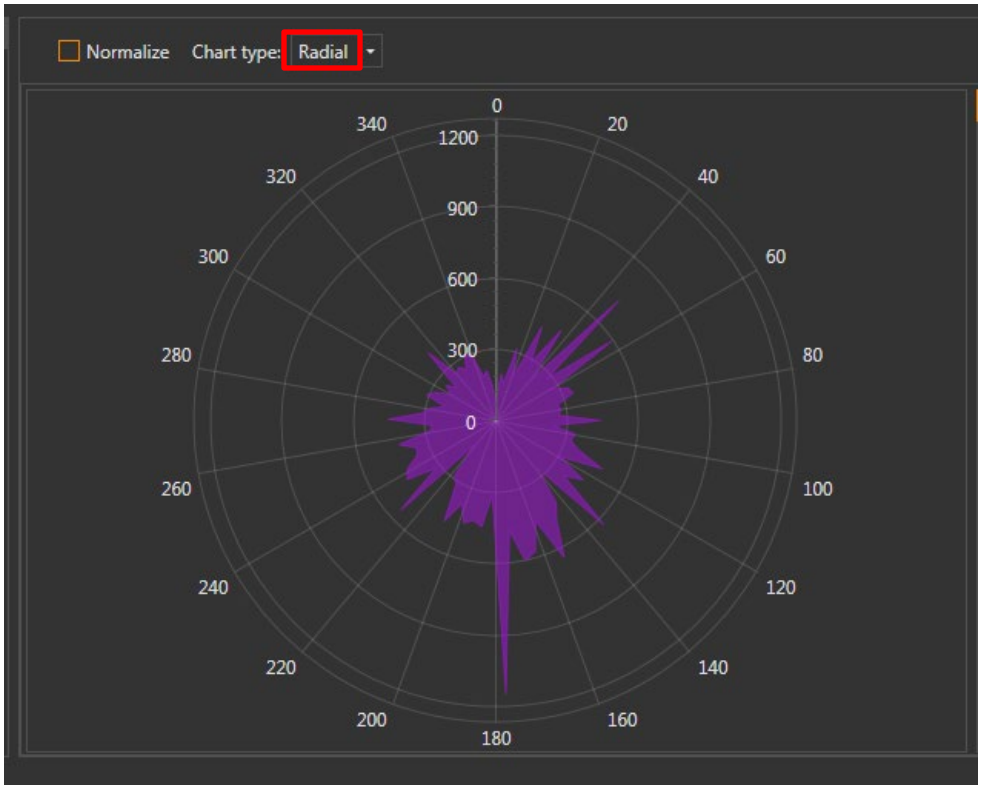
Point chart



Line chart

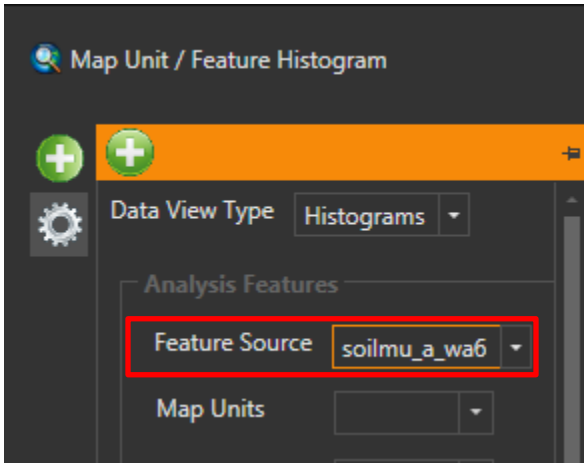


Radial chart *(aspect data)*



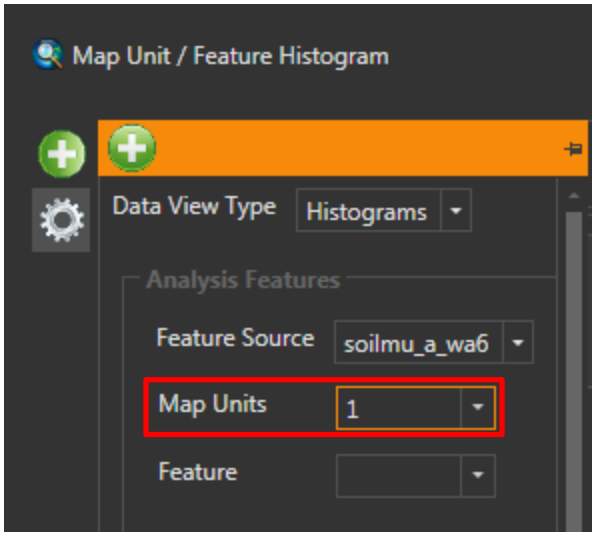
Feature Source:

Choose which feature analysis layer you would like to graph (polygons, points, lines, or discrete raster).



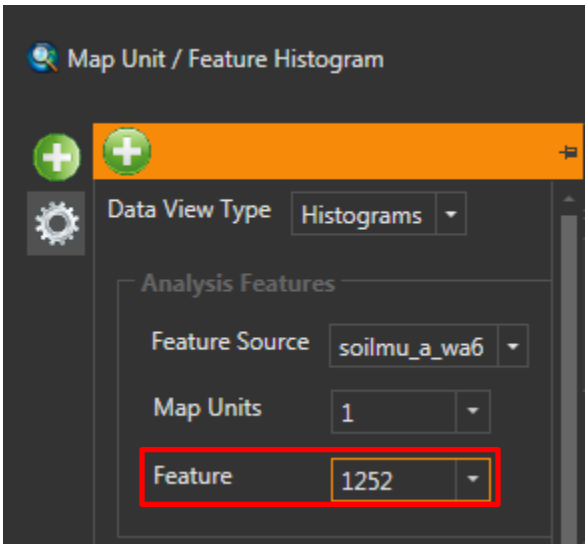
Map Unit:

Choose a map unit (optional). If a map unit column was identified for the selected analysis feature you can restrict the graph to a single map unit. Alternatively, you can leave the map unit blank and select an individual feature (see below).



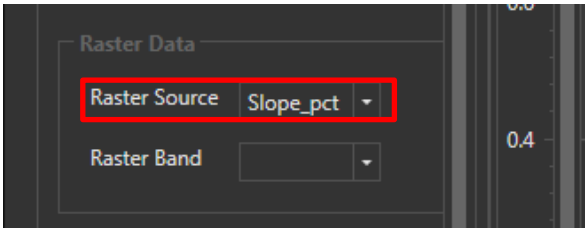
Feature: Choose an individual feature (optional)

You can select an individual feature to further restrict the data included in the graph. This is the Feature ID or FID. If a map unit is selected, only the features belonging to that map unit will appear in the dropdown list. If no map unit is selected, all features from the selected feature source will be available. You can leave this blank, provided a map unit has been selected, to view statistics for the all features in the map unit (see below).



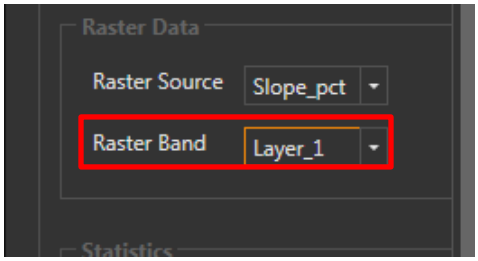
Raster Source:

Select the raster layer you wish to view the statistics from.



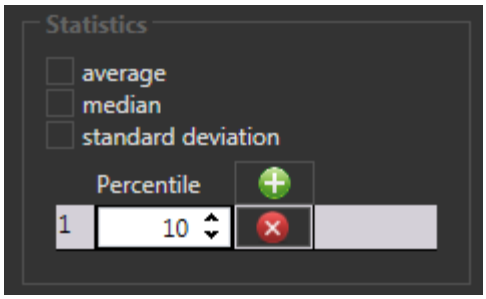
Raster Band:

Select the desired band from the raster layer. The software will populate this field automatically for single-band raster datasets.



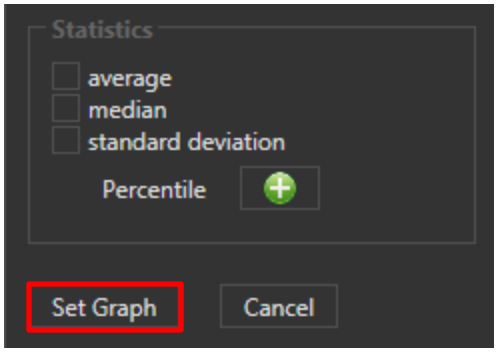
Statistics:

Choose the statistics that you would like to see on the chart.



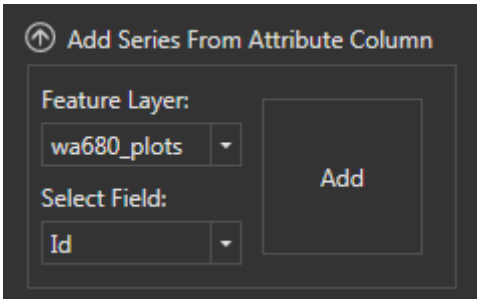
Set Graph:

Click the **Set Graph** button to generate the graph.



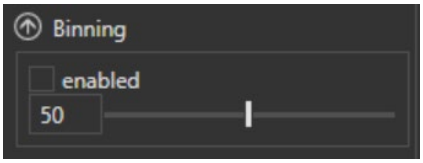
Add Series From Attribute Column:

Graph a field from one of the Feature Layers.

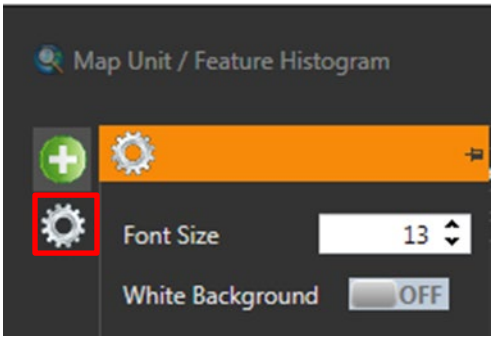


Binning Slider:

Bins the histograms together with the number of bins corresponding to the value of the slider. This is useful if you're dealing with floating point data.

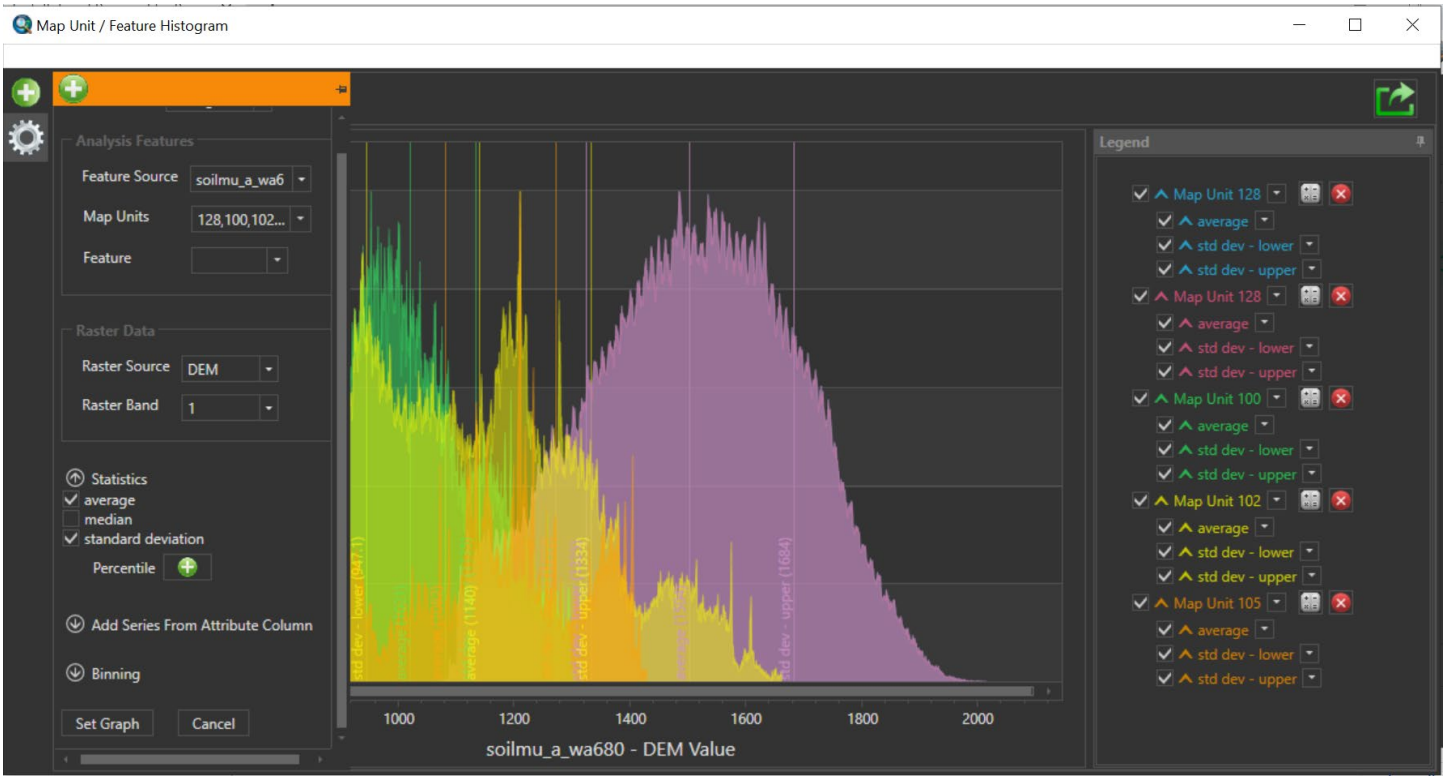


Adjust Font Size and Background Color:
Click the sprocket button on the upper left corner of the graph window.



Common tasks with graphs

How do I add more individual features or map units to same graph?
Within the Add Series pane, simply select a new feature source (if desired), map unit, feature, or raster source. Click **Set Graph** and the new feature or map unit will be added to the graph. The new content is displayed in a different color.

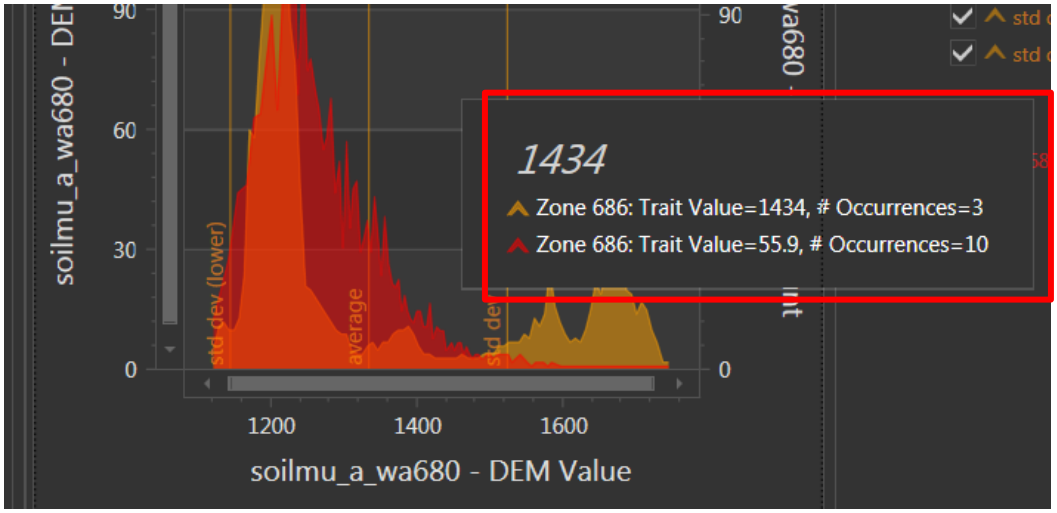


Can I add multiple axes to the graph? For example, graphs of elevation and percent slope?

To add another axis to your graph window, select the feature source, the map unit (and optionally feature) on interest, and a new raster data source. You will notice in the graph legend that map units and features are separated by the raster layer they represent (see next page).

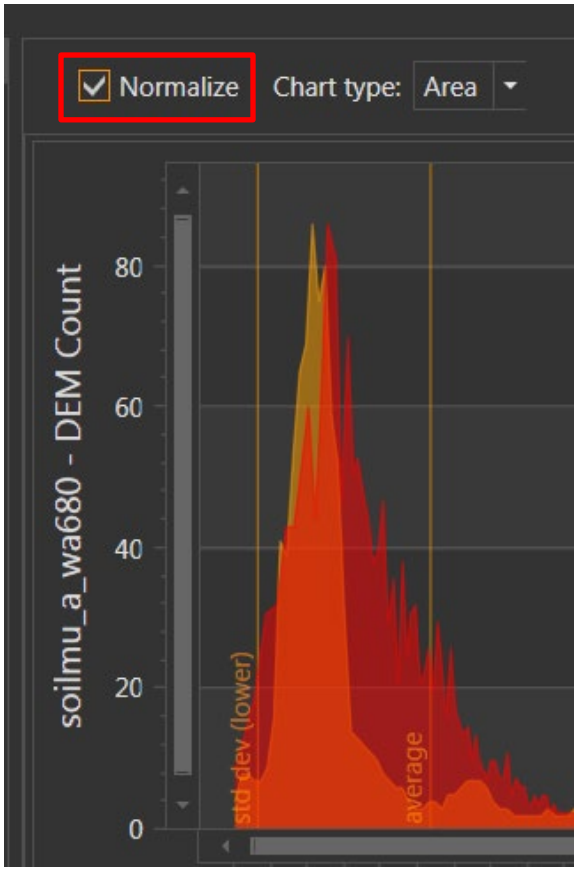
Is there a way to find a specific value on the graph?

If you hover over the graph, a window will appear showing the specific values that your cursor is on. This is valuable if you are trying to identify outliers in your data (see below).



Can I normalize the data ranges?

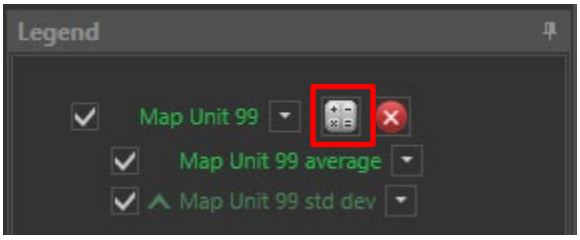
To normalize data so that data ranges are comparable within the graph window, check the **normalize** button at the top of the graph. The Y axis now has a range of 0–100% (see below).



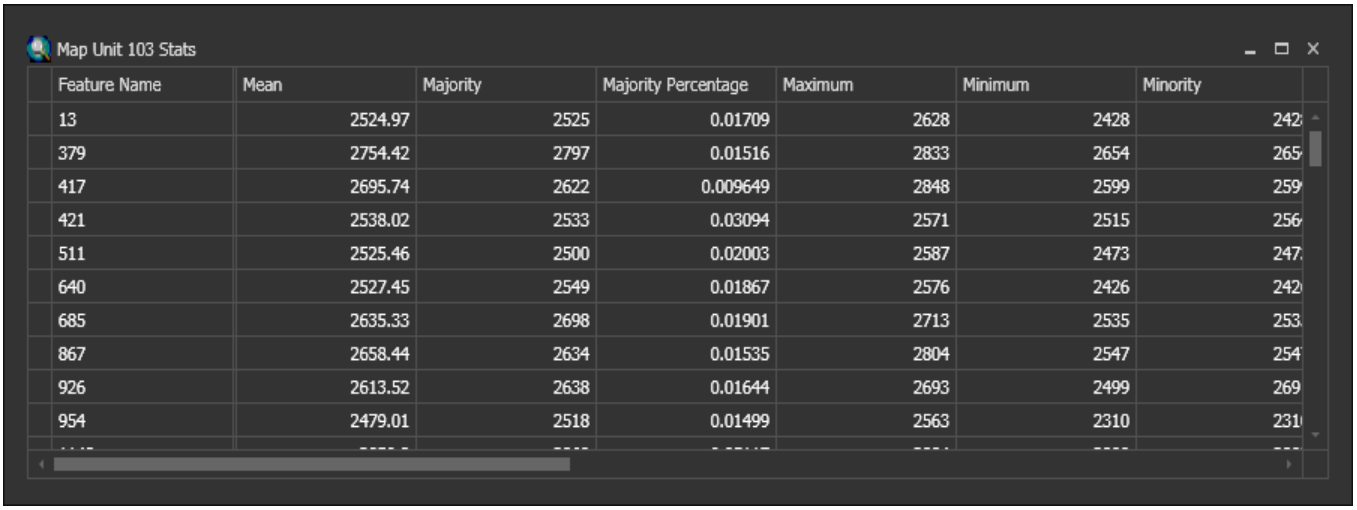
How do I remove a graph series from the graph window?

Simply hit the red X next to the graph series you would like to remove in the graph legend (see below).

How do I view the tabular data associated with each map unit or feature in the graph window?
To view the tabular and descriptive statistics of each map unit or feature in the graph window, simply select the table icon next to the data series in the graph legend (see below).



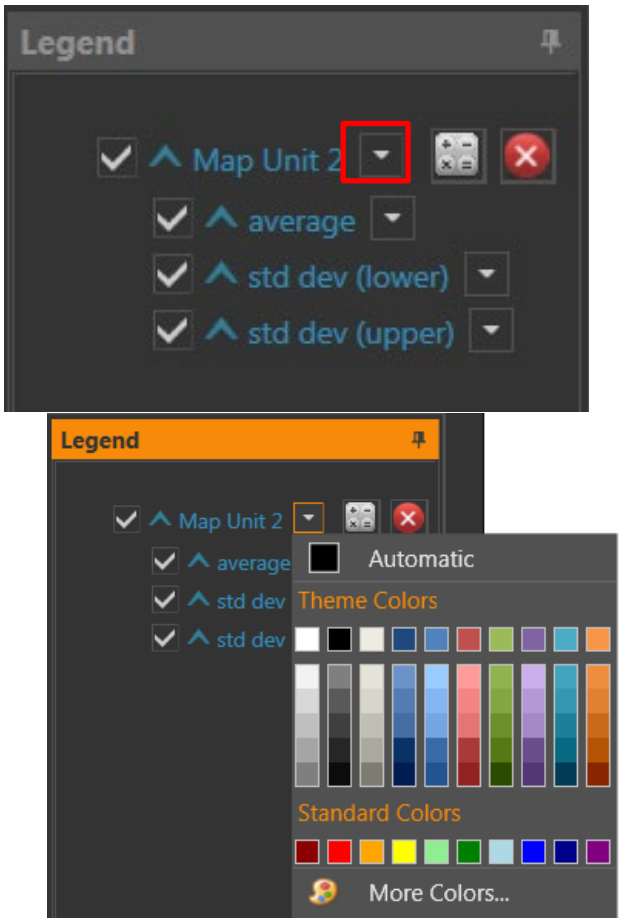
For map units, the table includes the aggregated value for the entire map unit so you can compare individual features to their respective overall map units (see below).



Feature Name	Mean	Majority	Majority Percentage	Maximum	Minimum	Minority
13	2524.97	2525	0.01709	2628	2428	242
379	2754.42	2797	0.01516	2833	2654	265
417	2695.74	2622	0.009649	2848	2599	259
421	2538.02	2533	0.03094	2571	2515	256
511	2525.46	2500	0.02003	2587	2473	247
640	2527.45	2549	0.01867	2576	2426	242
685	2635.33	2698	0.01901	2713	2535	253
867	2658.44	2634	0.01535	2804	2547	254
926	2613.52	2638	0.01644	2693	2499	269
954	2479.01	2518	0.01499	2563	2310	231

How do I change a graph series color?

Users can change the color of a graph series by clicking on the down arrow next to the series name in the legend and selecting the desired color from the palette (see below).

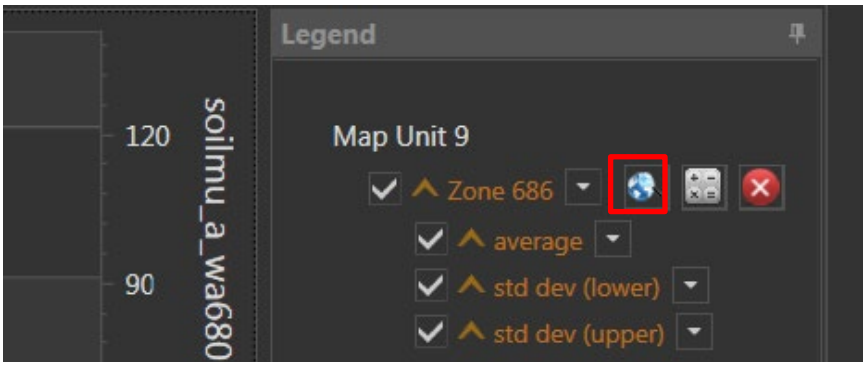


How do I zoom in and out of the graph window?

Right click in the graph window then use the scroll wheel to zoom in and out. The reset the graph to its full extent, right click in the window then click **Reset zoom** (see below).

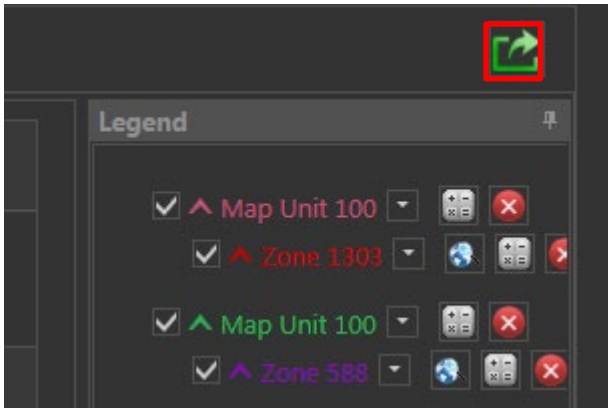
How do I zoom to (in the ArcMap viewer) an individual feature that I have graphed?

To zoom to a particular feature, select the **globe** button next to the feature in the graph legend. The ArcMap viewer should then zoom to that feature. Note that this function does **not** work for map units (see below).



How do I print a graph?

To print a graph, select the **print** button (green box with arrow in upper right of graph pane). A dialog will open up and allow the user to print the graph or export it in many different formats (.jpeg, .bmp, .pdf, etc.) (see next page).



SECTION 5. Using the Conditioned Latin Hypercube sample tool

Conditional Latin hypercube sampling (cLHS) is a stratified random sampling technique for multidimensional data that uses a constrained Monte-Carlo sampling scheme to maximize sample site selection efficiency. While several sample design approaches, such as k-means clustering, have been designed to ensure an even distribution of sample sites in ***geographic space***, cLHS is designed to ensure balanced selection of sites across ***feature or data space***. The tool ensures that samples are drawn only from the existing range of ancillary data such as

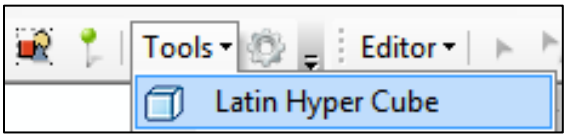
environmental raster data. Therefore, the sample population drawn from a digital elevation model (DEM), for example, would be restricted to values existing in the data given to the tool. The cLHS tool has been widely adopted within the digital soils mapping community for the selection of efficient field sampling locations.

Minasny, Budiman, and Alex B. McBratney. "A conditioned Latin hypercube method for sampling in the presence of ancillary information." *Computers & Geosciences* 32.9 (2006): 1378-1388.

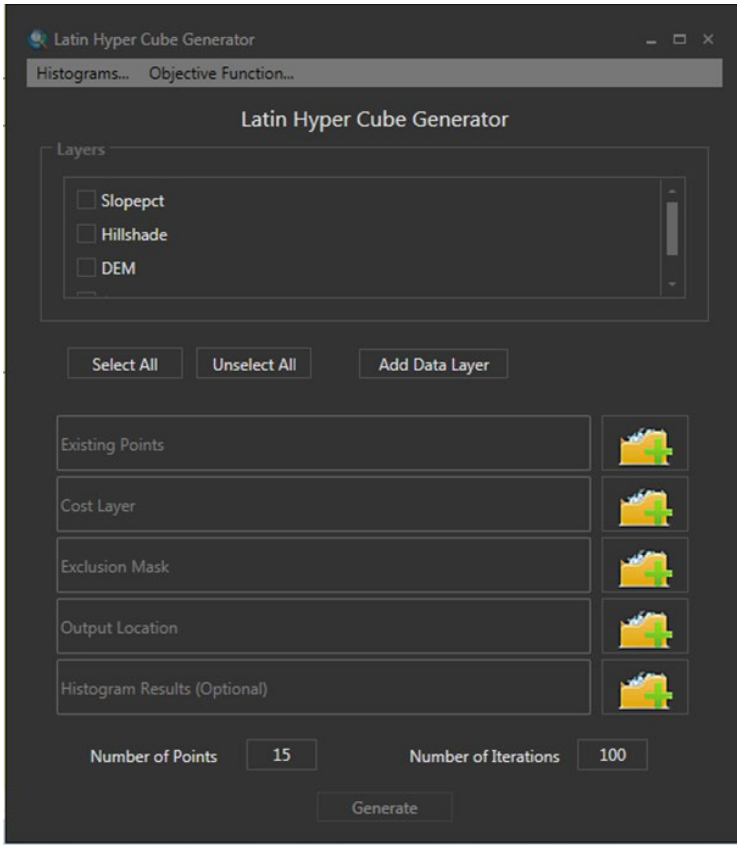
Requirements:

- All raster data must cover the same extent
- All raster data must be in the same projection or the tool will fail

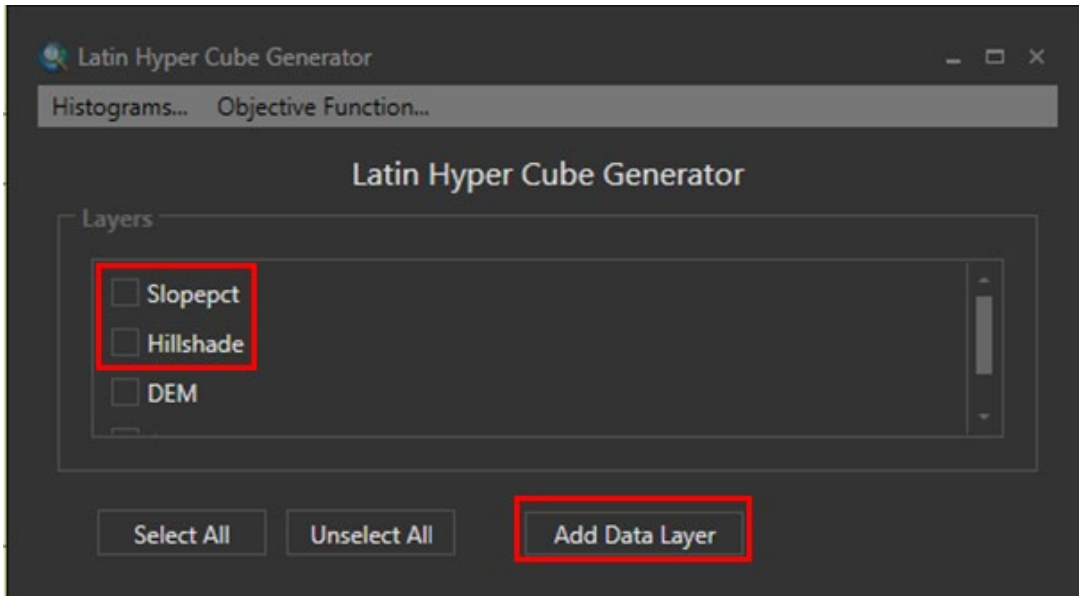
1. On the toolbar, click **Tools** then click **Latin Hyper Cube**.



2. The Latin Hypercube Generator dialog will appear (see next page).



3. Select the **Add Data Layer** button to add layers. If you have a current TEUI Toolkit project open, the tool will automatically add those layers to the selection dialog (see next page).



4. A window will appear allowing you to navigate to the raster data of choice.

   Your raster data can be continuous or discrete. You can select as many layers as you wish. Be aware though, the larger your project area and the more raster layers you choose, the longer the tool will take to run.

5. Be sure to **place a check in the box next to each raster layer you would like to use**.

6. Next, there are several additional fields to choose from. Note that some are optional while others are required. To the right of each field is a folder icon you can click to set a file path:

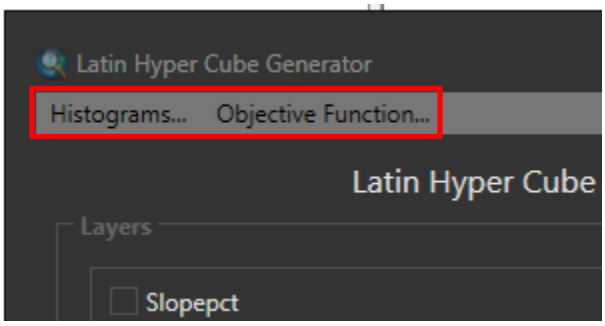
   Existing points (optional): These are point data (as a shapefile or a feature class within a file geodatabase) of existing sample locations that you would like to exclude from selection in the next run. For example, if you have existing plot data, you would not want to resample that location.

   Cost layer (optional): The cost layer is a raster layer that indicates relative "cost" to sample either in effort or in money (e.g., travel costs). Low values represent areas that are easier to sample; higher values represent areas that are harder to sample. One example might be that a greater effort is required to sample sites that are farther from a road. This needs to be an ordinal (ex. 0-100), continuous or integer raster.

Exclusion mask (optional): An exclusion mask is a binary (0/1) raster where a value of 1 indicates areas to exclude from being selected such as the middle of a lake or areas with limited access (e.g., the top of a mountain).

Output Location (required): Set the file name and location for the resulting sample site point file (.shp).

Histogram Results (recommended): Allows users to save the resulting histogram and points graph outputs for further inspection. This option must be used in order for the Histograms and Objective Function graphs to work (see next page).

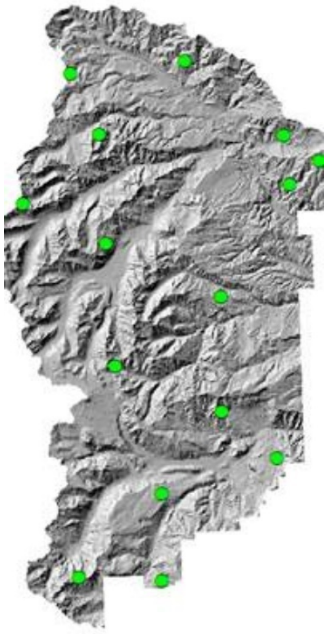


Number of Points (required): Enter the number of **sample points** you would like to have returned (minimum of 1).

Number of Iterations (required): Enter the number of **iterations** (Monte Carlo iterations). A higher number will result in more processing time being required, but will theoretically yield more accurate results.

7. Click on **Generate** to create your sample locations. The tool is very processing intensive, so please be patient! The Tool's progress is indicated at the bottom of the tool.

   The resulting product will be a point shapefile layer attributed with the values of each raster at each sample point. The layer will be added to the ArcMap table of contents when completed (see below).

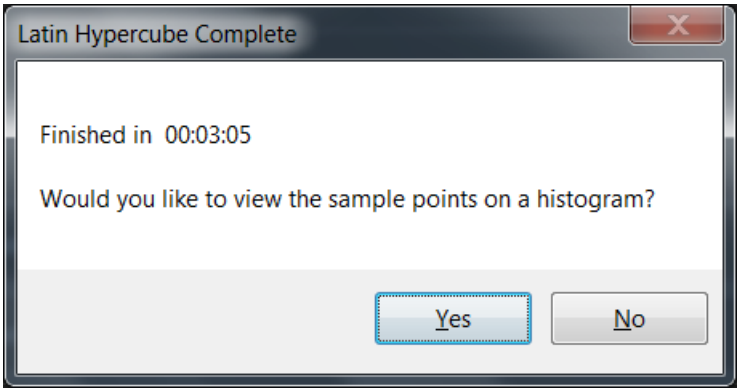


Table

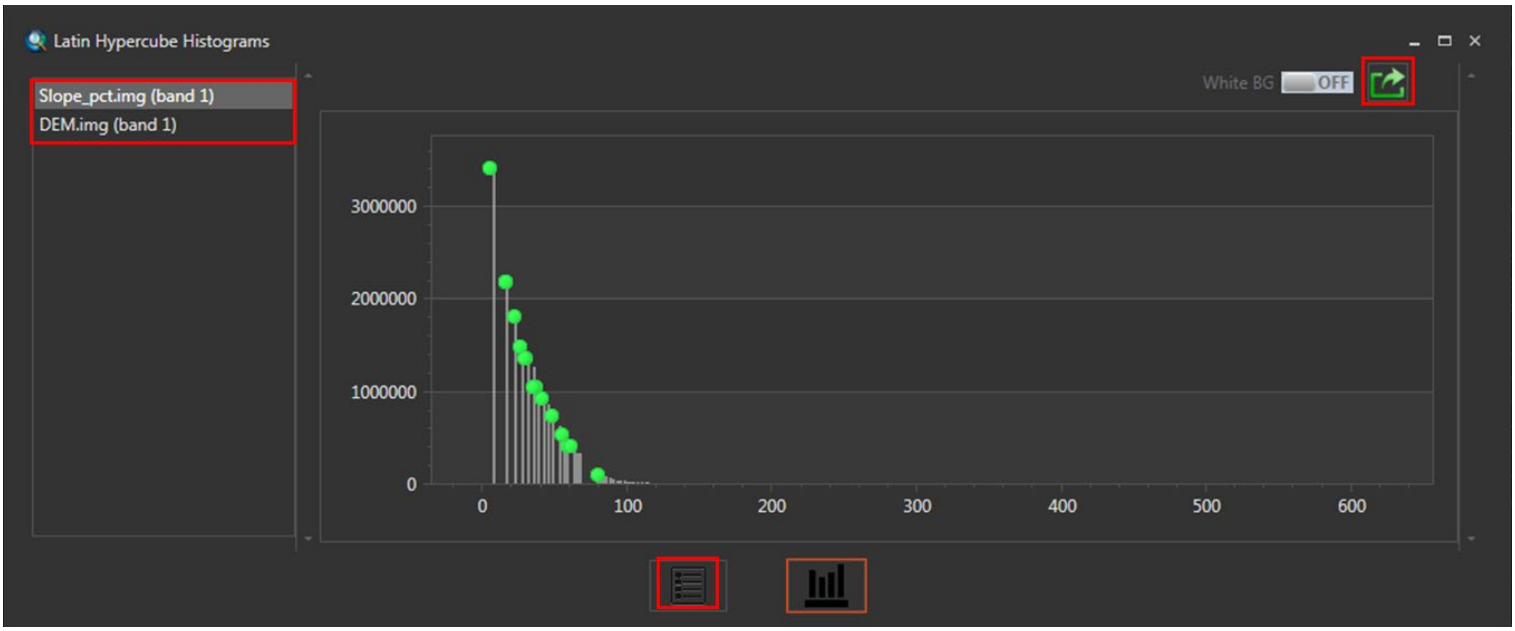
Output.shp

FID	Shape	Id	lat	long	Aspect	Slope_pct	DEM
0	Point	0	5178405.53172	629257.888391	60.524112701416	33.0246124267578	1477
1	Point	1	5203275.53172	653927.888391	189.462326049805	15.2069063186646	1736
2	Point	2	5162895.53172	634937.888391	326.309936523438	18.0277557373047	1392
3	Point	3	5215375.53172	637657.888391	168.690063476563	38.2426452636719	1427
4	Point	4	5167195.53172	648827.888391	40.2363586425781	21.2867336273193	1122
5	Point	5	5206505.53172	627327.888391	261.46923828125	50.5593719482422	1634
6	Point	6	5200385.53172	650367.888391	271.080932617188	66.2617950439453	1048
7	Point	7	5198065.53172	618087.888391	7.69605159759521	46.6703872680664	1665
8	Point	8	5213885.53172	623787.888391	118.610458374023	31.3249111175537	1411
9	Point	9	5186785.53172	642077.888391	135	8.83883476257324	1326
10	Point	10	5193285.53172	628147.888391	101.309928894043	25.4950981140137	1564
11	Point	11	5152335.53172	634917.888391	30.9637565612793	29.1547603607178	1729
12	Point	12	5152755.53172	624847.888391	351.158172607422	56.9264869689941	1966
13	Point	13	5206395.53172	649657.888391	227.602569580078	38.9310302734375	1248
14	Point	14	5172895.53172	642127.888391	187.594650268555	37.8318634033203	1441

8. When the tool is finished, you will receive a dialog box asking if you would like to review the output histogram. Selecting **Yes** will bring up a graph with a histogram for each raster layer. The graph also shows where the sample points fall on the histogram (see next page).



13. Users can select the raster layer of interest on the left panel. Users can also investigate previous Latin hypercube runs, if available, by selecting the **List of runs** button at the bottom left of the histogram viewer window.

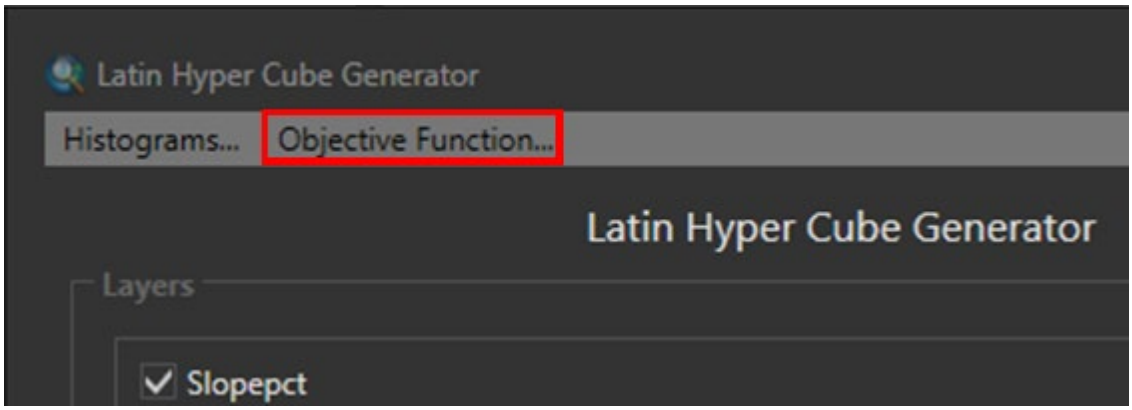


14. Users can also print the output histogram by selecting the green box with arrow in the upper right-hand corner of graph window (see above).

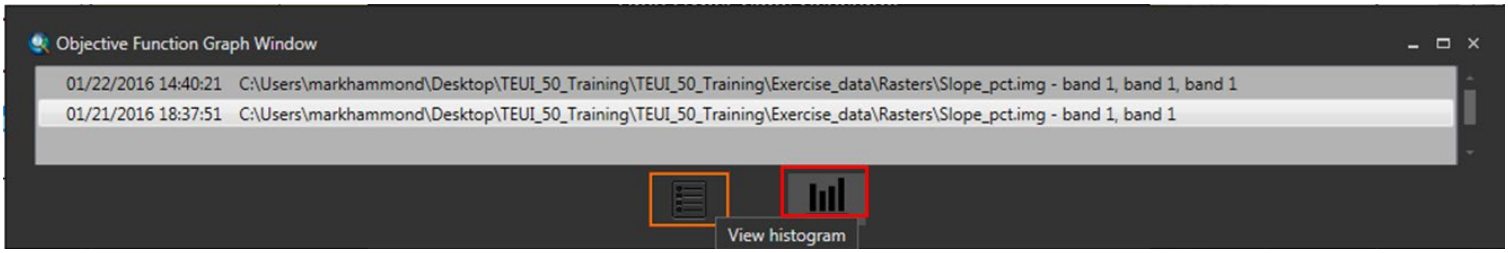
15. Click the Objective Function button at the top of the Latin Hypercube Generator window to see a graph of the Objective Function values (see below).

    - In simple terms, the objective function is akin to the probability of selecting a better or a more "globally representative" matrix of values from multiple input raster data layers with each increasing iteration. In most cases, the objective value never gets to zero before the time or the number of iterations is reached. Therefore, one can

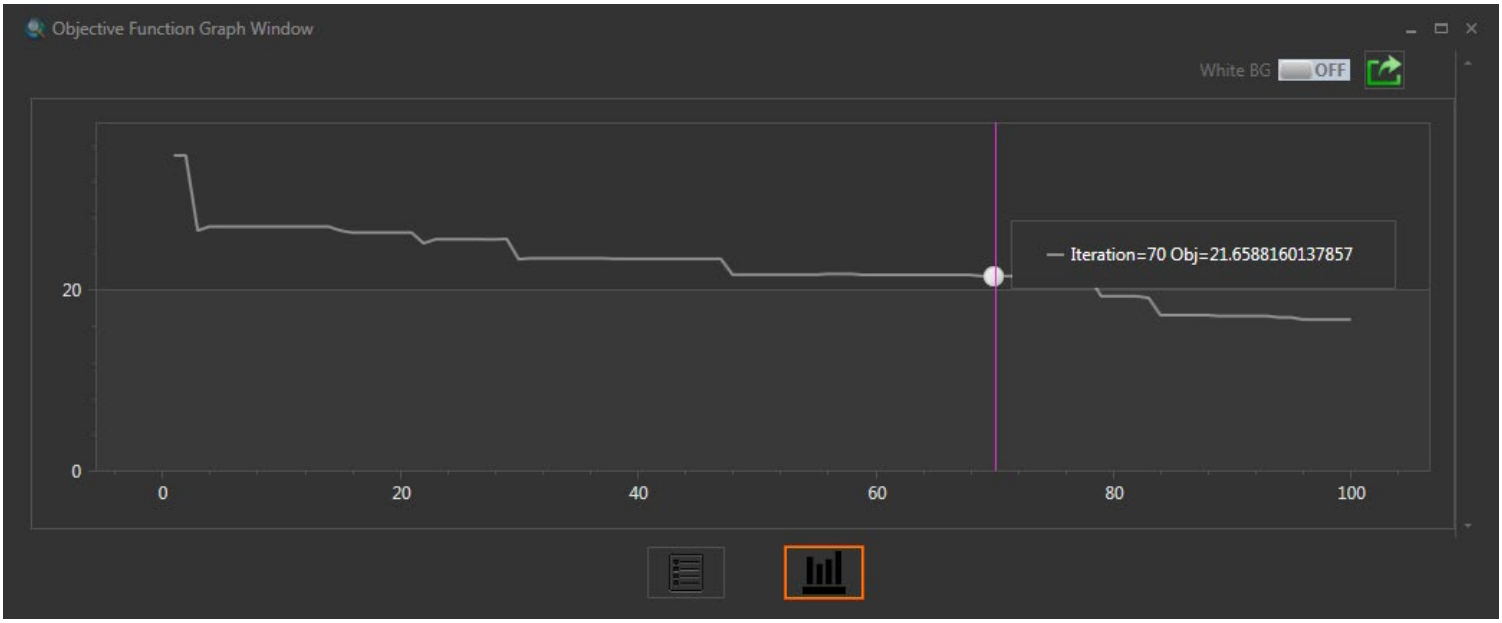
examine the plot of the objective function (y- axis) vs iteration number (x-axis) to determine if more iterations are needed to reach an acceptable or optimal sample selection. The Toolkit implements a streamlined or simplified cLHS process. We suggest the use of the 'cLHS' package in the R statistical software should one want more control over the entire cLHS process.



16. In the Objective Function Graph Window, double-click a file in the list of runs to open the graph (or single click and press the **View histogram** button at the bottom right of the window).



17. Hover your cursor over the graph line to see the value for a given iteration of the Objective Function. The closer the value is to zero the better the sample is. If you want the Objective Function to achieve a lower value then set a higher "Number of Iterations" value and run the cLHS tool again (see below).



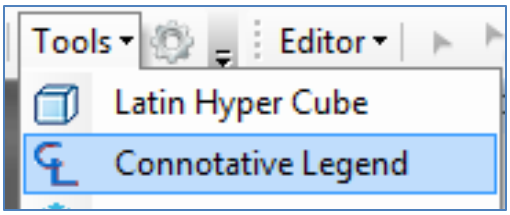
SECTION 6. Using the Connotative Legend tool

The Connotative Legend Tool is a utility designed to assist with generating map unit symbols by incorporating discrete landscape information from raster layers such as slope, aspect, elevation, and vegetation. The tool uses the zonal statistics created by the Toolkit to determine the majority values underlying each polygon or zone. Using a user-defined data classification and labeling scheme, the tool attributes each zone with the appropriate label, concatenating all labels for each layer into a single map unit symbol. The tool is useful for developing and attributing TEUI and Soil Survey pre-maps and for conducting quality assurance or quality control of existing mapping. The tool is designed to handle both continuous and discrete raster data and to be used in an iterative manner.

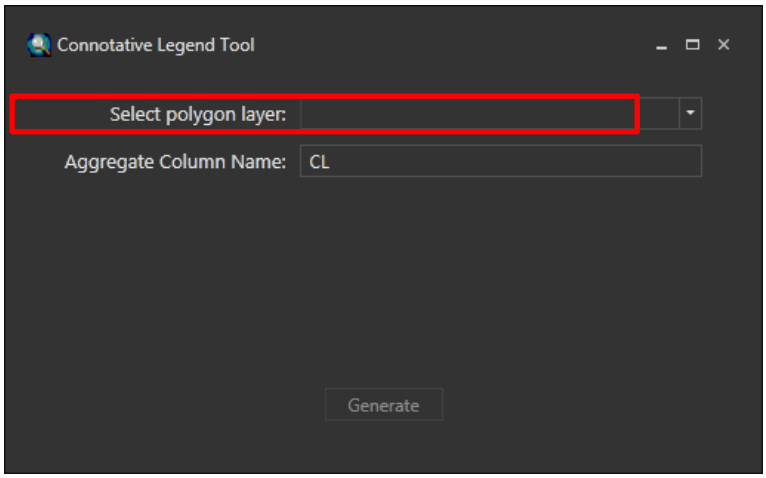
Requirements:

- A Toolkit project with statistics already run.

1. On the main toolbar, click the Tools menu and select the **Connotative Legend** button.

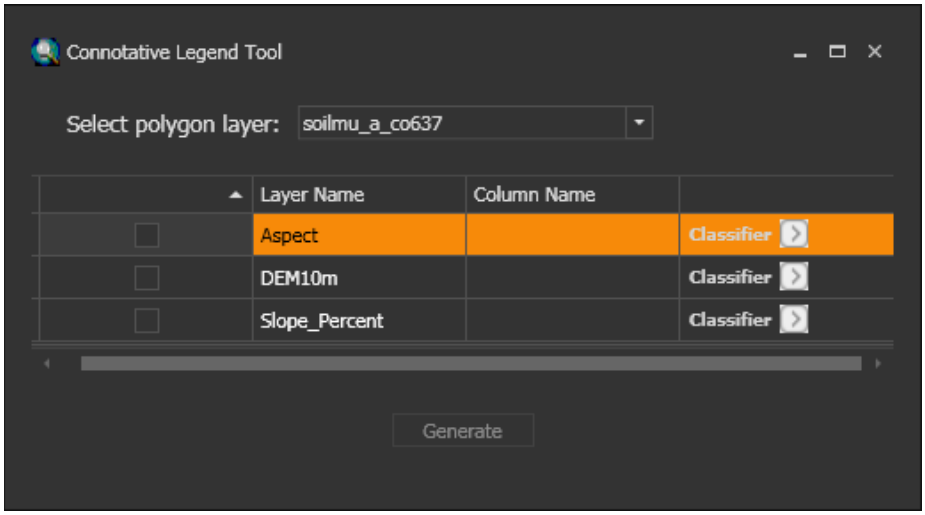


2. **Select the polygon** or zone layer you wish to use from the dropdown menu (see below).



3. The Aggregate Column Name field is for a default attribute added to the polygon layer. The values in this column will be concatenation values of all layers you choose to classify. Each layer you mark for classification will add another attribute column to the polygon layer. Specify a **label for the attribute aggregate column name** (the default is "CL"). Standard ArcGIS shapefile and feature class attribute naming rules apply.

4. A new window will open up within the dialog box showing layers available for classification (see below).

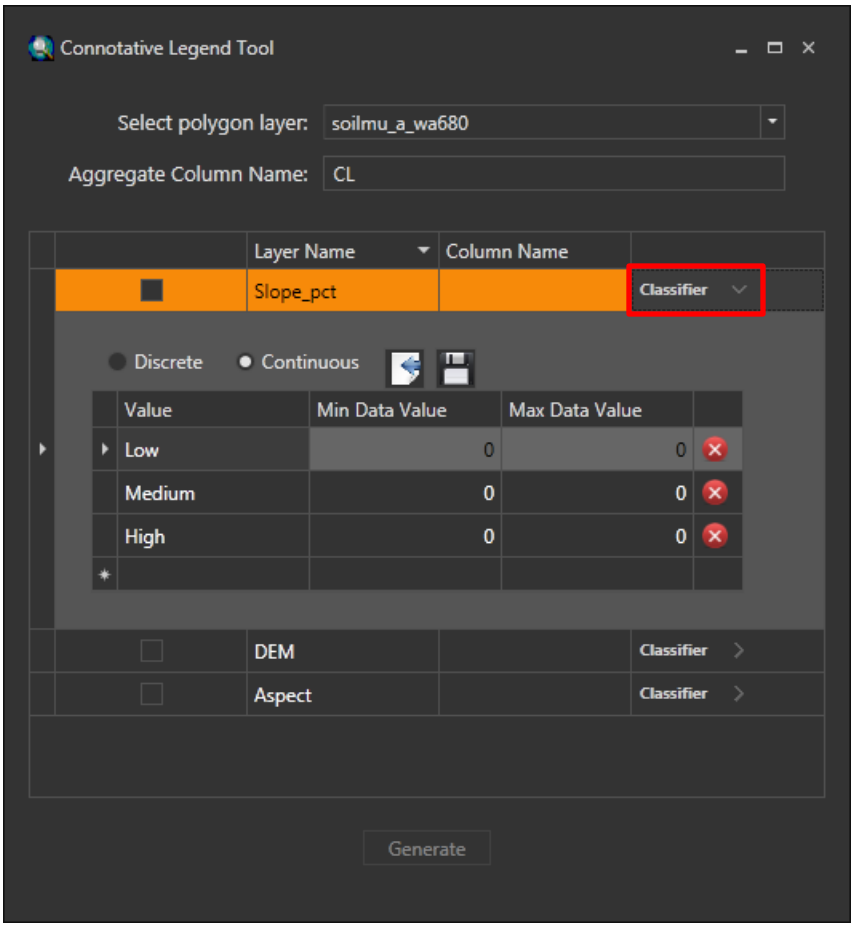


5. Place a **check in the box** next to each layer you would like to participate in the connotative legend.

6. You can sort the list by layer name by clicking on the “Layer Name” column header. Clicking again will toggle between ascending and descending order. This also applies to all other columns.

7. Under Column Name**, enter in a name for the column** that will hold the **classification label** for each layer. Standard ArcGIS shapefile and feature class attribute naming rules apply. Do not use “CL” for a name because that is already the default Aggregate Column Name.

8. When finished, **click on arrow next to “Classifier” in the first data layer**. The window will expand. You may wish to expand the window even further by dragging the corner of the window (see below).



9. For each layer, you will need to **enter a classification**.

10. First, **select the type of raster data you are using**. **Continuous** is for layers with continuous values such as DEM, slope, or aspect while **Discrete** would be for thematic data such as a geology or vegetation map.

11. Under the **Value column**, you will notice the default labels of “Low”, “Medium”, and “High.” These are just the defaults. In each row**, enter in the label for each class**. It can be a letter, word, number, etc. **No special symbols like \, #, %, $, etc**. To add additional classes, click on the star to the bottom left of the last class.

12. **Enter the min and max value for each of your data layers.** Be sure you cover the full range of values (the tool will check and will issue a warning message if the range is not covered). Note: The value specified as Max Data Value is interpreted as ‘up to but not included’. Also the default values used to populate the min and max values are derived from the dataset statistics and may reflect outlier values. Be sure to review those breaks to assure that they reflect meaningful splits.

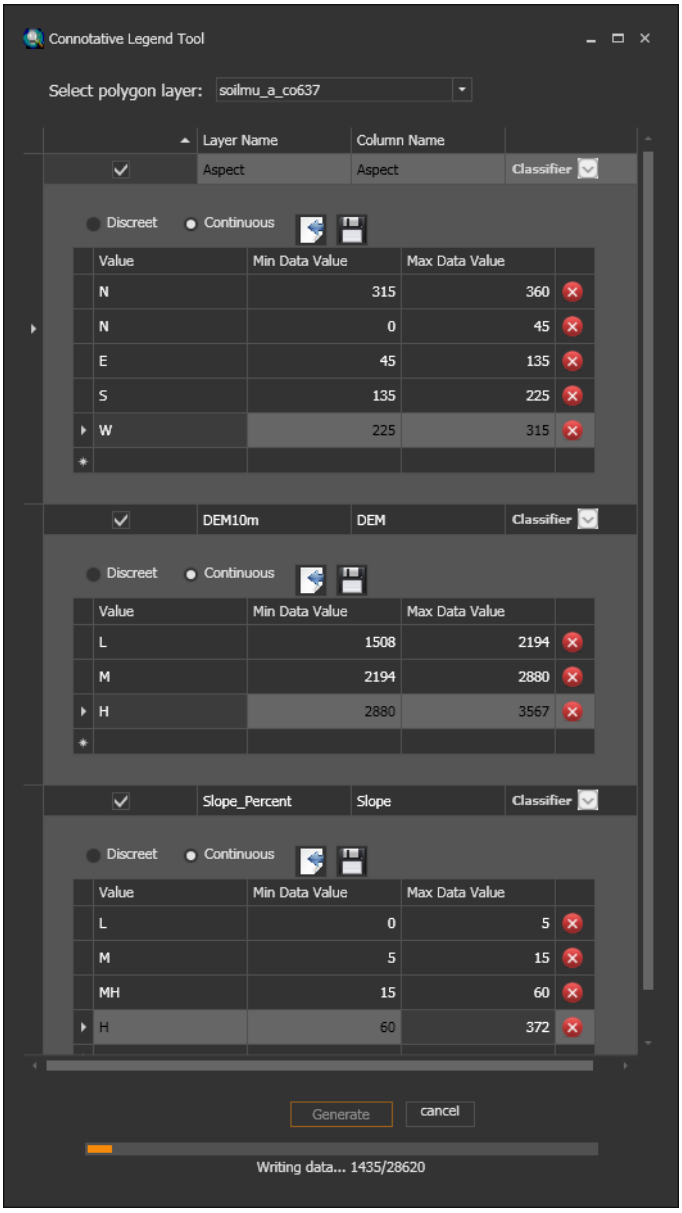
13. You can hit the **red “X”** next to each row to **remove the class** if you wish.

14. Click on the **floppy disk image** to **save the classification** if you would like to use it later for other projects. Alternatively, you can also hit the **paper with blue arrow to import a classification** from a previous project.

15. Repeat this same procedure for all layers you are interested in using for your connotative legend.

16. When finished, click on the **Generate** button at the bottom of the window. (See next page for graphic.)

17. Open the attribute table of your shapefile in the table of contents in ArcMap and view the results (see next page).


Connotative Legend Tool
Select polygon layer: soilmu_a_co637
Layer Name
Column Name
Aspect
Aspect
Classifier
Discreet
Continuous
Value
Min Data Value
Max Data Value
N 315 360
N 0 45
E 45 135
S 135 225
W 225 315
DEM10m
DEM
Classifier
Discreet
Continuous
Value
Min Data Value
Max Data Value
L 1508 2194
M 2194 2880
H 2880 3567
Slope_Percent
Slope
Classifier
Discreet
Continuous
Value
Min Data Value
Max Data Value
L 0 5
M 5 15
MH 15 60
H 60 372
Generate
cancel
Writing data... 1435/28620

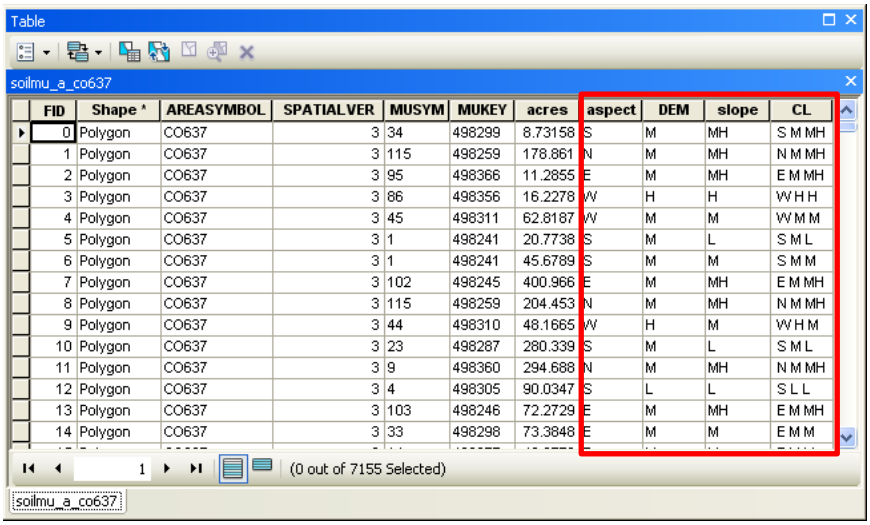


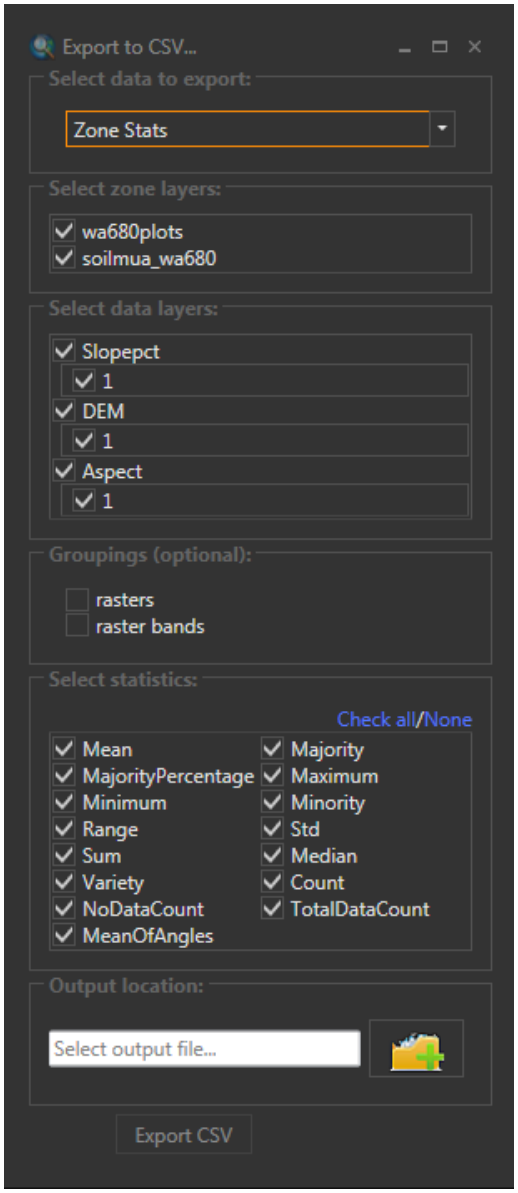
Table
soilmu_a_co637
FID Shape * AREASYMBOL SPATIALVER MUSYM MUKEY acres aspect DEM slope CL
0 Polygon CO637 3 34 498299 8.73158 S M MH S M MH
1 Polygon CO637 3 115 498259 178.861 N M MH N M MH
2 Polygon CO637 3 95 498366 11.2855 E M MH E M MH
3 Polygon CO637 3 86 498356 16.2278 W H H W H H
4 Polygon CO637 3 45 498311 62.8187 W M M W M M
5 Polygon CO637 3 1 498241 20.7738 S M L S M L
6 Polygon CO637 3 1 498241 45.6789 S M M S M M
7 Polygon CO637 3 102 498245 400.966 E M MH E M MH
8 Polygon CO637 3 115 498259 204.453 N M MH N M MH
9 Polygon CO637 3 44 498310 48.1665 W H M W H M
10 Polygon CO637 3 23 498287 280.339 S M L S M L
11 Polygon CO637 3 9 498360 294.688 N M MH N M MH
12 Polygon CO637 3 4 498305 90.0347 S L L S L L
13 Polygon CO637 3 103 498246 72.2729 E M MH E M MH
14 Polygon CO637 3 33 498298 73.3848 E M M E M M
1
(0 out of 7155 Selected)
soilmu_a_co637

SECTION 7. Exporting statistics data

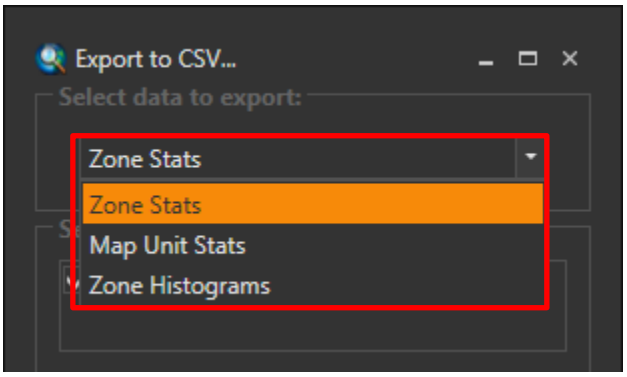
The statistical data summaries produced by the Toolkit can be exported to Excel as a .CSV (comma-separated values) file for further use. Data can be summarized by zone or map unit, or provided as a histogram by zone.

Export statistics

1. On toolbar, click the **Export Data to CSV** button.



2. Select the data to export.



3. Select the zone layers (feature analysis layers) and data layers (raster data) to include in the data export. For multi-band data, select the desired bands.

4. Select desired groupings (optional) by clicking one or both of the **Groupings** check boxes (**rasters** or **raster bands)**.

    a. **Rasters** – Exporting by rasters yields a table where each row represents an individual feature and each column represents by raster, the representative zonal statistic.
    b. **Raster bands** – Exporting by raster bands yields a table where each row represents an individual feature times the number of raster bands being exported. Each column represents the zonal statistic.

5. Select the **statistics** you want included.

6. Click on the **folder icon** and navigate to the location in which you would like to save the CSV file. Give the file a name and click **Save**.

7. Click **Export CSV** to export the data.

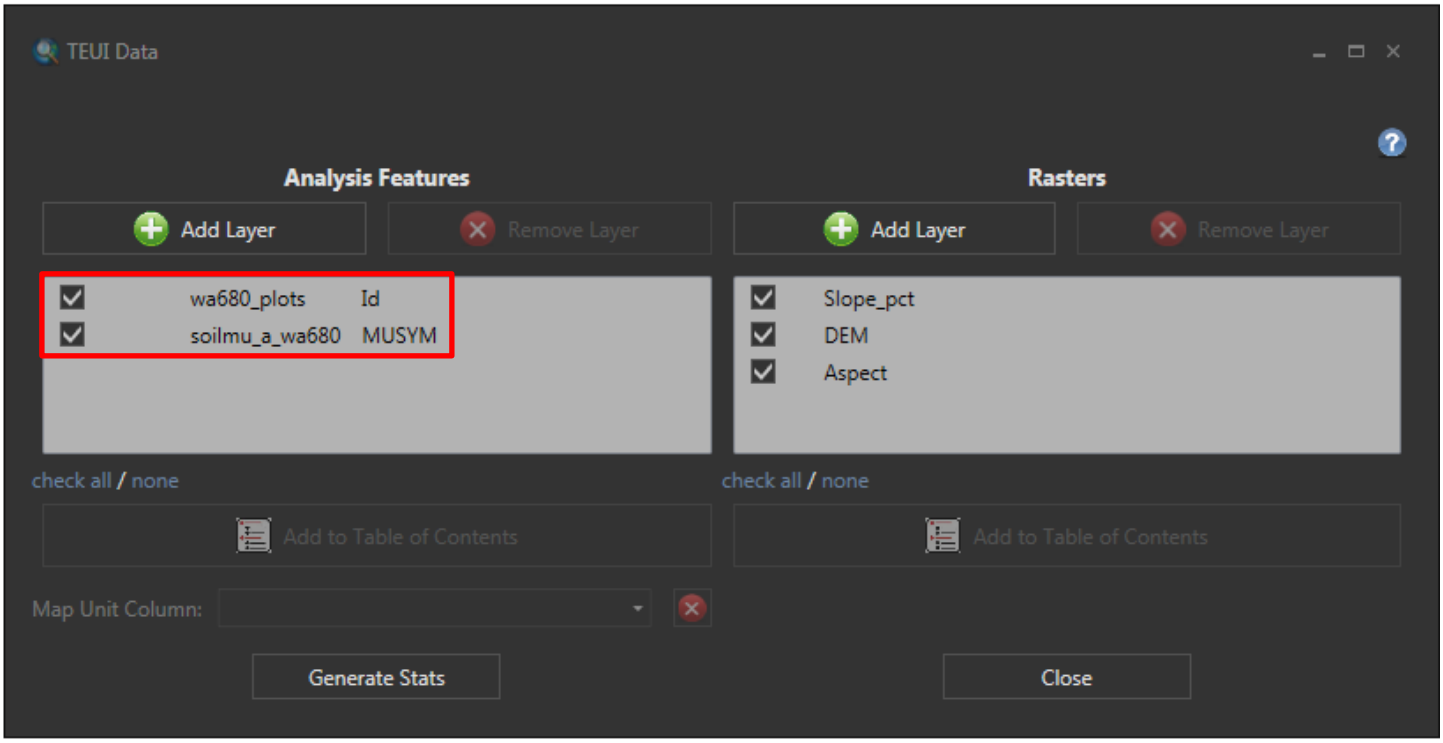
SECTION 8. Using the Validate Points tool

The validate points tool is designed to check the map unit symbology of individual features against the map unit symbology of individual points which reside within those features. This tool flags point data for which the symbol does not match the symbol of the polygon in which the

point lies. Also, the tool flags points that lie outside of any polygon. The user can then zoom to each flagged point and make necessary changes.

Prerequisites

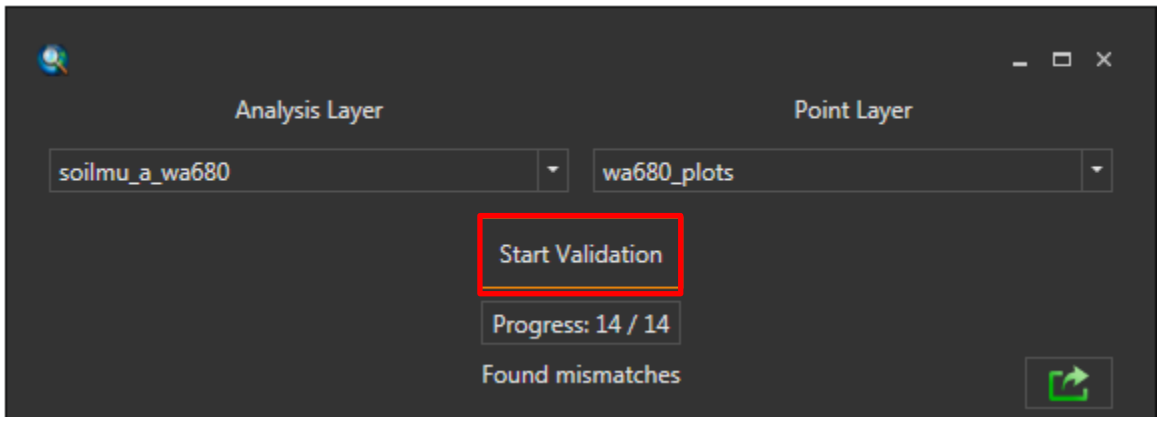
- Must have polygon or raster feature analysis layer that has a map unit symbol identified
- Must have point data with a map unit symbol identified (see below).



Check map unit symbology

1. Click the **green pin** icon on the main Toolkit menu bar to launch the Validate Points tool.

2. Select the Analysis Layer and Point Layer you wish to check then click **Start Validation** (see next page).



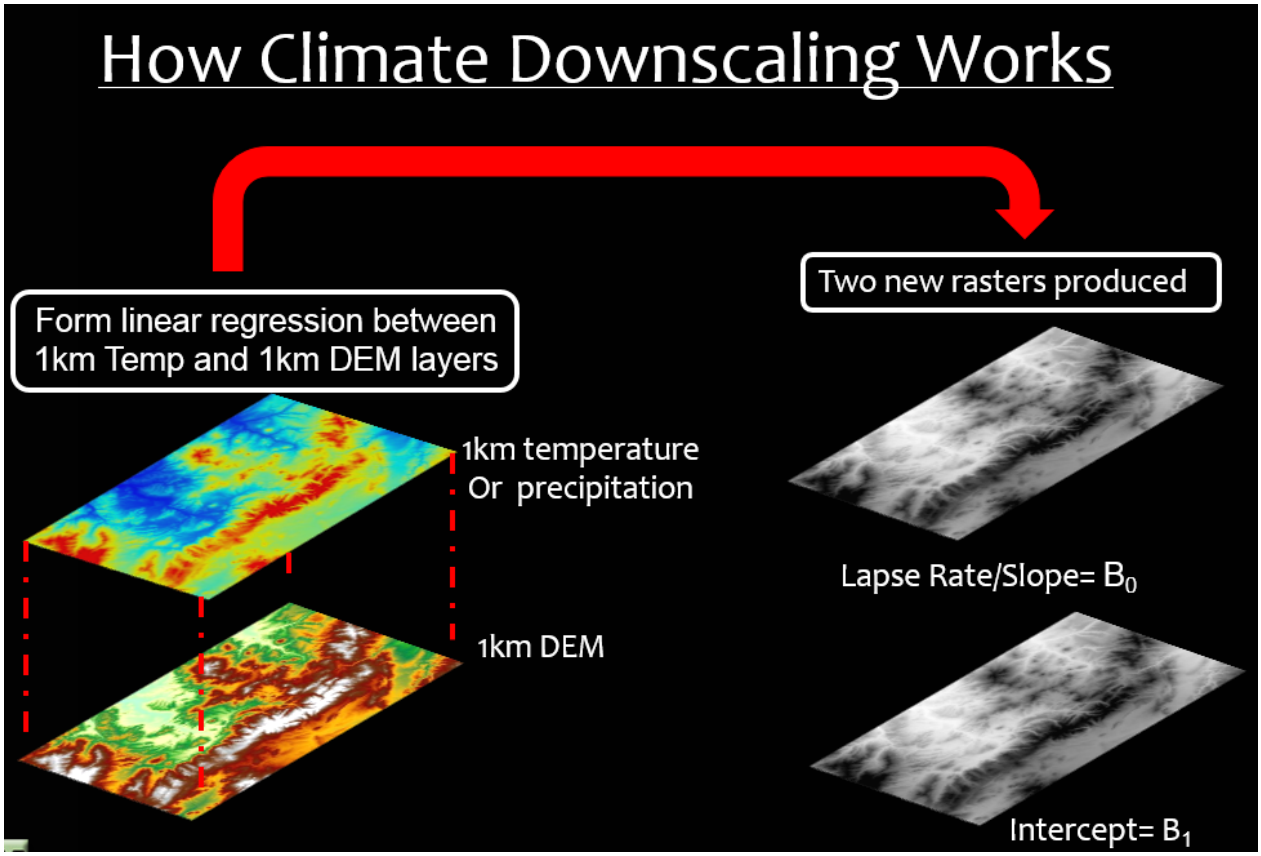
3. The tool will list the points and corresponding features for which the values did not match. You may need to expand the window to see the list of mismatches.

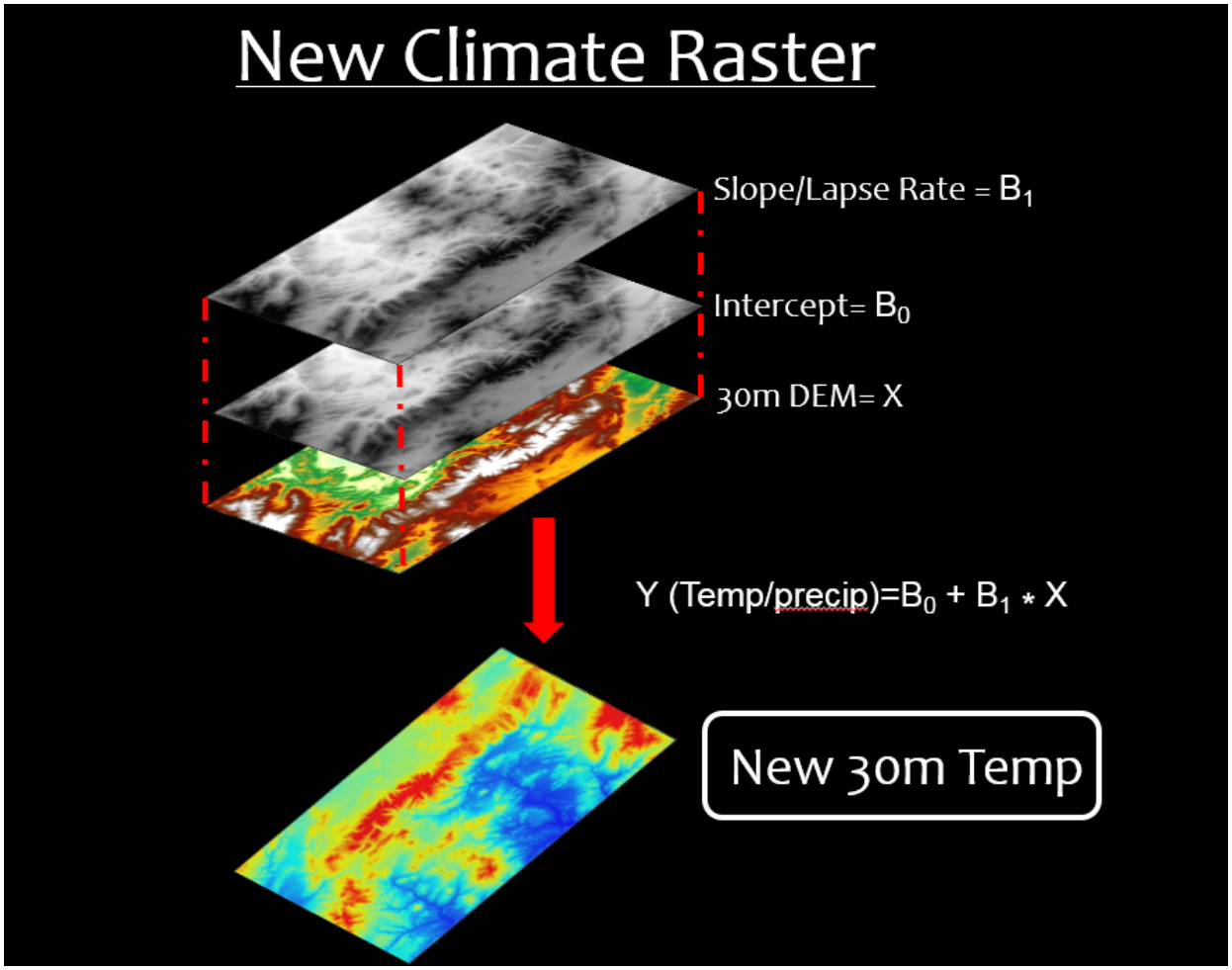
4. **Double click on a row to zoom to the selected point.** The first example here, point ID 4, does not have an existing polygon or feature under it, hence all feature information is empty. The second point feature, point ID 5, has a mismatching point feature map unit symbol. The point map unit symbol is 999 while the feature map unit symbol is 11.

5. To correct the mismatches, start an editing session in ArcMap for the wa680_plots layer, open the attribute table, and adjust the Point or Feature Map Unit values.

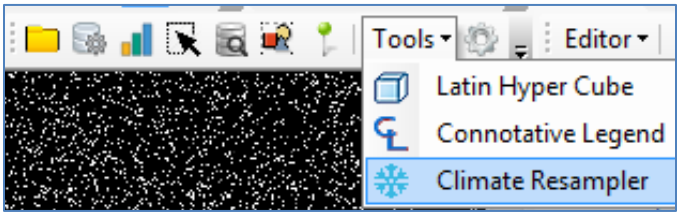
SECTION 9. Climate Resampler Tool

The climate resampler tool is designed to downscale climate rasters (i.e. precipitation and temperature layers) to resolutions fine enough for GIS-based ecological analysis and modeling.


How Climate Downscaling Works
Form linear regression between 1km Temp and 1km DEM layers
1km temperature Or precipitation
1km DEM
Two new rasters produced
Lapse Rate/Slope= B_0
Intercept= B_1



1. On the Toolbar, click the **Tools** menu then **Climate Resampler**.



2. In the Climate Resampler dialog, click the yellow folder button next to the **Climate Raster** field to add the climate raster you want to downscale.

3. In the **DEM Raster** field, add a DEM which has **the same spatial resolution as the Climate Raster**.

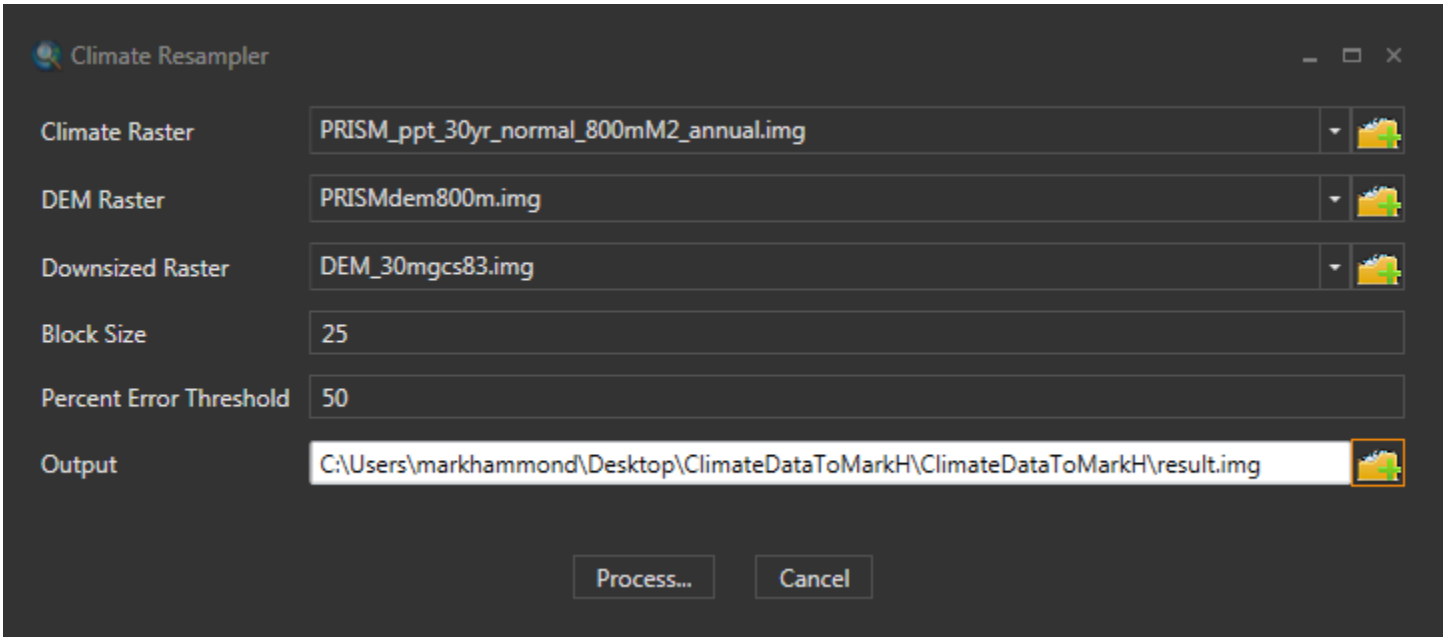
4. In the **Downsized Raster** field, add a DEM which has the spatial resolution that you want your climate raster to be downscaled to.

    - **All data need to be in the same projection!**
    - **Be sure to have an extent at least one block size wider than your final area of interest. This will ensure that the full extent is covered by the tool.**

5. Set the **Block Size** field.
    - When reading a source raster, the tool breaks it up into blocks (with the user defined size) so that the application won't use too much memory and crash.

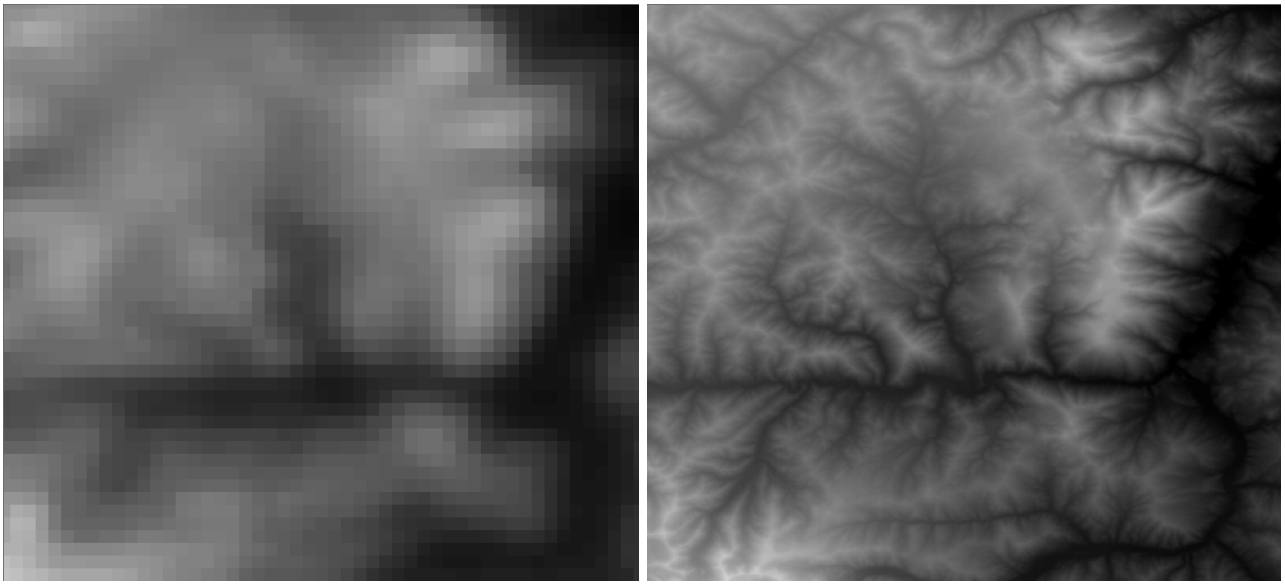
6. Set the **Percent Error Threshold** field.
    - As the resampler iterates through a block, it keeps track of the no data count for the current block. If that no data count exceeds the percent error threshold, a no data value (-9999) is written to the resulting raster.

7. Choose your **Output** file location.



8. Click **Process**.

9. Compare the original coarse-scale climate layer to the output downscaled climate layer in ArcMap.



SECTION 10. TEUI Command Line Tool

The TEUI Command Line Tool is intended for those who want to include some of the TEUI functionality in their own scripts.

Requirements

- ArcGIS 10.0 or above
- At least 4 GB free space. More space may be needed depending on the project size.

How to download the TEUI Command Line Tool

- The TEUI Command Line Tool can be downloaded from the following web address: https://www.fs.usda.gov/about-agency/gtac/teui
- After you have downloaded TEUI.Commandline.zip we recommend you extract it to your C drive (C:\TEUI.Commandline).

Adding TEUI.Commandline.exe to the environment variables.

You can make an adjustment on your computer so it's easier to use the TEUI Command Line Tool. In this section we will add the tool's directory to the search path for your computer. When you have completed this step you will be able to run the tool from any directory on your computer. This is an advantage when you have a large project.

Without administrative privileges you will only be able to edit your (the user's) Environmental Variables and not the System variables. If you want the environmental variable edit to be applied to the system for any user you must make the edits with administrative privileges in the System variables section. In this case add c:\TEUI.Commandline to the end of the path list separated from the other paths by a semicolon (;).

1. Open the **Start Menu** and right-click on **Computer**.

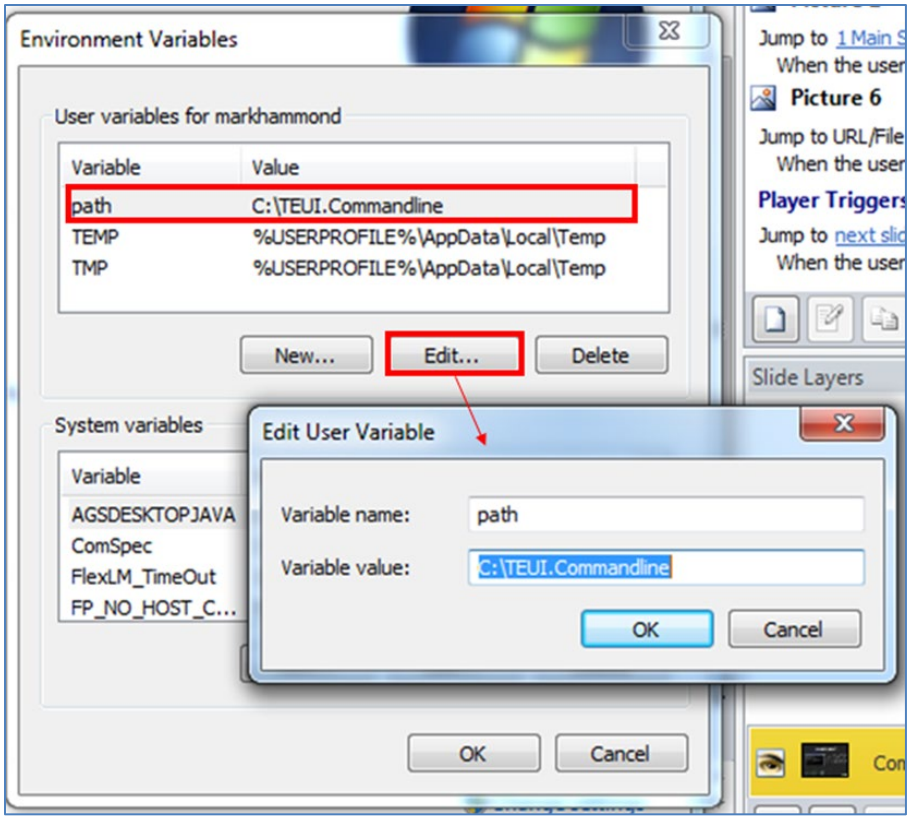
2. Select **Properties** from the drop down menu.

3. Click **Advanced system settings**.

4. In the System Properties dialog click the **Environment Variables** button at the bottom of the **Advanced** tab.

5. In the Environmental Variables dialog box, ensure the Variable **path** is selected in the "**User variables for** your-user-name". If the Variable **path** is not listed, click **New...** to create it.

6. Click **Edit** (see below).



7. Enter the directory for TEUI.Commandline.exe (if there is already a path value then just append to it, separated by a semicolon (;)) then click **OK**.

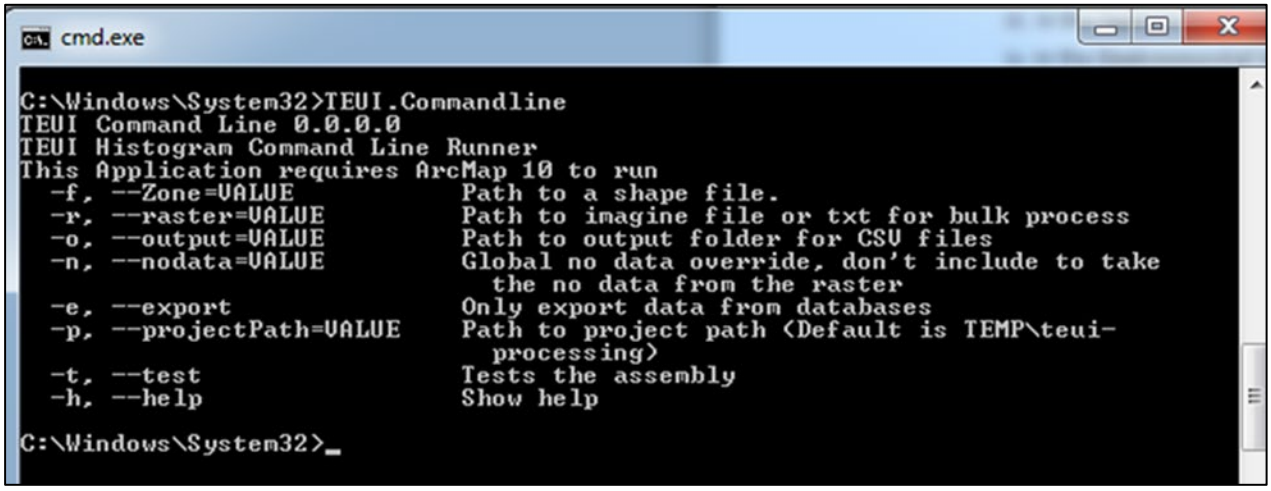
8. Click **OK** in the remaining dialog boxes to close them and retain the edit. Now let's quickly test the new environmental variable.

9. Open a Command Prompt (**Start Menu|All Programs|Accessories|Command Prompt**) and ensure you are not in the **C:\TEUI.Commandline** directory (you may see something like C:\Windows\System32>).

10. Type **TEUI.Commandline** in the Command Prompt and press **Enter**.

    - You should now see a description of the TEUI command line executable "TEUI.Commandline.exe" (see following graphic).

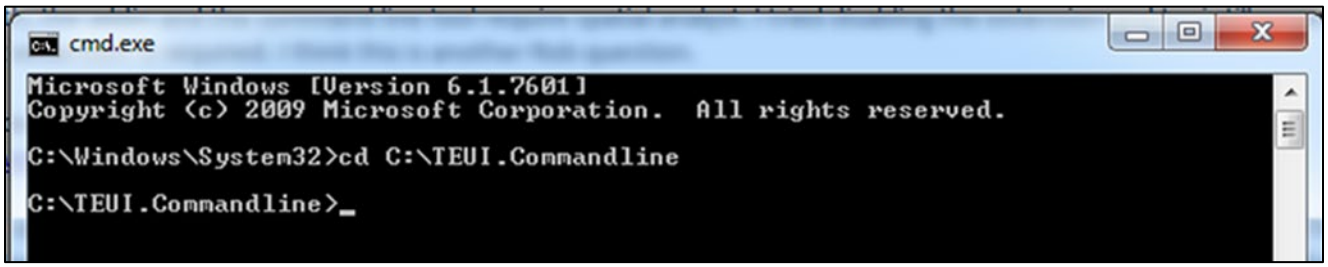
    - If the command prompt did not recognize TEUI.Commandline as a command, the edits you made to the path environmental variable were not successful. If this is the case you can repeat the above steps and try again, ask the course instructor, or contact your IT support for further assistance.



Running the TEUI.Commandline.exe command

1. Open a DOS command prompt (**Start Menu|All Programs|Accessories|Command Prompt**).

2. If you skipped the previous section then you'll need to change the directory to where the TEUI.Commandline.exe is located. Type in **cd C:\TEUI.Commandline** (or wherever you placed that folder) then hit **Enter** (see following graphic).



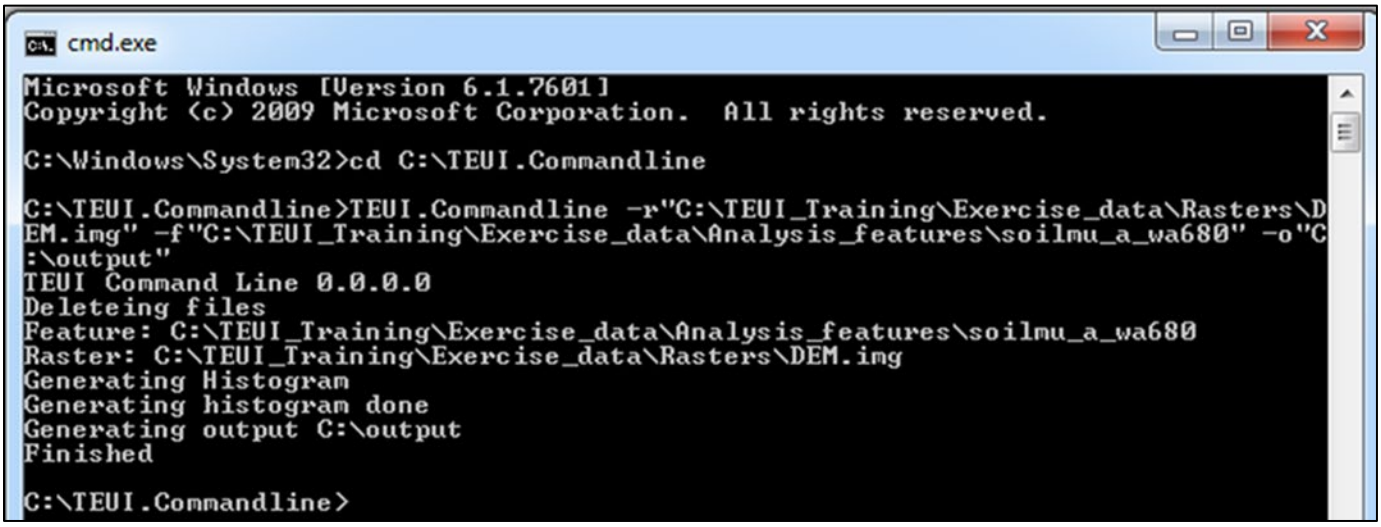
Now let's use the command prompt to run a simple TEUI command to generate map unit summary stats for a DEM layer. The components of the command are as follows:

- **TEUI.Commandline**: The TEUI Command Line executable (there is no need to include the '.exe' in the command prompt).
- **-r"C:\TEUI_Training\Rasters\DEM.img"**: The DEM file that the statistics are generated from.
- **-f"C:\TEUI_Training\Analysis_features\soilmu_a_wa680.shp**": The polygon shapefile that will be used to organize the DEM summary stats into map units.
- **-o"C:\output"**: The output .csv file path.

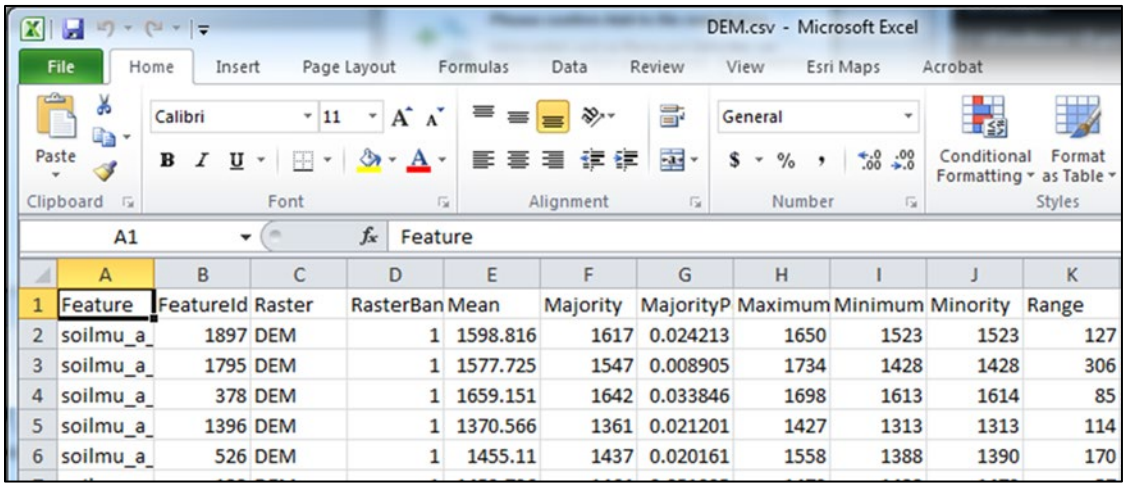
When using the command prompt, remember to use back slashes (\) for file paths and place a single space between each section of the command. An easy way to avoid typos when entering file paths is to navigate to the file in Windows, copy the path, then paste it by right clicking in the command prompt.

You can use the up and down arrows to recall previous commands executed in the same command prompt window. This is very useful when you mess up the syntax and only need to change a character or two. You can edit the commands by moving the cursor with left and right arrows and using the insert key to control insert/overstrike.

3. Type in the command as you see below, then press **Enter**:
   TEUI.Commandline -r"C:\TEUI_Training\Rasters\DEM.img" -f"C:\TEUI_Training\Analysis_features\soilmu_a_wa680.shp" -o"C:\output"



4. Navigate to the output directory and inspect the **DEM.csv** file.



	A	B	C	D	E	F	G	H	I	J	K
1	Feature	FeatureId	Raster	RasterBan	Mean	Majority	MajorityP	Maximum	Minimum	Minority	Range
2	soilmu_a_	1897	DEM	1	1598.816	1617	0.024213	1650	1523	1523	127
3	soilmu_a_	1795	DEM	1	1577.725	1547	0.008905	1734	1428	1428	306
4	soilmu_a_	378	DEM	1	1659.151	1642	0.033846	1698	1613	1614	85
5	soilmu_a_	1396	DEM	1	1370.566	1361	0.021201	1427	1313	1313	114
6	soilmu_a_	526	DEM	1	1455.11	1437	0.020161	1558	1388	1390	170

Now that you know how to run a TEUI command in the DOS command prompt, you can create batch files to efficiently run large sets of commands.