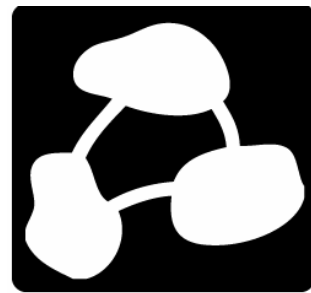


CorridorDesigner Evaluation Tools

corridordesign.org



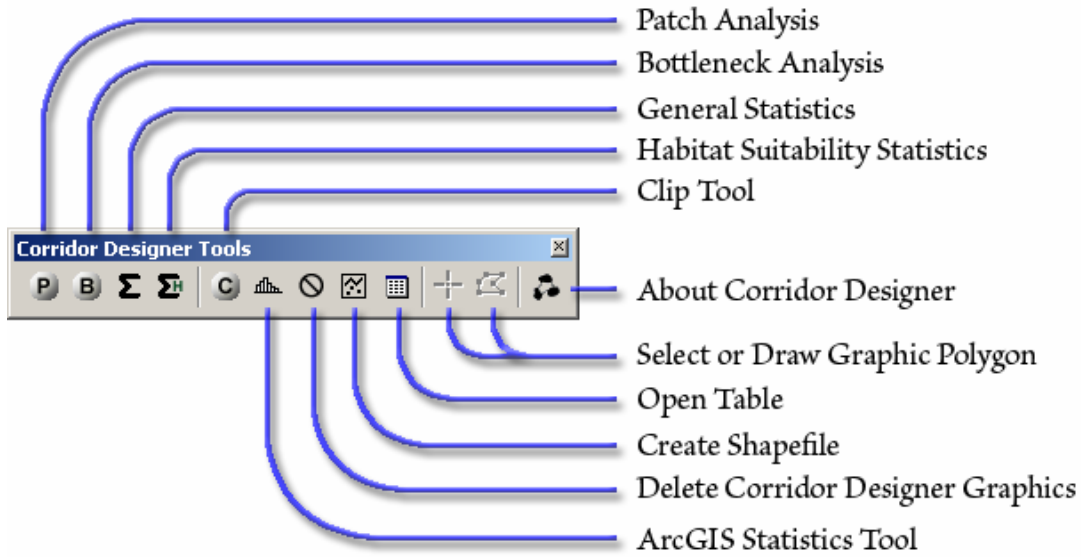
Last updated 2 January 2008

Jeff Jenness

Dan Majka

Paul Beier

Corridor Designer Evaluation Tools



<http://www.corridordesign.org>

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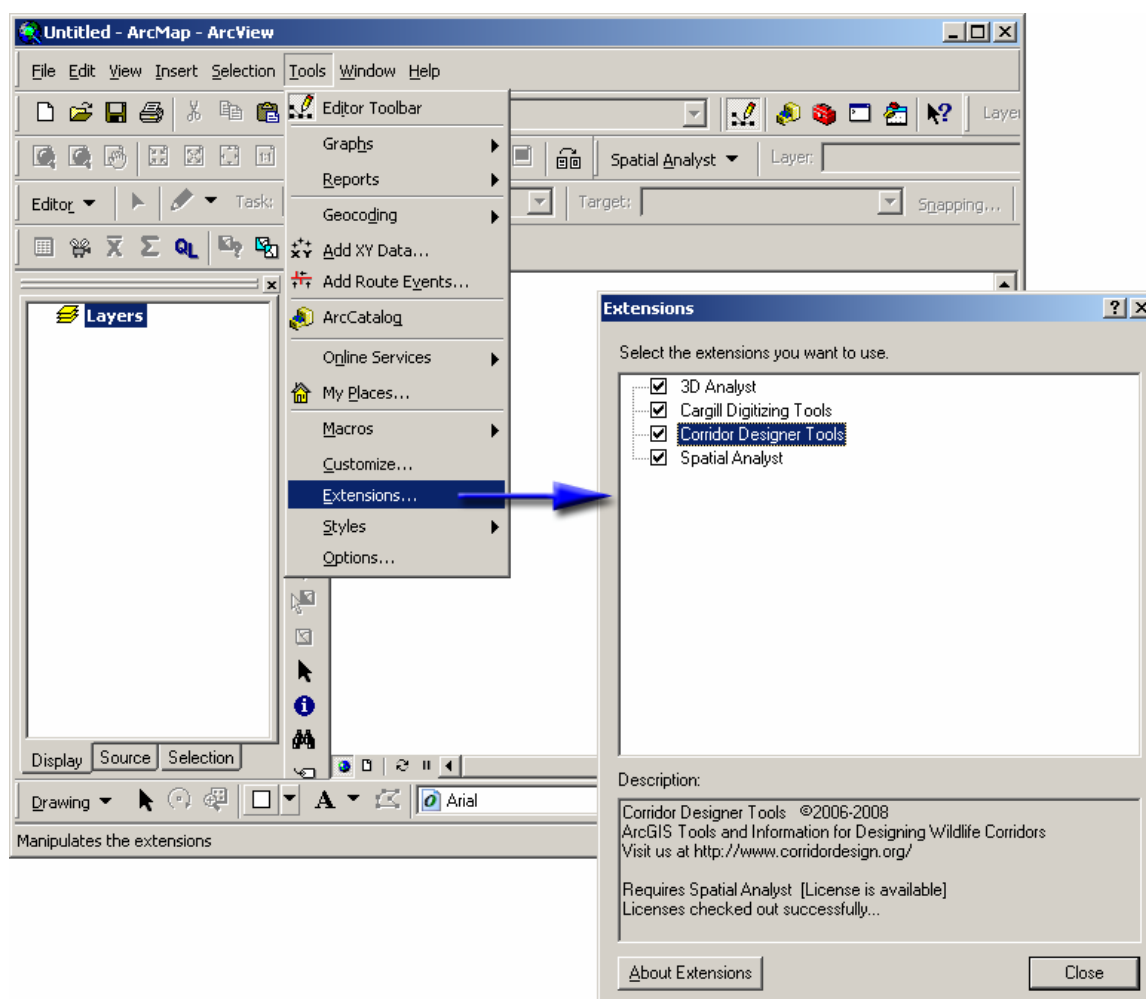
ABOUT CORRIDOR DESIGNER AND MANUAL 50

Description and Installation

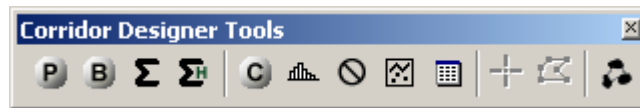
Install the Corridor Designer Extension by double-clicking on the file “CorridorDesign.EXE” and following the instructions. The installation routine will register the Linkages.dll with all the required ArcMap components.

The default install folder for the extension is named “Corridor_Designer” and is located inside the folder “Program Files”. This folder will also include some additional files and this manual.

This tool is installed as an Extension in ArcMap so you may need to turn on the extension in ArcMap after you have installed it. If you do not see the toolbar after installing the extension, then open ArcMap, click the “Tools” menu, choose the item “Extensions”, and then make sure that the extension “Corridor Designer Tools” is checked.



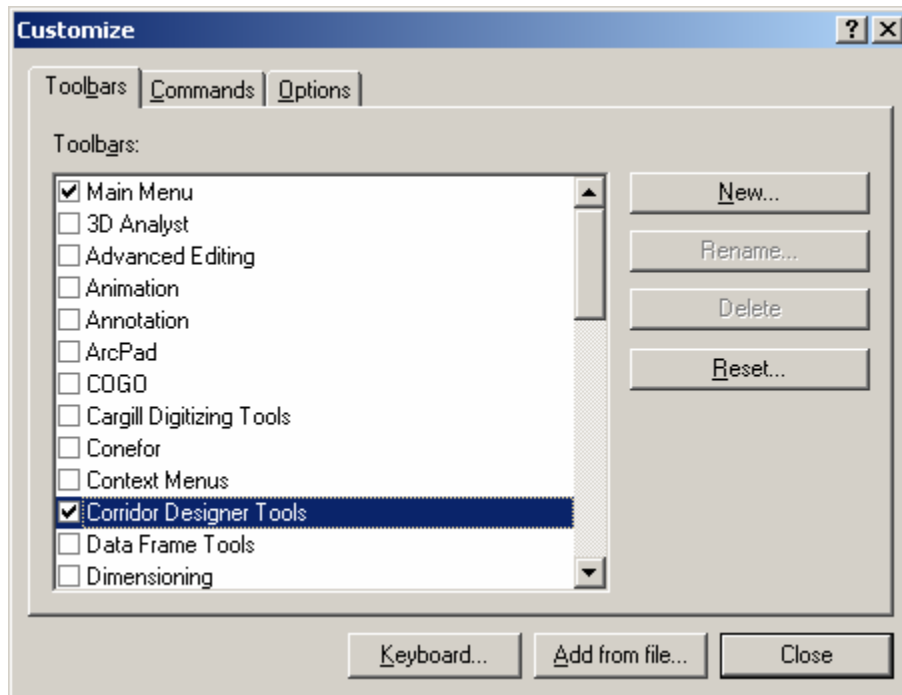
You should see the following new toolbar in your map (it may also be embedded in your standard ArcMap toolbars, rather than as a standalone object):



If you do not see this toolbar, then open your “Customize” tool by either:

- 1) Double-clicking on a blank part of the ArcMap toolbar, or
- 2) Clicking the “Tools” menu, then “Customize”.

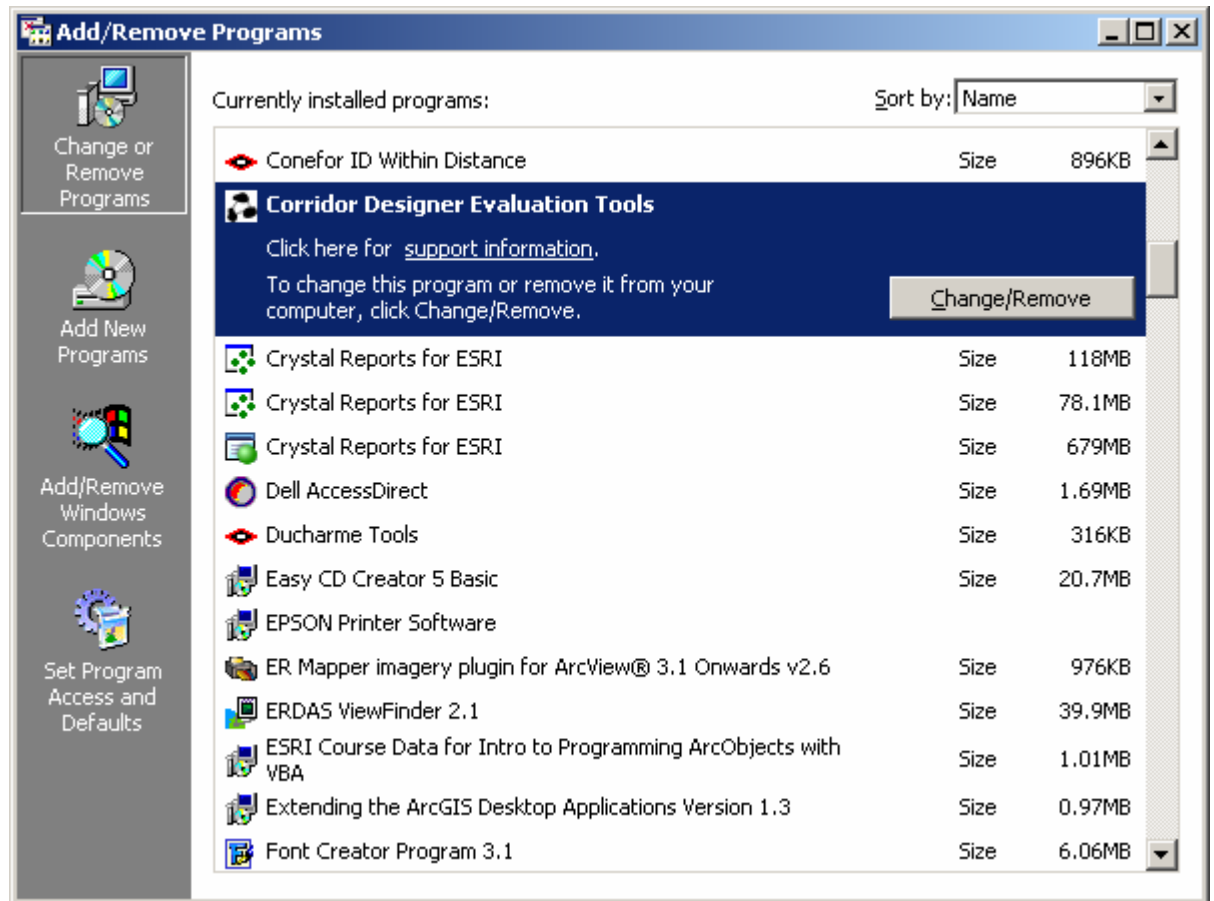
In the “Customize” dialog, click the “Toolbars” tab and check the box next to “Corridor Designer Tools”:



You should now see the Corridor Designer toolbar.

Uninstalling Corridor Designer

- 1) Click the Start button.
- 2) Open your Control Panel.
- 3) Double-click “Add or Remove Programs”.
- 4) Scroll down to find and select “Corridor Designer Evaluation Tools”.
- 5) Click the “Remove” button and follow the directions.



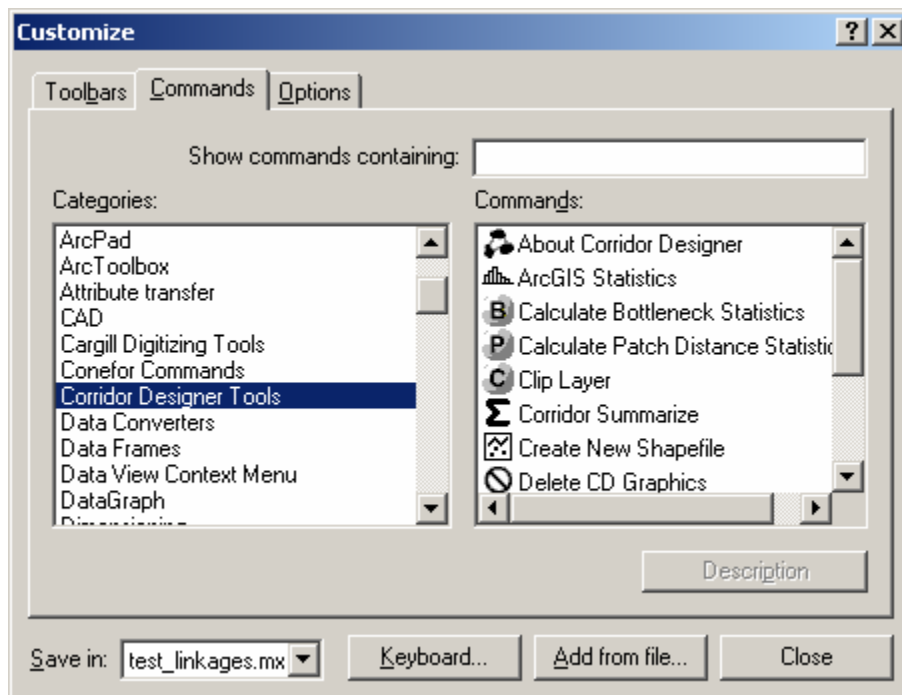
Copying Corridor Designer Tools to Other Toolbars

Because of the way ArcGIS handles toolbars and command buttons, you may add any Corridor Designer command buttons to any toolbar you wish. For example, if you would like to keep the *Open Table* tool available even when the Corridor Designer toolbar is not turned on, you may easily add that tool to any of the existing ArcGIS toolbars.

To do this, open your “Customize” tool by either:

- 1) Double-clicking on a blank part of the ArcMap toolbar, or
- 2) Clicking the “Tools” menu, then “Customize”.

In the “Customize” dialog, click the “Commands” tab and scroll down to select “Corridor Designer Tools”:



Finally, simply drag any of the commands out of the Customize dialog up into any of the existing ArcGIS toolbars.

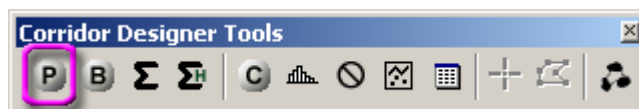
NOTE: Please be aware that all Corridor Designer tools are enabled only if the extension itself is turned on. This was done intentionally because most of the tools use Spatial Analyst functions, and would crash if Spatial Analyst were not available. The Corridor Designer Extension can only be turned on if Spatial Analyst is available.

If Corridor Designer Crashes

If the tool crashes, you should see a dialog that tells us what script crashed and where it crashed. I would appreciate it if you could take screenshots of those dialogs and email them to me at jeffj_CD@jennessent.com.

Primary Analysis Tools

Patch Analysis:




After you have generated a corridor polygon that connects two habitat blocks, the next step is to evaluate how well that corridor serves the species of interest. This Patch Analysis tool is intended for cases where you feel that the habitat within the corridor may be of marginal or poor quality, and therefore the species will have to move through some amount of unsuitable habitat as it makes its way across.

Presumably you have some idea of a threshold distance that you feel a species could handle as it traverses unsuitable habitat. This distance value may be based on your knowledge of typical foraging movement patterns of that species, or possibly juvenile dispersal distances.

Your corridor polygon may or may not have patches of good habitat distributed throughout its extent. If patches are available, and if those patches are of sufficient size and quality to support the species at the level you feel is necessary, then these patches may serve as stepping stones for the species as it moves through the corridor, and potentially reduce the expanse of unsuitable habitat that a species must cross at any one time.

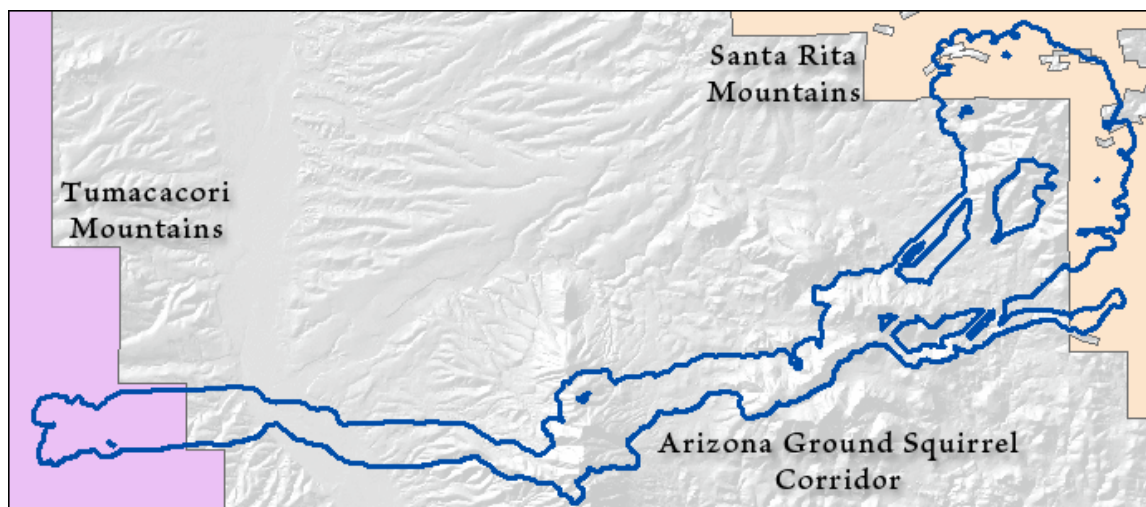
This Patch Analysis tool identifies the path through the corridor that minimizes the distance between patches of high-quality habitat. If no patches are available, then it will simply calculate the minimum distance necessary to move from one habitat block to the other, while staying within the corridor.

NOTE: This tool accomplishes its purpose reasonably well, but it can take a very long time to work depending on the shape of the corridor and the number of patches available. For example, the analysis illustrated in the example below took 1 hour and 22 minutes to complete. The problem is that the tool occasionally calls upon Spatial Analyst-based least-cost-path functions which dramatically increase the processing time. We are looking into alternatives to these Spatial Analyst functions, which we believe should speed up the analysis, but we do not know when or if we will be able to successfully implement these alternatives. In the meantime, if you wish to get a quick and rough estimate of the maximum patch-to-patch distance necessary to get through the corridor without using this Patch

Analysis tool, you may use the standard ArcGIS Measure tool  to simply draw a line over what you visually determine to be the longest gap the species will have to cross.

USING THE PATCH ANALYSIS TOOL:

As an example, suppose that we have previously generated a corridor for Arizona ground squirrels that connects the Santa Rita Mountains to the Tumacacori Mountains in southern Arizona:

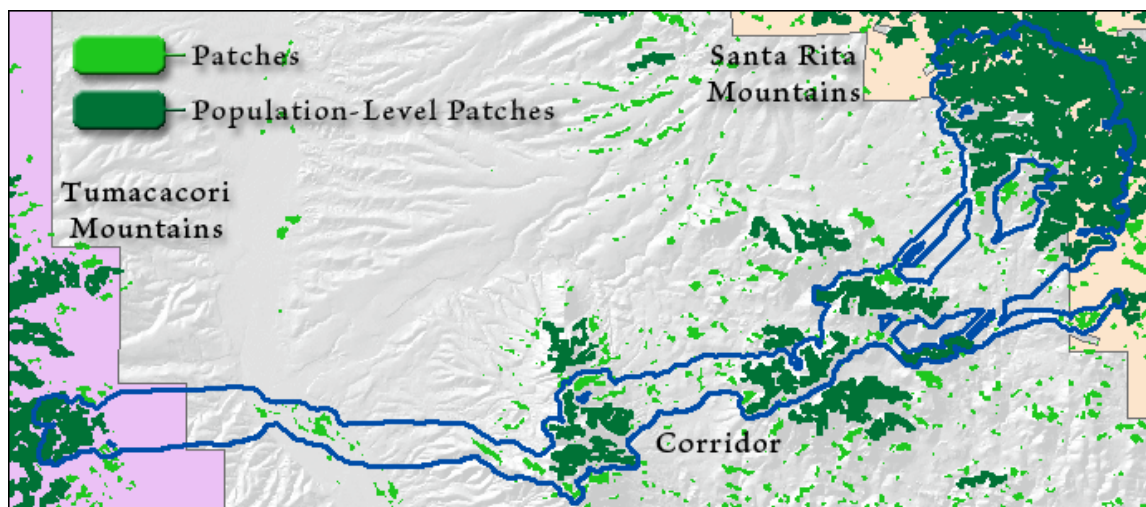


The corridor itself is quite long, at about 22 km. There are also a fairly large number of high-quality habitat patches within the corridor:

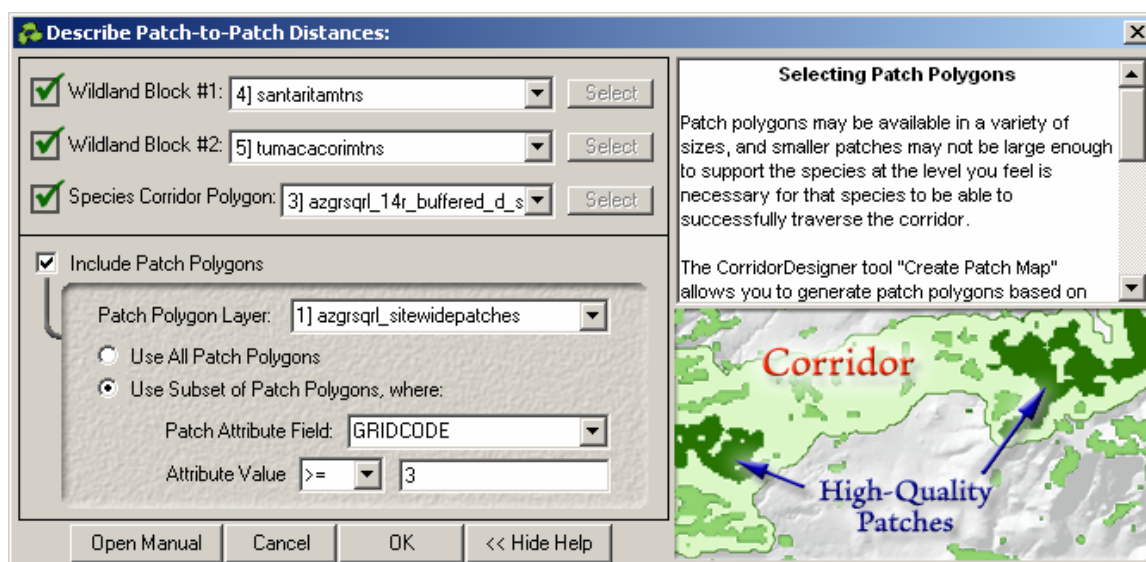


For Arizona ground squirrels, we may feel that they will require a fairly long time to cross this corridor. Therefore we may only want to consider patches that are large enough to support the species for multiple generations.

If we generated these patches using the Corridor Designer “Create Patch Map” tool, then we may have specified a size threshold which would support a sustainable population over multiple generations. In this case we can easily identify these polygons using the “Gridcode” attribute in the Patch polygon layer: In this example, population-level patches are identified with a Gridcode value = 3.

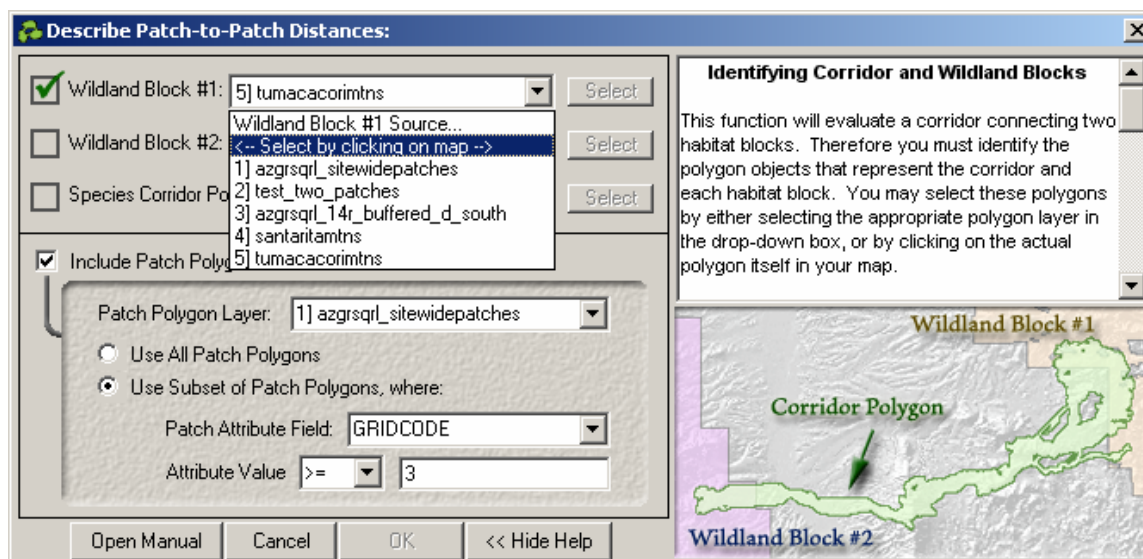


Click the Patch Analysis button  to open the analysis parameter dialog:



Select the polygons that correspond to your corridor and habitat blocks. You may only select a single polygon for each object, although that polygon may be a multi-part polygon. If you have a polygon layer containing only a single feature, then you may simply select that layer from the list in the dropdown box. If you wish to select a single polygon from an existing layer, or if you wish to select or draw a graphic polygon, then click the second item in the drop-down list “Select by clicking on map”:

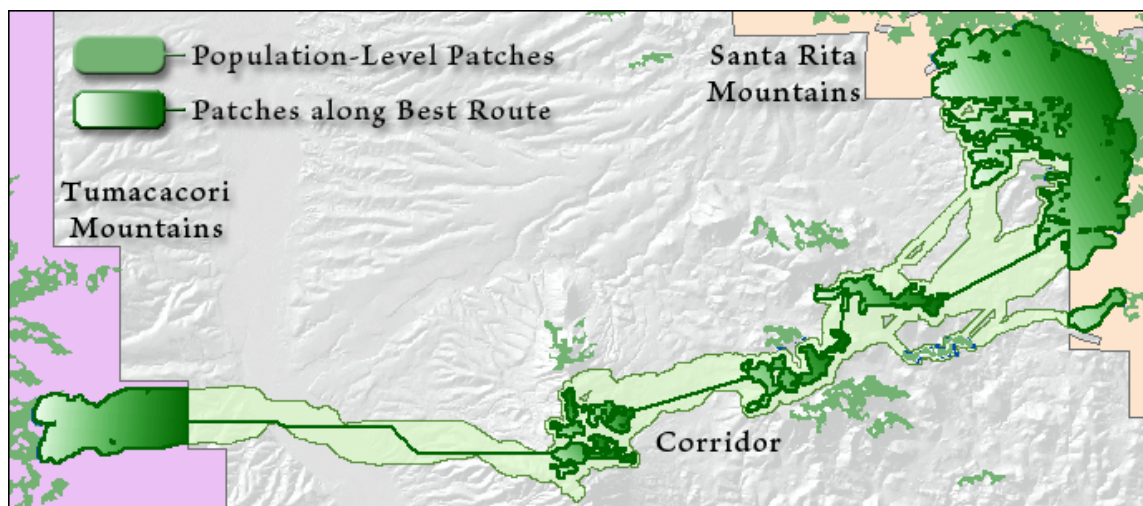
NOTE: This tool will not let you use several separate polygons as a single “wildland block” or “corridor” object. If you wish to use several polygons for this purpose, you will need to combine them into a single entity first. We have a separate stand-alone tool available which will do this function, available for free download at http://www.jennessent.com/arcgis/shapes_graphics.htm (see especially the discussion of the “Combine Features” tool).

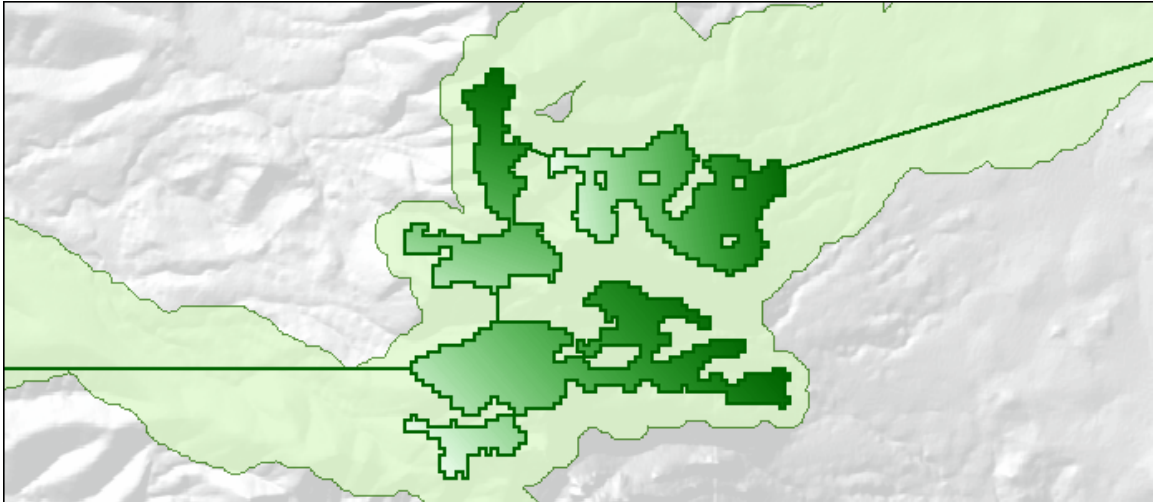


This will enable the “Select” button just to the right of the drop-down list. Click the “Select” button to open the “Selecting or Drawing Polygons” function (see Selecting or Drawing Polygons [p. 47] for details on this on using this tool).

After identifying your corridor and habitat blocks, specify whether you are using patch polygons in this analysis. In the example above, we are using patches from the polygon layer “azgrsqr_l_sitewidepatches”, and we are only considering those patches with a GRIDCODE value ≥ 3 .

Click ‘OK’ and wait for a potentially very long time for it to finish. Upon completion, the tool will add graphic connector lines and graphic patch polygons indicating the route through the corridor that minimizes the patch-to-patch distances:





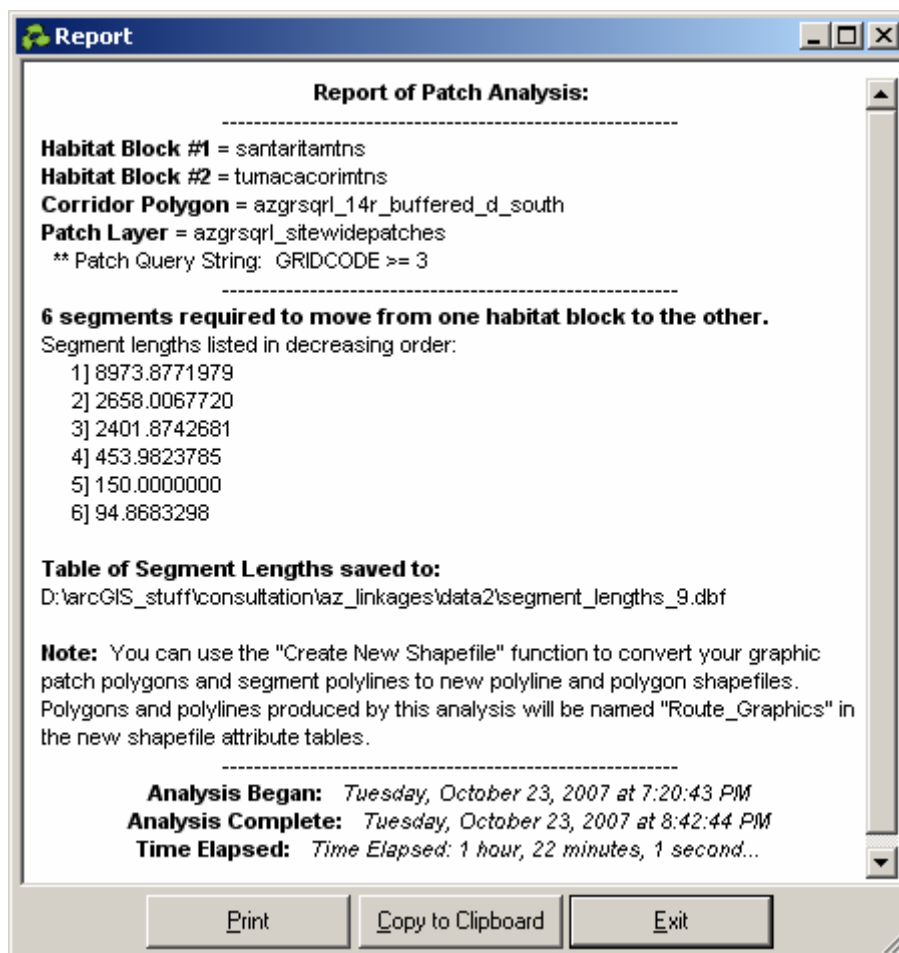
These are only graphics on the screen and can be easily deleted using the “Delete Corridor Designer Graphics” tool (see p. 44). You may also convert them to permanent polyline and polygon shapefiles using the “Create New Shapefile” tool (see p. 45).

The tool will also generate a table of all the connector lengths, listed in decreasing order, and add it as a standalone table to your map document. Remember that all standalone tables are available by clicking the “Source” tab at the bottom of the Table of Contents window:

	OID	Unique_ID	Seg_Length
▶	0	1	8973.877198
	1	2	2658.006772
	2	3	2401.874268
	3	4	453.982379
	4	5	150
	5	6	94.86833

Record: 1 Row: ▼

Finally, the tool will generate a report detailing the analysis and results:



Note that in this example, Arizona ground squirrels will have to cross a gap of almost 9km in order to make it from one habitat block to the other.

TECHNICAL DETAILS: For those interested in the methods used by this function, the basic algorithm works as follows:

- 1) *Step 1: General Error-Checking:* Just makes sure that corridor and habitat block polygons are valid polygons, and that the corridor actually connects them. This step also confirms that the two habitat blocks are not already connected (or are possibly referring to the same polygon), in which case no corridor would be needed.
- 2) *Prepare the Corridor, Habitat Block and Patch Polygons:* This includes extracting only the outermost ring of the habitat block polygons so that any internal holes are ignored. The tool only intends to connect the outermost edges of the habitat block polygons and therefore internal holes are irrelevant to the analysis. This step also involves clipping the habitat polygons to the general extent of the corridor polygon and checking to see if any sub-polygons of possibly multi-part habitat polygons can be excluded from the analysis. Finally, all patch polygons are clipped to the corridor polygon. All polygons are set to the projection of the corridor polygon.
- 3) *Generate a Raster Analysis Environment:* This function will likely require some Spatial Analyst processes, and therefore generates a raster analysis environment based on the extent of the corridor polygon +5% on all sides. The cell size is

calculated as the longer of the height vs. width of the analysis extent, divided by 600.

- 4) *Generate Distance Matrix of all patches and habitat polygons.* This reflects the distance between polygons when constrained to the interior of the corridor polygon, and therefore the connection segments may bend around corners. If patches cannot be connected (such as if they lie within different corridor strands), then no distance is calculated.

NOTE: This step is exactly why this function takes so long. It is not difficult to calculate the absolute Euclidian distances between polygons but it takes a long time to calculate the distance around corners. This step first generates a connection line that connects the closest points on each polygon, and then checks whether that connection line extends outside the corridor boundary. If so, then the tool resorts to Spatial Analyst least-cost-path functions to recreate that connection line.

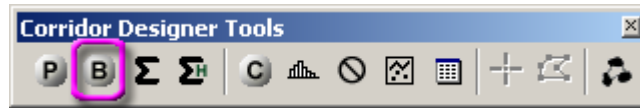
- 5) *Identify Path that Minimizes Patch-to-Patch Distances:* This step utilizes a concept called a Minimum Spanning Tree (MST), which is a method of connecting all nodes in a graph while using the shortest overall accumulated connection segments. The patches and habitat blocks are treated as nodes, and the method is modified a bit because the goal is not to connect all patches but rather to connect the origin habitat block with the destination habitat block. Therefore the origin habitat block can only have outgoing connections and the destination habitat block can only have incoming connections, and the analysis is complete when the habitat blocks are connected, not when all polygons are connected in a complete MST.

This function implements a variation on *Kruskall's Algorithm* to generate the modified MST. Please refer to p. 174-177 of O'Rourke¹ for additional information on MSTs and Kruskall's Algorithm. In simple terms, this algorithm does the following:

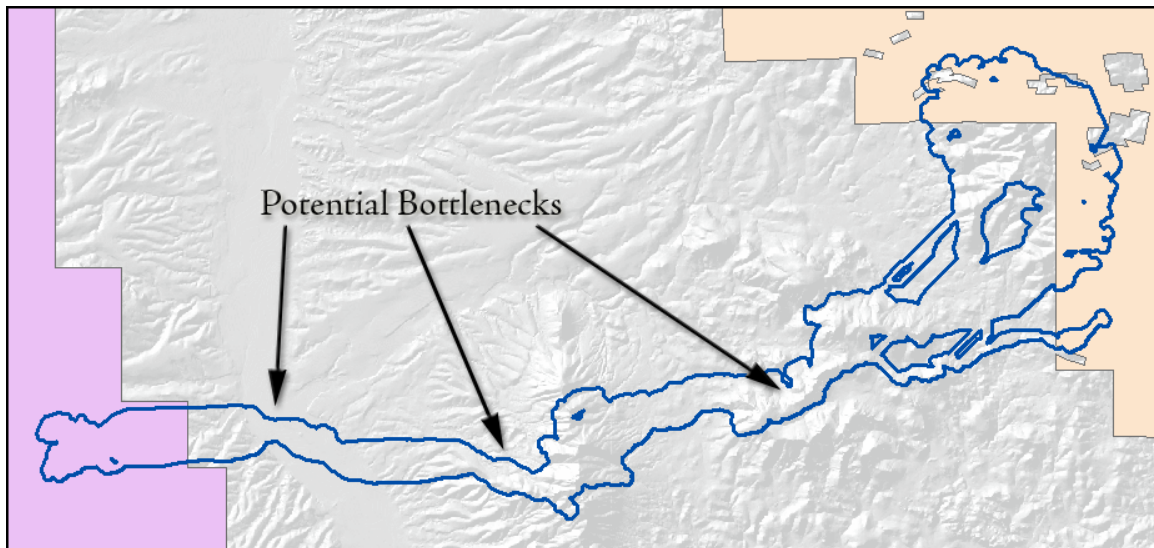
- a. Sorts all possible polygon-to-polygon connection segments by length.
- b. Starting with the shortest segment, progressively builds an MST graph by adding each successively longer segment to the graph.
- c. After adding each segment, the function checks for two conditions:
 - i. If the two polygons directly connected by the new segment have already been connected by some series of shorter segments, then this new segment is rejected. This is referred to as testing for *acyclicity*.
 - ii. If this new segment forms the last link in a continuous connection path between the two habitat blocks, then the goal has been achieved and the algorithm is suspended.
- 6) At this point we have an abbreviated MST that connects the habitat blocks, plus probably has a few extraneous branches that are irrelevant to the analysis. Therefore the final step is to prune the extraneous branches, leaving only the single route.

¹ O'Rourke, J. 2000. *Computation Geometry in C*, 2nd Ed. Cambridge University Press, Cambridge, United Kingdom. 376 pp.

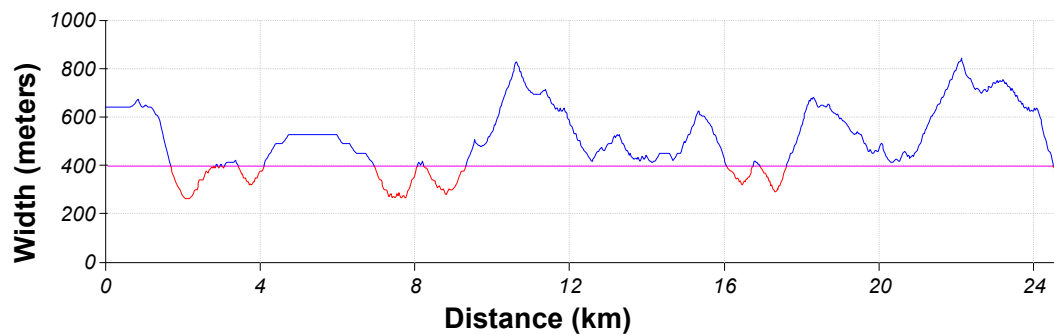
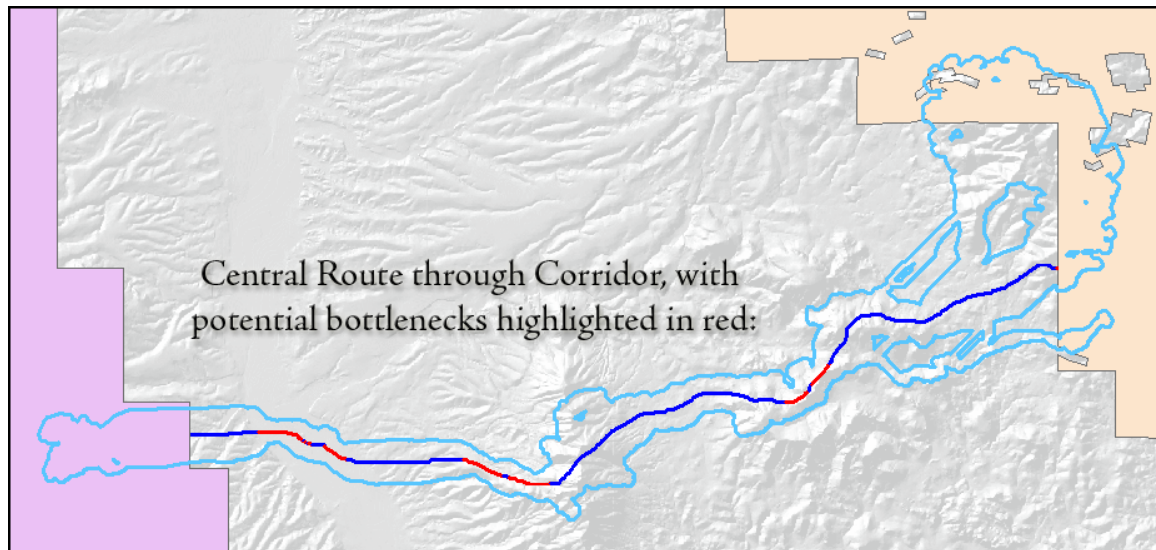
Bottleneck Analysis:



For species that are sensitive to development or edge effects, or who require some level of isolation from disturbance, corridors may not be usable if they are too narrow. A narrow spot in the corridor is considered a bottleneck and severe bottlenecks may render the corridor useless for some species. Possibly a bottleneck may be overcome if it is not too long and not too narrow, and therefore the task is to identify both the presence and the length of potential bottlenecks.



This tool analyzes a corridor for potential bottlenecks by identifying a route that connects both habitat blocks and which extends through the center of the widest possible sections of the corridor polygon. It then calculates the width of the corridor (defined as twice the distance to the closest point on the corridor boundary) at regular intervals along that route and generates a graph illustrating the width along the entire route. This tool also allows you to set a threshold corridor width and identify all portions of the corridor that fall below that threshold.




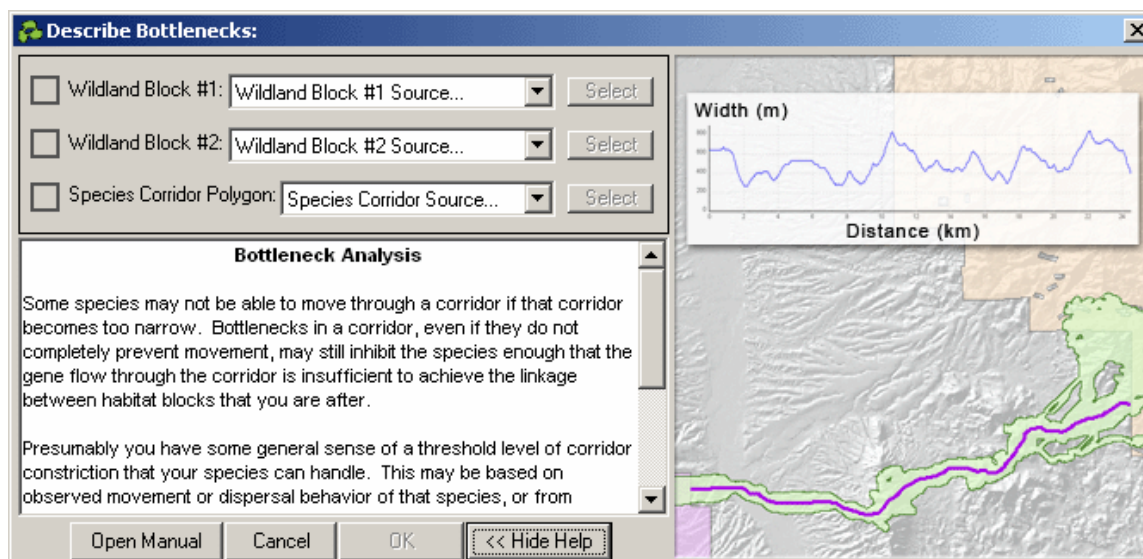
You can easily examine different threshold widths and expand the corridor at narrow spots if necessary. This tool will likely take about a minute per analysis so you can try different alternative scenarios without too much pain.

NOTE: This tool works much better if the corridor is projected into a foot- or meter-based coordinate system. The tool will still work with geographic data, but the threshold distances will be much harder to interpret.

USING THE BOTTLENECK TOOL:

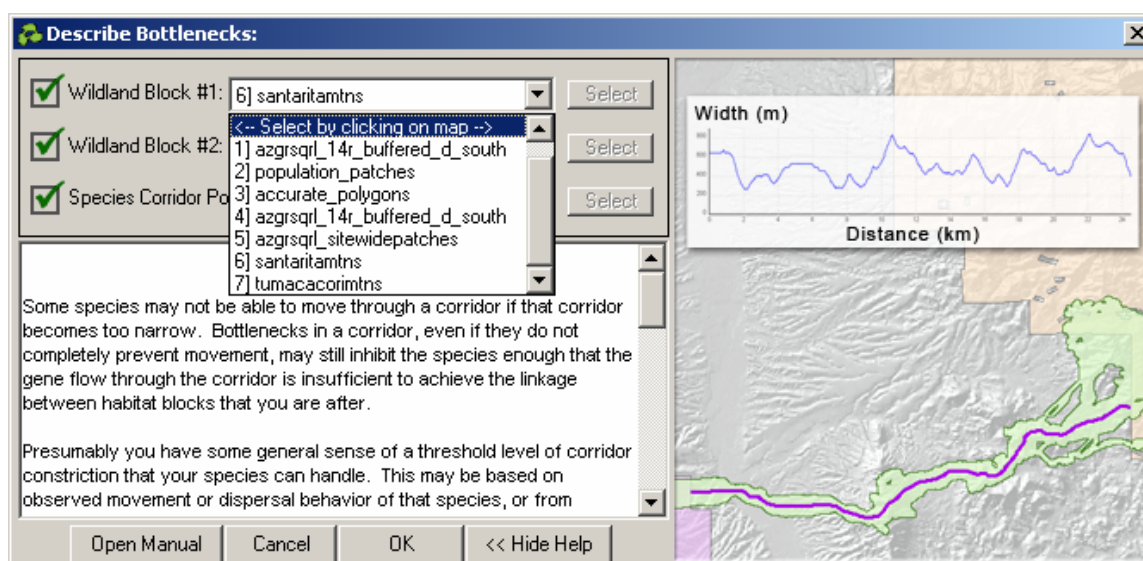
As with the Patch Analysis example, we will assume that we have previously generated a corridor for Arizona ground squirrels that connects the Santa Rita Mountains to the Tumacacori Mountains in southern Arizona (see illustration above).

Click the  button to open the “Describe Bottlenecks” dialog:



Select the polygons that correspond to your corridor and habitat blocks. You may only select a single polygon for each object, although that polygon may be a multi-part polygon. If you have a polygon layer containing only a single feature, then you may simply select that layer from the list in the drop-down box. If you wish to select a single polygon from an existing layer, or if you wish to select or draw a graphic polygon, then click the second item in the drop-down list “Select by clicking on map”:

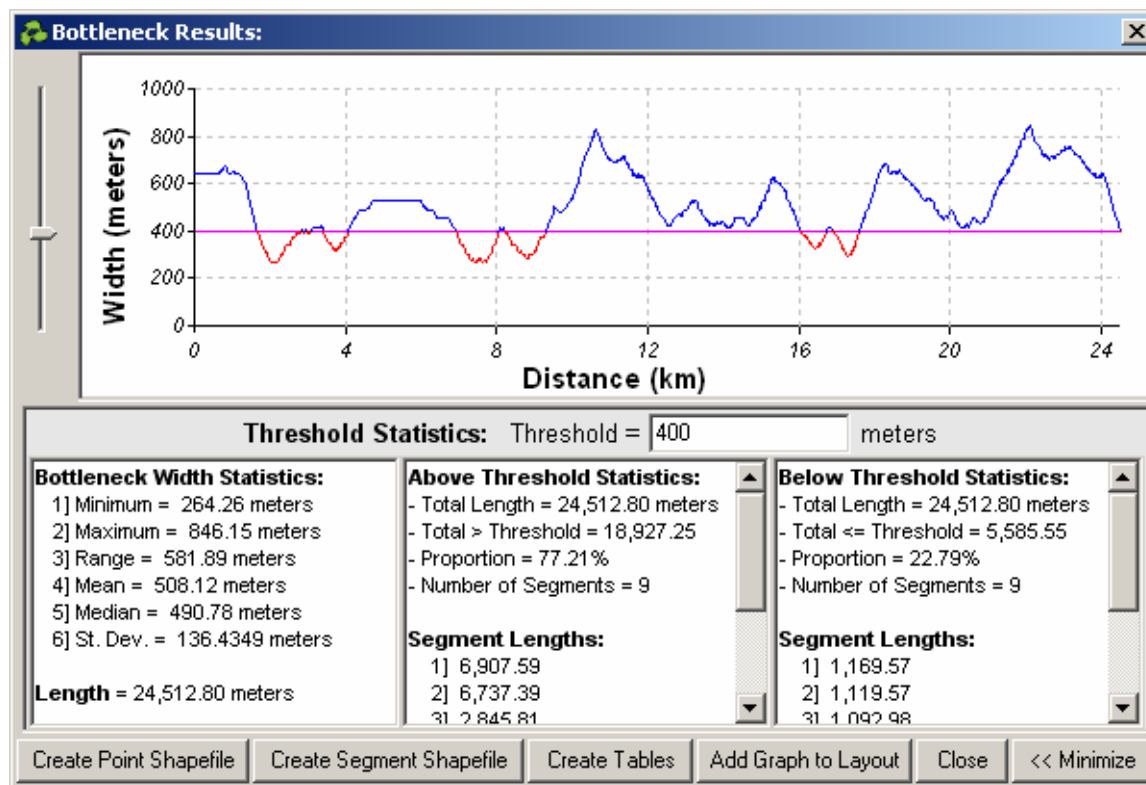
NOTE: As with the Patch tool, this tool will not let you use several separate polygons as a single “wildland block” or “corridor” object. If you wish to use several polygons for this purpose, you will need to combine them into a single entity first. We have a separate stand-alone tool available which will do this function, available for free download at http://www.jennessent.com/arcgis/shapes_graphics.htm (see especially the discussion of the “Combine Features” tool).



This will enable the “Select” button just to the right of the drop-down list. Click the “Select” button to open the “Selecting or Drawing Polygons” function (see Selecting or Drawing Polygons [p. 47] for details on this on using this tool).

After selecting your corridor and habitat block polygons, click 'OK' and wait for a minute or so. Upon completion, the tool will open up the "Bottleneck Results" dialog:

BOTTLENECK RESULTS DIALOG:



Note that the graph is linked to the map, so that the areas below the threshold are marked in red on both the graph and the map. The text boxes at the bottom of the dialog report detailed statistics on the amounts of the centerline route that lie above and below the threshold, including segment lengths sorted in decreasing order. For example, the illustration above shows the statistics for a threshold value of 400m. In this case, 23% of the corridor is narrower than 400m, and at least 3 stretches of below-threshold corridor sections are over 1km long. The narrowest point of the corridor is 264m and the average width along the best route is 508m. If this species is highly sensitive to bottlenecks, and if 400m is an absolute minimal requirement, then this corridor may not serve the species well.

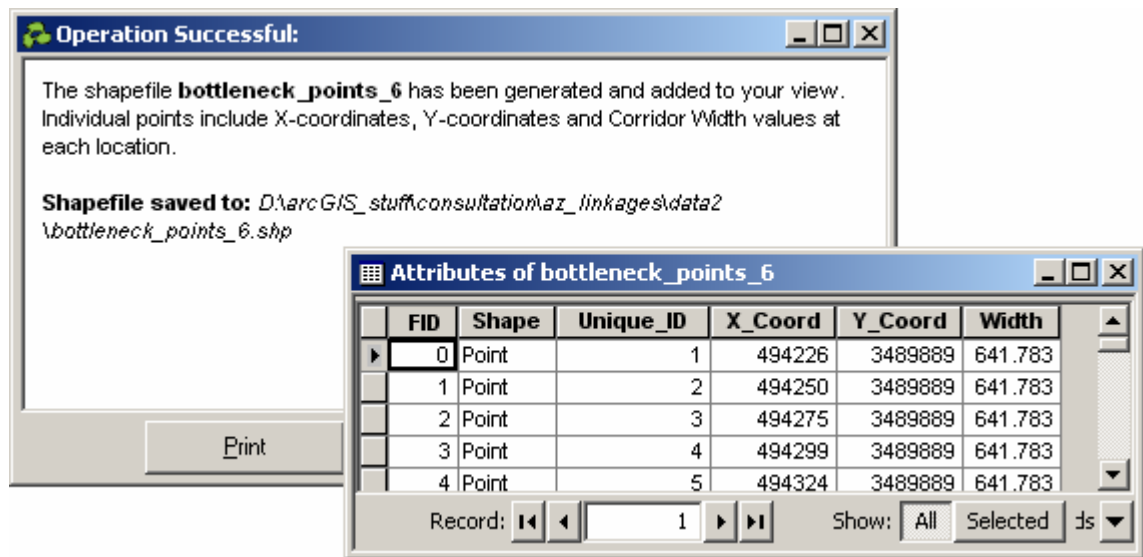
ADJUSTING THE THRESHOLD: You may adjust the threshold 3 ways:

- 1) Type in an exact threshold value in the text box.
- 2) Click on the graph at the point you would like to reset the threshold.
- 3) Move the slider control in the upper left corner up and down.

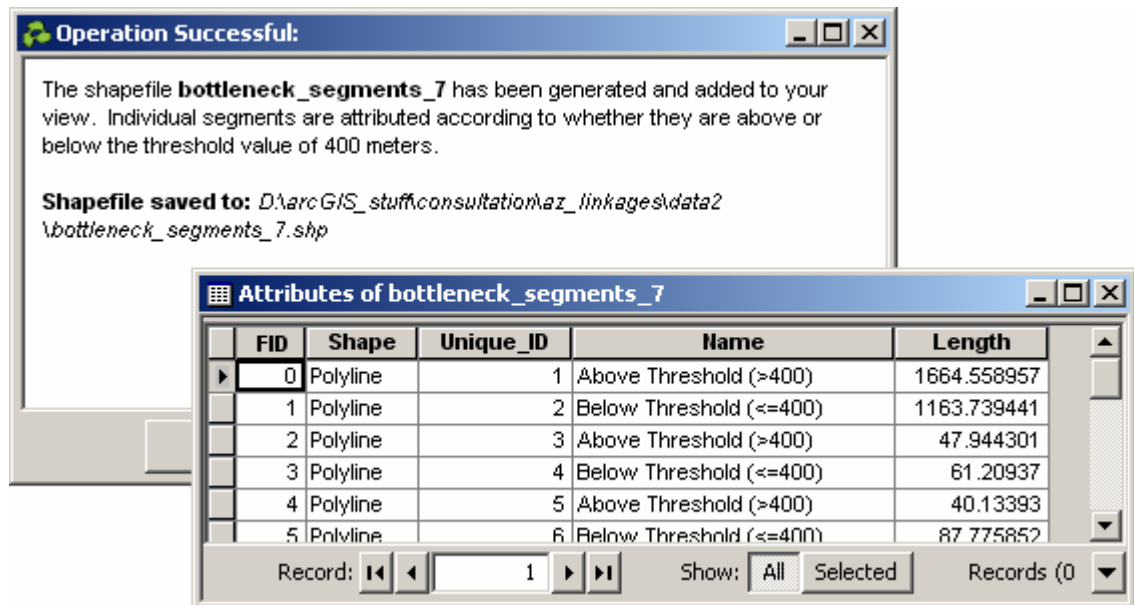
SAVING THE CORRIDOR ROUTE: If you wish to save the centerline route for any reason, you have several options to do so:

- 1) *Point Shapefile*: The "Create Point Shapefile" function will generate approximately 1000 evenly-spaced points along the centerline route, with attribute values for Unique ID, X-coordinate, Y-coordinate and Corridor Width at that point. Upon

completion, the function will open a report window and add the new shapefile to your map.



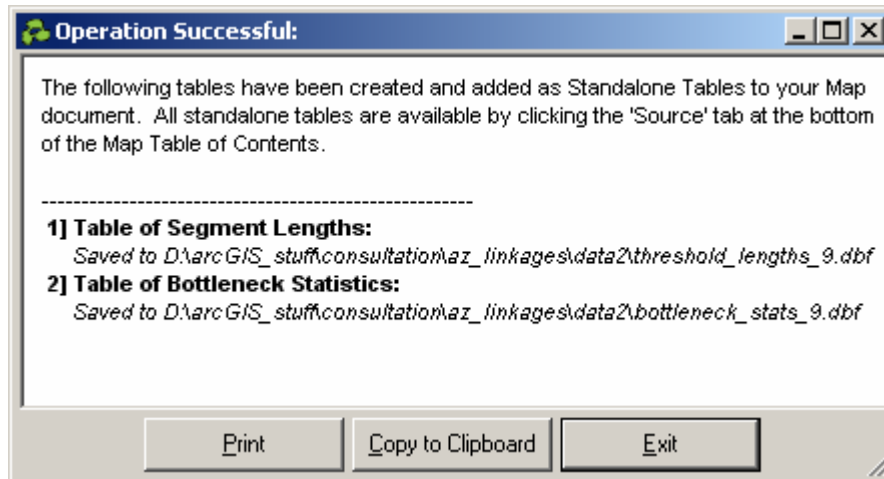
- 2) *Segment Shapefile*: The “Create Segment Shapefile” function will divide the route up into “Above Threshold” and “Below Threshold” segments and export them to a polyline shapefile. Segments will include attribute values indicating whether they are above or below the threshold, as well as the lengths of those segments.



- 3) *Segment Shapefile*: You may also use the Corridor Designer “Create New Shapefile” function (see p. 45) to convert the graphic segments to a polyline shapefile.

GENERATING DBASE TABLES: The “Create Tables” button will generate 2 tables and add them as standalone tables to your map document. Remember that all standalone tables are available by clicking the “Source” tab at the bottom of the Map Table of Contents. The two tables are:

- 1) *Table of Segment Lengths:* Contains the threshold value, total length of the centerline route, and lengths of all segments above and below the threshold sorted in decreasing order. The dBASE table will be named “bottleneck_segments_#.dbf”, where “#” is the lowest possible integer value that guarantees a unique filename.
- 2) *Table of Bottleneck Stats:* Contains general descriptive statistics on the corridor width along the entire centerline route, as well as proportions and lengths of the centerline route above and below the current threshold value. This table will be named “bottleneck_stats_#.dbf”, where “#” is the lowest possible integer value that guarantees a unique filename.



Attributes of bottleneck_stats_9				
OID	Unique_ID	Statistic	Value	
0	13	Minimum Width	264.264	
1	14	Maximum Width	846.151	
2	15	Range of Width Values	581.887	
3	16	Mean Width	508.124965	
4	17	Median Width	490.775	
5	18	Standard Deviation of Width	136.434921	
6	19	Centerline Length	24512.8	
7	20	Width Threshold Value	555	
8	21	Length Below Threshold	16236.118054	
9	22	Proportion Below Threshold	0.662353	
10	23	Length Above Threshold	8276.681946	
11	24	Proportion Above Threshold	0.337647	

Record: 1 Show: All Selected records

Attributes of threshold_lengths_9				
OID	Unique_ID	Name	Length	
0	1	Total Length	24512.8	
1	2	Threshold Value	555	
2	3	Above Threshold #1	3016.212455	
3	4	Above Threshold #2	2037.050493	
4	5	Above Threshold #3	1436.797267	
5	6	Above Threshold #4	1252.935043	
6	7	Above Threshold #5	533.686689	
7	8	Below Threshold #1	8598.269076	
8	9	Below Threshold #2	3064.576347	
9	10	Below Threshold #3	2283.753713	
10	11	Below Threshold #4	1999.342005	
11	12	Below Threshold #5	290.176913	

Record: 1 Show: All electe

ADD GRAPH TO LAYOUT: This function converts the graph in the “Bottleneck Results” dialog to a Windows Enhanced Metafile (*.emf) format and automatically adds it to your Map Layout. It then produces a report notifying you of where the file is, in case you also want to add the graph to other documents.

NOTE: One nice thing about the *.emf format is that Microsoft has attempted to make it some sort of standard, so there are at least a few other programs that recognize it. Not surprisingly, Microsoft Word documents handle *.emf images just fine and therefore they can easily be inserted in reports. For example, the author simply dragged-and-dropped the image file “bottleneck_stats_9.emf” below into this manual:



NOTE: Even though the graph appears in your layout, this graphic is not automatically saved into the Map document. ArcMap only stores a reference to the graphic file on the hard drive, not the graphic itself. If you delete the *.emf file from the hard drive, then the graphic will be missing from your layout the next time you open your Map document. If you wish to save the actual graphic in the map document file itself, then right-click on the graphic, select 'Properties', select the 'Picture' tab, and check the box for 'Save Picture as Part of Document'. If you do this, then your Map document will increase in size by a few KB, and you can delete the *.emf file from the hard drive.

MINIMIZING THE DIALOG: If the Bottleneck Results dialog takes up too much screen space for you to see your map properly, you can temporarily shrink it by clicking the “Minimize” button. To reset it to full size, simply click the “Maximize” button.

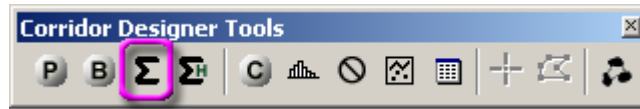
TECHNICAL DETAILS: For those interested in the methods used by this function, the basic algorithm works as follows:

- 1) *Step 1: General Error-Checking:* Just makes sure that corridor and habitat block polygons are valid polygons, and that the corridor actually connects them. This step also confirms that the two habitat blocks are not already connected (or are possibly referring to the same polygon), in which case no corridor would be needed.
- 2) *Prepare the Corridor and Habitat Block Polygons:* This includes extracting only the outermost ring of the habitat block polygons so that any internal holes are ignored. The tool only intends to connect the outermost edges of the habitat block polygons and therefore internal holes are irrelevant to the analysis. This step also involves clipping the habitat polygons to the general extent of the corridor polygon and checking to see if any sub-polygons of possibly multi-part habitat polygons can be excluded from the analysis. All polygons are set to the projection of the corridor polygon.
- 3) *Generate a Raster Analysis Environment:* This function depends on least-cost-path analysis and therefore uses Spatial Analyst processes. The function generates a raster analysis environment based on the extent of the corridor polygon +10% on all sides. The cell size is calculated as the longer of the height vs. width of the analysis extent, divided by 1000.
- 4) *Generate a Distance from Edge Grid:* The “Distance from Edge” grid reflects the **internal** Euclidian distances from the edge of the corridor polygon. All regions outside the corridor polygon have a “Distance from Edge” value of 0.
- 5) *Identify Central Cells of Corridor:* This is done by treating the “Distance from Edge” grid as a pseudo-elevation dataset, where the highest “elevation” values

naturally occur in the center of the polygon (i.e. with the highest “distance from edge” values). We then perform a streamflow accumulation analysis on the “elevation” dataset and identify all those grid cells with zero accumulated streamflow. These represent the pseudo-ridgelines, or central cells, in the “Distance from Edge” grid.

- 6) *Generate Cost Grid through Corridor:* The cost grid has relatively low costs within the central cells, and extremely high costs elsewhere within the corridor. Areas outside the corridor are completely restricted from the analysis.
- 7) *Generate Cost Distance and Direction Grids:* This is done twice, using each of the two habitat blocks as an origin source.
- 8) *Generate a Set of Potential Centerline Routes:* Typically a large number of potential centerline routes will be generated. A least-cost-path polyline is generated at every point where one of the habitat polygon boundaries intersects a central cell (from step 5 above). There can be many such cells, especially if the corridor is multi-stranded or has holes. If a habitat polygon does not intersect any centerline cells (a rare but theoretically possible case), then a least-cost-path polyline is generated for all cells along the intersection of the habitat boundary line and the corridor polygon.
- 9) *Calculate Statistics on All Competing Routes:* For each of the routes generated in step 8 above, we identify:
 - a. The narrowest point encountered along the route (measured at cell-sized [see step 3] intervals along the route using the “Distance from Edge” grid [see step 4]).
 - b. The total accumulated cost of traveling the route (calculated at the endpoint of the route, using the “Cost Distance” grid generated in step 7 above).
 - c. The total length of the route.
- 10) *Choose Best Route:* This is an iterative process:
 - d. First the route(s) with the widest narrow point is selected. Only the routes that go through the widest parts of the corridor will be considered. If multiple routes have the same widest narrow point, then:
 - e. From this subset, select the route(s) with the lowest accumulated travel cost. If there are still multiple routes, then:
 - f. From this new subset, select the shortest routes. If there are still multiple routes, then:
 - g. At this point they are probably multiple versions of the same route, which might happen if the same route was generated going to and from each habitat block. In this case there is no real difference among the remaining routes, so simply take the first in the list.
- 11) *Complete the Analysis:* The corridor width values (calculated in step 9.a.) of the final selected route are then sent to the Bottleneck Results dialog, which then generates all statistics and graphs.

Calculating General Summary Statistics Within Corridor Polygons:




The Corridor Designer Evaluation tools provide a function to calculate general summary statistics on numeric and categorical data from both vector and raster datasets. The types of statistics offered vary depending on the data type and are summarized below. In all cases, statistics are provided in both a dBASE table and a textual report:

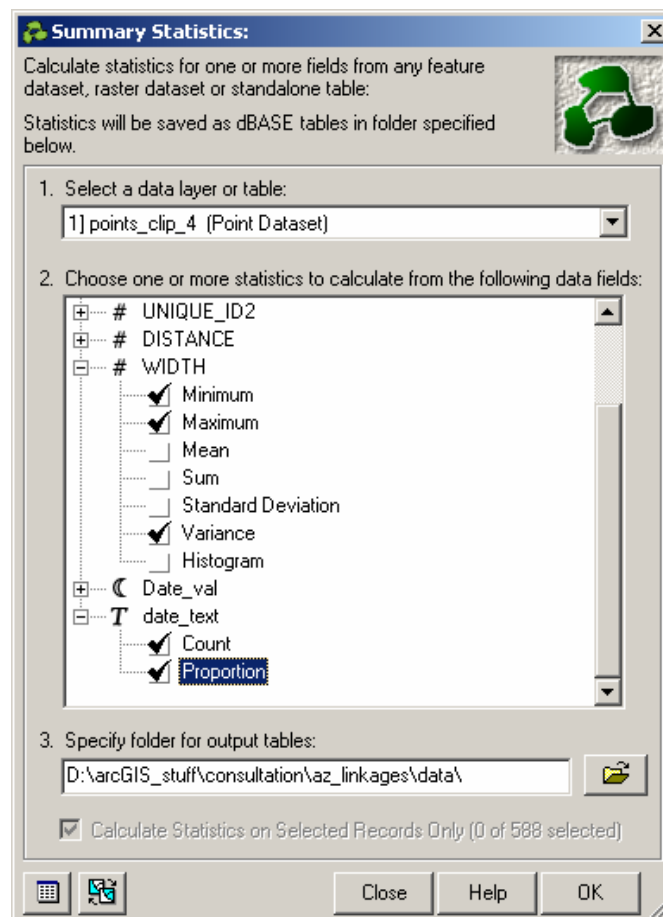
FEATURE DATA (Points, Polygons or Polygons) AND STANDALONE TABLES:

- Point Layers, Multipoint Layers and Standalone Tables:
 - Numeric fields: Available stats are:
 - Minimum
 - Maximum
 - Mean
 - Sum
 - Standard Deviation
 - Variance
 - Histogram
 - Text Fields
 - Count (of each unique value)
 - Proportion (of each unique value)
 - Date Fields
 - Earliest Date
 - Latest Date
- Polygon Themes:
 - Numeric fields: Available stats are:
 - Minimum
 - Maximum
 - Mean
 - Mean_WBA (weighted by area of polygon)
 - Sum
 - Standard Deviation
 - Standard Deviation_WBA (weighted by area of polygon)
 - Variance
 - Variance_WBA (weighted by area of polygon)
 - Histogram
 - Text Fields
 - Count (of each unique value)
 - Proportion (of each unique value)
 - Area (of each unique value)
 - Date Fields
 - Earliest Date
 - Latest Date
- Polyline Themes:
 - Numeric fields: Available stats are:
 - Minimum
 - Maximum
 - Mean
 - Mean_WBL (weighted by length of line)
 - Sum
 - Standard Deviation
 - Standard Deviation_WBL (weighted by length of line)
 - Variance
 - Variance_WBL (weighted by length of line)
 - Histogram
 - Text Fields
 - Count (of each unique value)
 - Proportion (of each unique value)
 - Length (of each unique value)
 - Date Fields
 - Earliest Date
 - Latest Date



RASTER DATA:



- Grids with Tables (integer and small floating point grids):
 - Numeric fields: Available stats are:
 - Minimum
 - Maximum
 - Mean
 - Median
 - Mode
 - Sum
 - Standard Deviation
 - Histogram
 - Count (of each unique number)
 - Proportion (of each unique number)
 - Area (of each unique number)
 - Text Fields
 - Count (of each unique value)
 - Proportion (of each unique value)
 - Area (of each unique value)
 - Date Fields
 - Earliest Date
 - Latest Date
- Grids without tables (generally large floating point grids):
 - No table or fields available, so standard statistics include:
 - Minimum
 - Maximum
 - Mean
 - Standard Deviation
 - Histogram

Open the general summary statistics tool by clicking the  button:



The Summary Statistics dialog allows you to calculate a variety of statistics on multiple fields from one of the data layers or tables in your map document. **IMPORTANT:** This function will not automatically clip your dataset to your corridor polygon. This tool will calculate statistics based on the entire dataset, or optionally on the selected features in a vector dataset, so in most cases you will need to clip your dataset prior to running this tool. Please refer to “Using the Clip Tool” (see p. 40) for more information on how to clip datasets.

All feature layers and grids are listed in the drop-down box at the top of the dialog. When you select one of these layers, the large box in the center of the dialog will fill with the available attribute fields and statistics. Attribute field names are prefaced with a symbol indicating whether the field is of type Number (#), Date() or Text ().

If you choose a feature layer (i.e. one composed of points, lines or polygons), and if any of those features are selected, then you have the option to calculate statistics on only the selected set of features by clicking the checkbox near the bottom of the dialog. The checkbox is disabled if no features are selected. You may switch the selection at any time by clicking the  button, and you may easily open and view the table for the current selected dataset by clicking the  button.

NOTE: In many cases, the calculated statistics are weighted by the size of the feature. For example, if you wish to calculate the mean flow rate of two river segments, where the 1st segment is 500m long and has a flow rate of 100, and the 2nd segment is 1000m long and has a flow rate of 10, then the weighted mean flow rate will be calculated as:

$$\begin{aligned}\text{Mean Flow Rate} &= \frac{(\text{Seg. 1 Length})(\text{Seg. 1 Flow Rate}) + (\text{Seg. 2 Length})(\text{Seg. 2 Flow Rate})}{(\text{Seg. 1 Length}) + (\text{Seg. 2 Length})} \\ &= \frac{(500)(100) + (1000)(10)}{500 + 1000} \\ &= 40\end{aligned}$$

In general, weighted statistics are calculated as follows:

Where:

X_i = the value

W_i = the weight (i.e. count, area or length)

Then:

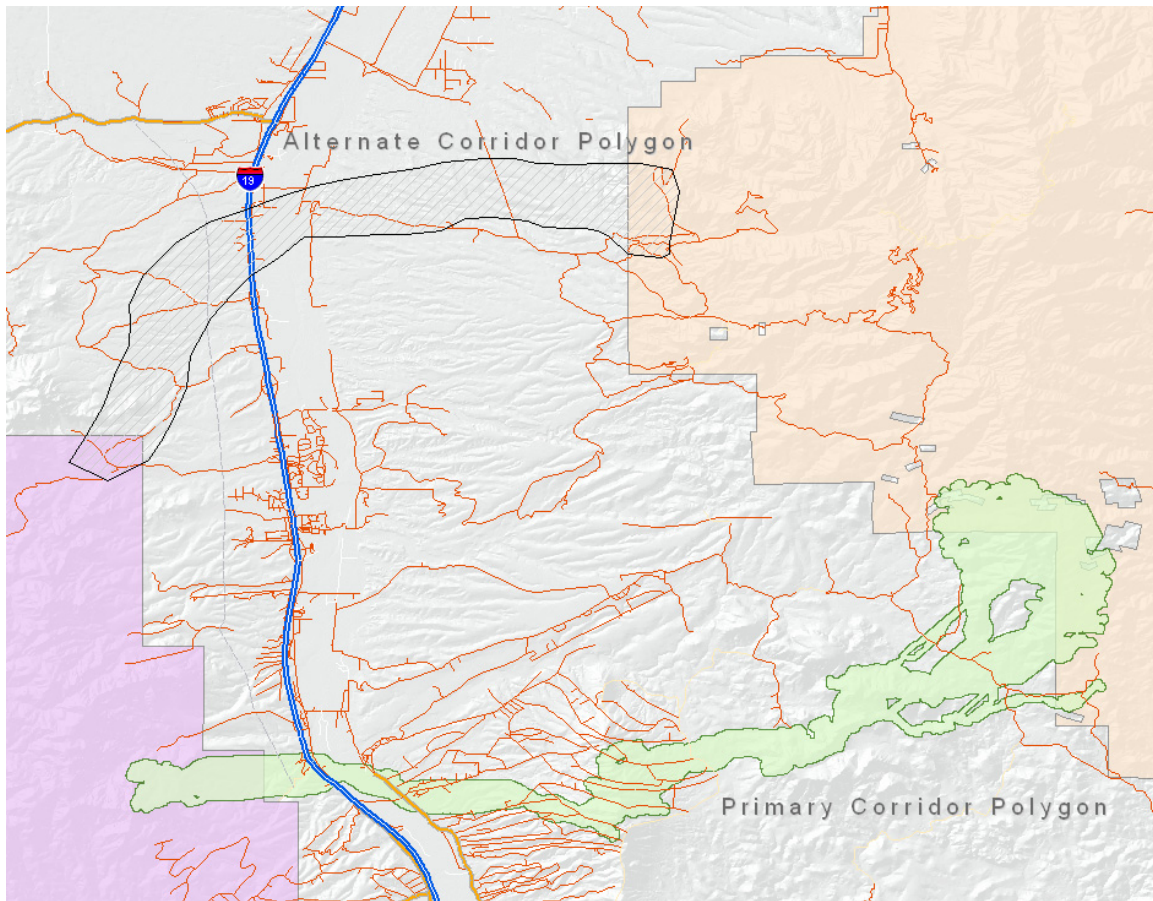
$$\text{Weighted Mean} = \frac{\sum_{i=1}^n X_i W_i}{\sum_{i=1}^n W_i} = \bar{X}$$

$$\text{Weighted Variance} = \frac{\sum_{i=1}^n W_i (X_i - \bar{X})^2}{\sum_{i=1}^n W_i}$$

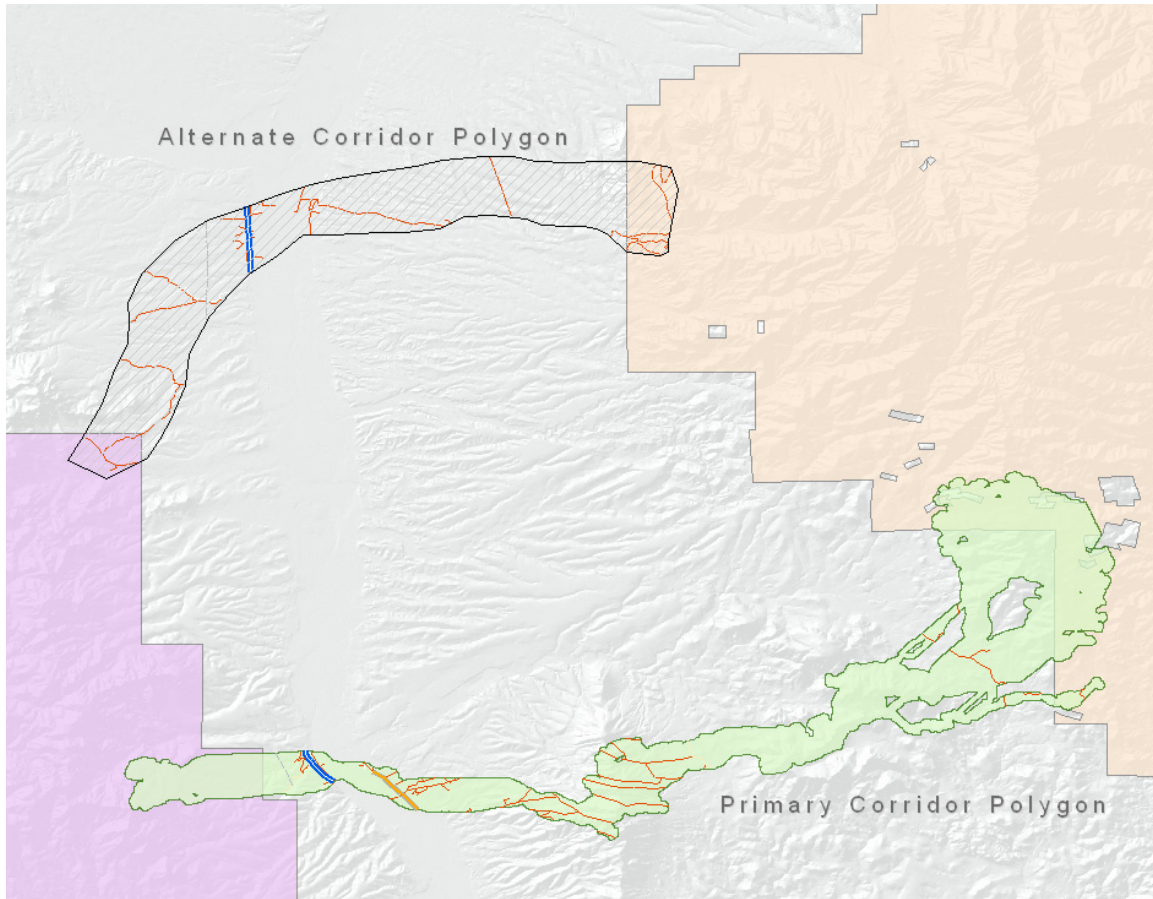
$$\text{Weighted Standard Deviation} = \sqrt{\frac{\sum_{i=1}^n W_i (X_i - \bar{X})^2}{\sum_{i=1}^n W_i}}$$

AN EXAMPLE WITH POLYLINE DATA:

Suppose we were interested in the total lengths of different types of roads that existed within our primary corridor polygon and an alternative corridor polygon.



We must first use the Clip Tool (see p. 40) to clip our road network to both the primary and alternative corridor polygons.



Next, open the summary statistics tool and select the road layer that has been clipped to your primary corridor polygon, as well as the field(s) you wish to analyze and the statistics you wish to generate. In this example, roads are classified in the field “Class_rte”:

Summary Statistics:

Calculate statistics for one or more fields from any feature dataset, raster dataset or standalone table:

Statistics will be displayed in a Report window, and saved in dBASE tables in folder specified below.

1. Select a data layer or table:
 [2] corridor_roads_utm (Polyline Dataset)

2. Choose one or more statistics to calculate from the following data fields:

- ☐ PRETYPE
- ☐ NAME
- ☐ TYPE
- ☐ SUFFIX
- ☐ CLASS_RTE
 - ☒ Count
 - ☒ Proportion
 - ☒ Length
- ☐ RAMP_CLASS
- ☐ FROM_ELEV
- ☐ TO_ELEV
- ☐ HWY_TYPE

3. Specify folder for output tables:
 D:\arcGIS_stuff\consultation\az_linkages\data2\

☒ Calculate Statistics on Selected Records Only (0 of 133 selected)

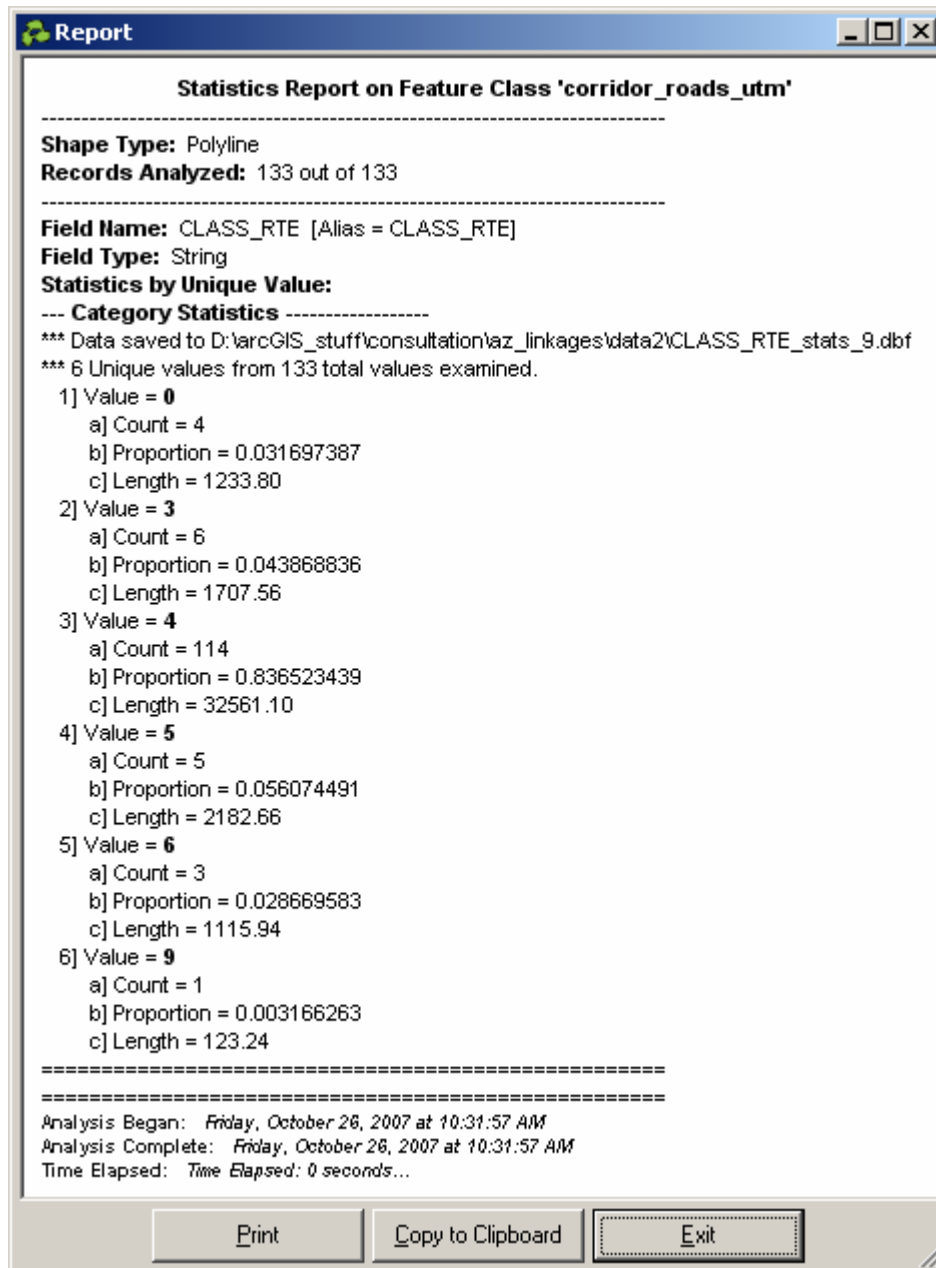
Close Help OK

Click 'OK' and this function will identify all unique "CLASS_RTE" values in the clipped road layer, and tell us the total number, proportion and length of roads in each "CLASS_RTE" class. These statistics are provided in both a table in your Map document and in a text report:

Attributes of CLASS_RTE_stats_3

	OID	Unique_ID	Value	Count	Proportion	Length
▶	0	1	0	4	0.031697	1233.79916
	1	2	3	6	0.043869	1707.564491
	2	3	4	114	0.836523	32561.10372
	3	4	5	5	0.056074	2182.661279
	4	5	6	3	0.02867	1115.943929
	5	6	9	1	0.003166	123.244642

Record: 1 Show: All Selected Records (0 out of 6 Selected) Options



For reference, the “CLASS_RTE” values are defined as follows:

CLASS_RTE Value	Definition
0	Limited Access (Freeway)
3	Major Road
4	Local Road
5	Minor Road
6	Other Road
9	Pedestrian Way

Therefore, our primary corridor contains 1,234m of freeway, 1,708m of major roads, 32,561m of local roads, 2,183m of minor roads, 1,116m of “other” roads, and 123m of pedestrian trails.

NOTE: All dBASE statistics tables are opened and saved in your Map document. If you close a table, you can easily find and reopen it by clicking the “Source” tab at the bottom left corner of your Map document. All standalone tables are listed in the “Source” tab. Also, the text report includes the hard drive location of the dBASE table.

For comparison purposes, we now calculate the statistics on the alternative corridor. The steps are identical, except that we now choose the road layer that has been clipped to the alternative polygon:

Summary Statistics:

Calculate statistics for one or more fields from any feature dataset, raster dataset or standalone table:

Statistics will be displayed in a Report window, and saved as dBASE tables in folder specified below.

1. Select a data layer or table:
2] corridor_roads_utm (Polyline Dataset)

2. Choose one or more statistics to calculate from the following fields:

- PRETYPE
- NAME
- TYPE
- SUFFIX
- CLASS_RTE
 - Count
 - Proportion
 - Length
- RAMP_CLASS
- FROM_ELEV
- TO_ELEV
- Hwy_TYPE

3. Specify folder for output tables:
D:\arcGIS_stuff\consultation\az_linkages\data

☒ Calculate Statistics on Selected Records Only

Report

Statistics Report on Feature Class 'Alternate_roads_utm'

Shape Type: Polyline
Records Analyzed: 83 out of 83

Field Name: CLASS_RTE [Alias = CLASS_RTE]
Field Type: String

Statistics by Unique Value:

--- Category Statistics ---
*** Data saved to D:\arcGIS_stuff\consultation\az_linkages\data2\CLASS_RTE_stats_8.dbf
*** 4 Unique values from 83 total values examined.

1) Value = 0
a) Count = 2
b) Proportion = 0.045895488
c) Length = 2049.82

2) Value = 4
a) Count = 71
b) Proportion = 0.819429964
c) Length = 36598.01

3) Value = 6
a) Count = 4
b) Proportion = 0.068824788
c) Length = 3073.91

4) Value = 9
a) Count = 6
b) Proportion = 0.065849760
c) Length = 2941.03

Analysis Began: Friday, October 26, 2007 at 10:24:44 AM
Analysis Complete: Friday, October 26, 2007 at 10:24:44 AM
Time Elapsed: Time Elapsed: 0 seconds...

Attributes of CLASS_RTE_stats_4

OID	Unique_ID	Value	Count	Proportion	Length
0	1	0	2	0.045895	2049.81967
1	2	4	71	0.81943	36598.01311
2	3	6	4	0.068825	3073.905782
3	4	9	6	0.06585	2941.032785

Record: 1 Show: All Selected Records (0 out of 4 Selected) Options

A table helps compare the amount of road by type in each polygon:

Road Class	Primary Corridor (m)	Alternative Corridor (m)
Limited Access (Freeway)	1,234	2,050

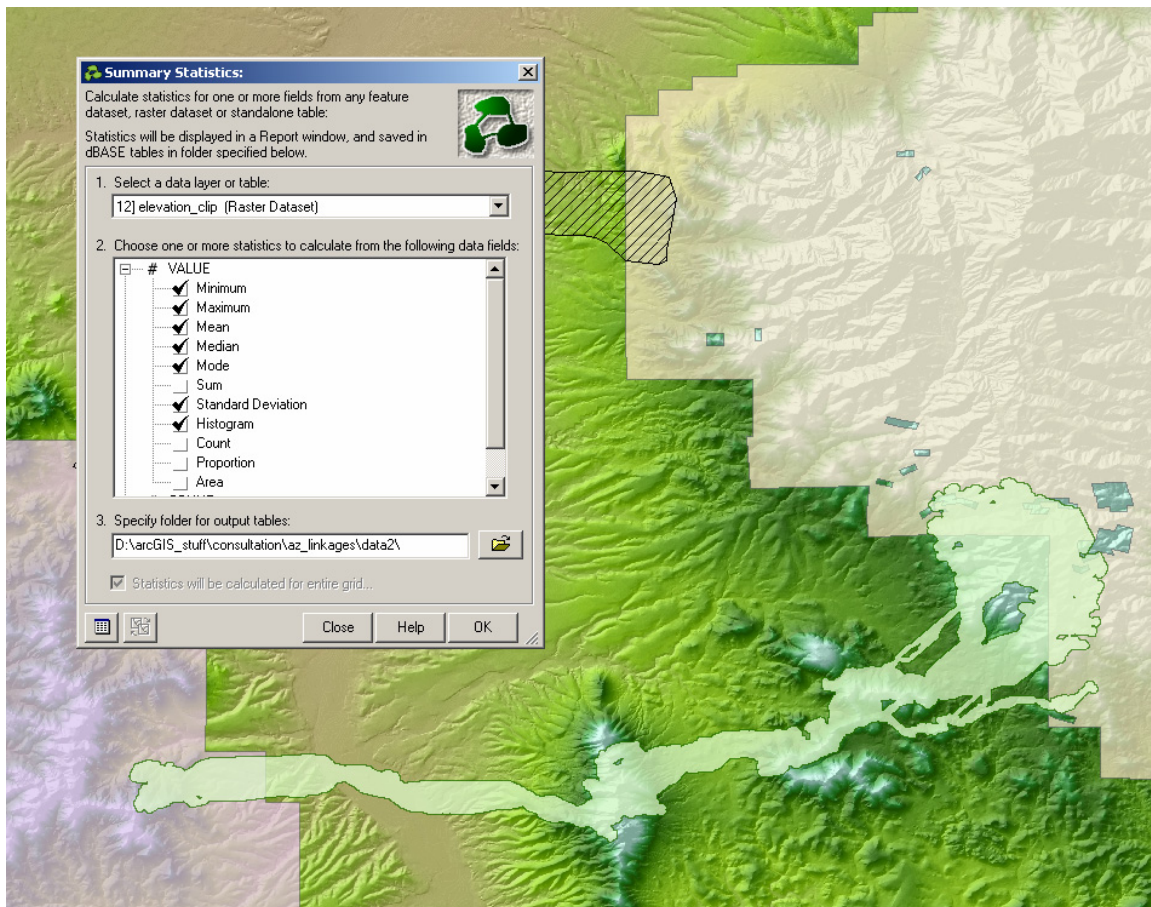
Major Road	1,708	0
Local Road	32,561	36,598
Minor Road	2,183	0
Other Road	1,116	3,074
Pedestrian Way	123	2,941

NOTE: Because all tables are saved in dBASE format, they can also be opened up separately in Excel for more advanced graphing functions.

NOTE: Road lengths (and polygon areas) are calculated according to the actual sizes of the feature. Therefore, if your features are in latitude/longitude coordinates, then your size values will be reported in “degrees” rather than any useful measure. Therefore you are recommended to apply this tool on projected data if you wish to calculate accurate size values.

AN EXAMPLE WITH GRID DATA:

The general statistics tool works equally well with vector and raster data. For example, if we wanted to calculate general statistics and a histogram of elevation values within our primary corridor polygon, we would first clip the elevation grid to the primary corridor polygon using the Clip Tool, and then apply the general summary statistics tool directly to the clipped elevation grid:



General statistics (mean, minimum, etc.) are generated in a separate table from histogram data, so this example will produce two separate tables.

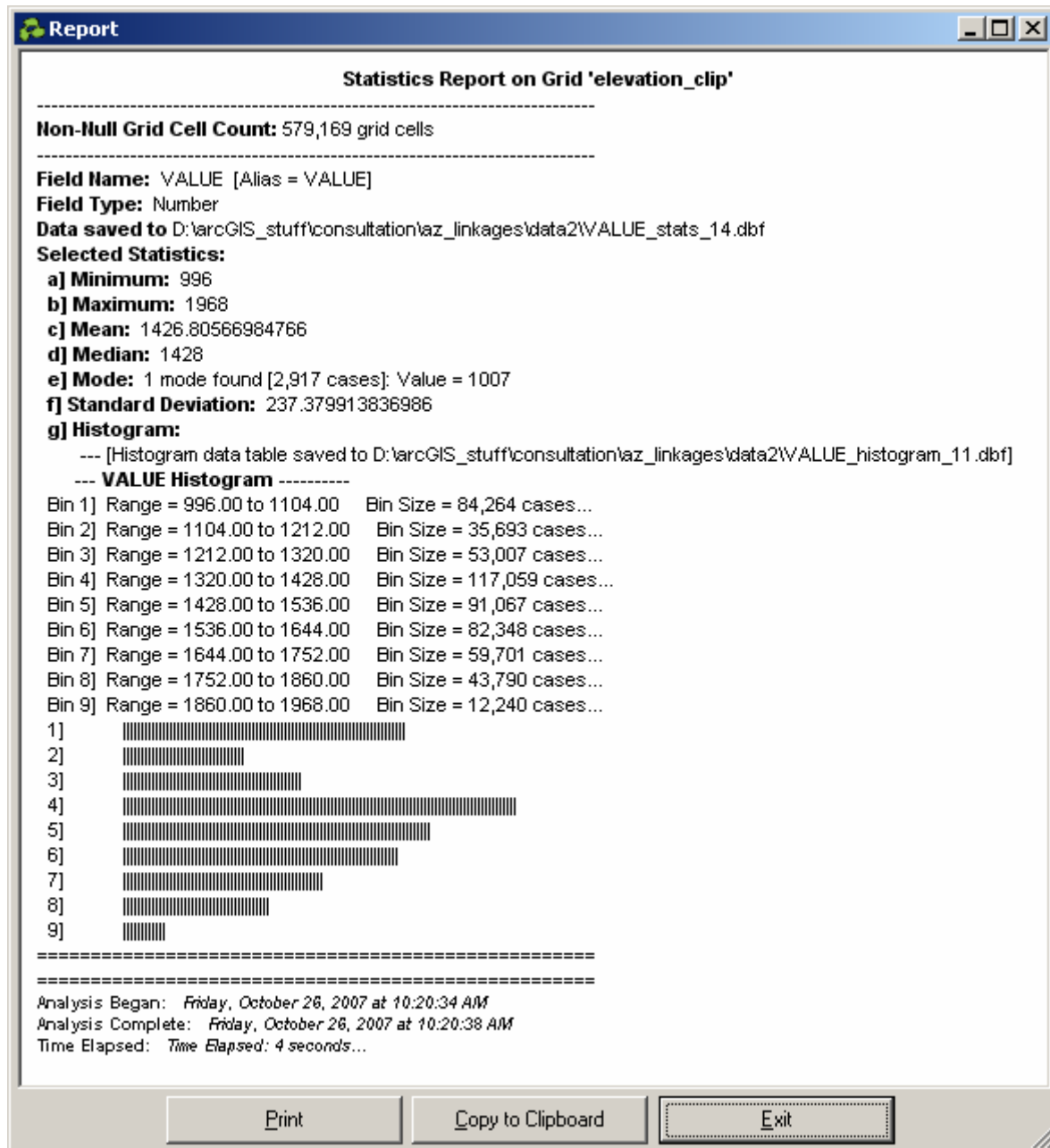
Attributes of VALUE_stats_7							
OID	Unique_ID	Minimum	Maximum	Mean	Median	Mode_Strng	St_Dev
0	1	996	1968	1426.80567	1428	1 mode found [2,917 cases]: Value = 1007	237.379914

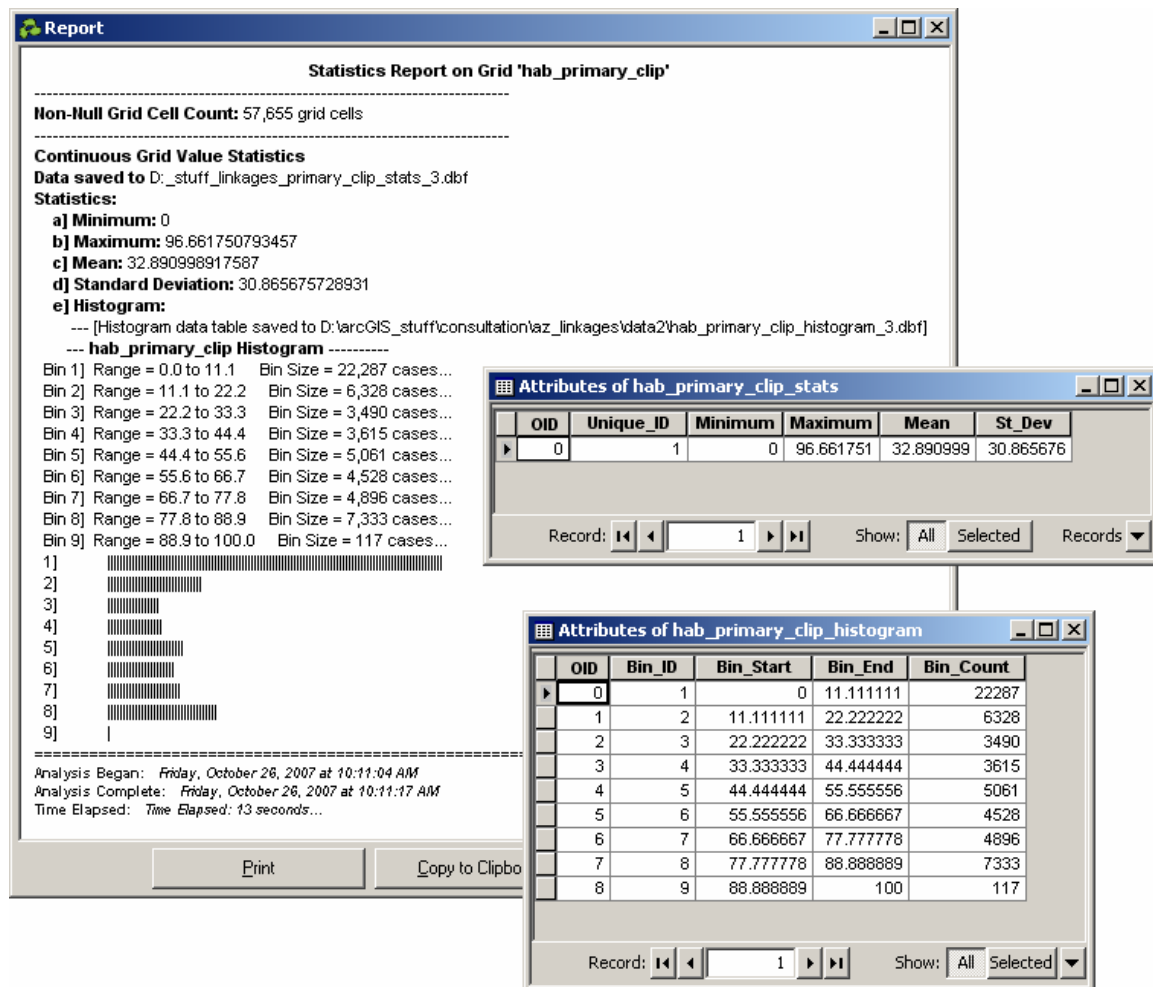
Record: 1 Show: All Selected Records (0 out of 1 Selected) Options

Attributes of VALUE_histogram_7					
OID	Bin_ID	Bin_Start	Bin_End	Bin_Count	
0	1	996	1104	84264	
1	2	1104	1212	35693	
2	3	1212	1320	53007	
3	4	1320	1428	117059	
4	5	1428	1536	91067	
5	6	1536	1644	82348	
6	7	1644	1752	59701	
7	8	1752	1860	43790	
8	9	1860	1968	12240	

Record: 1 Show: All Selected

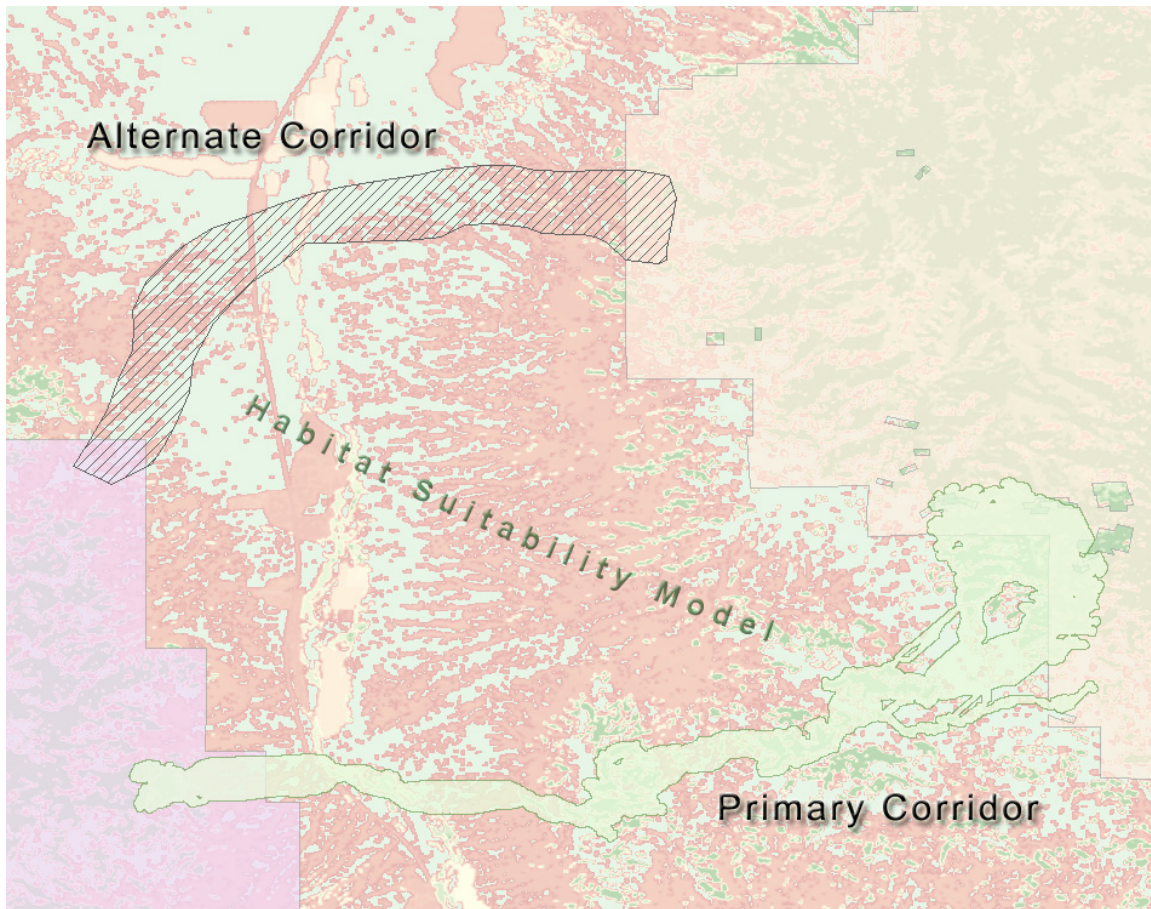
All statistics will be provided in a single text report:



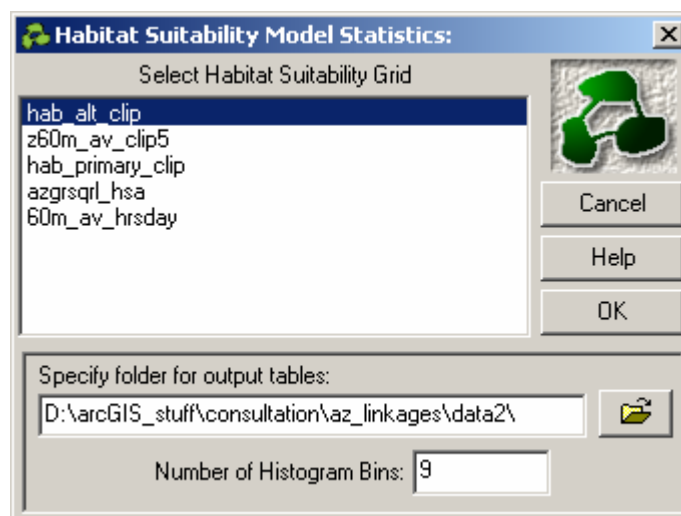


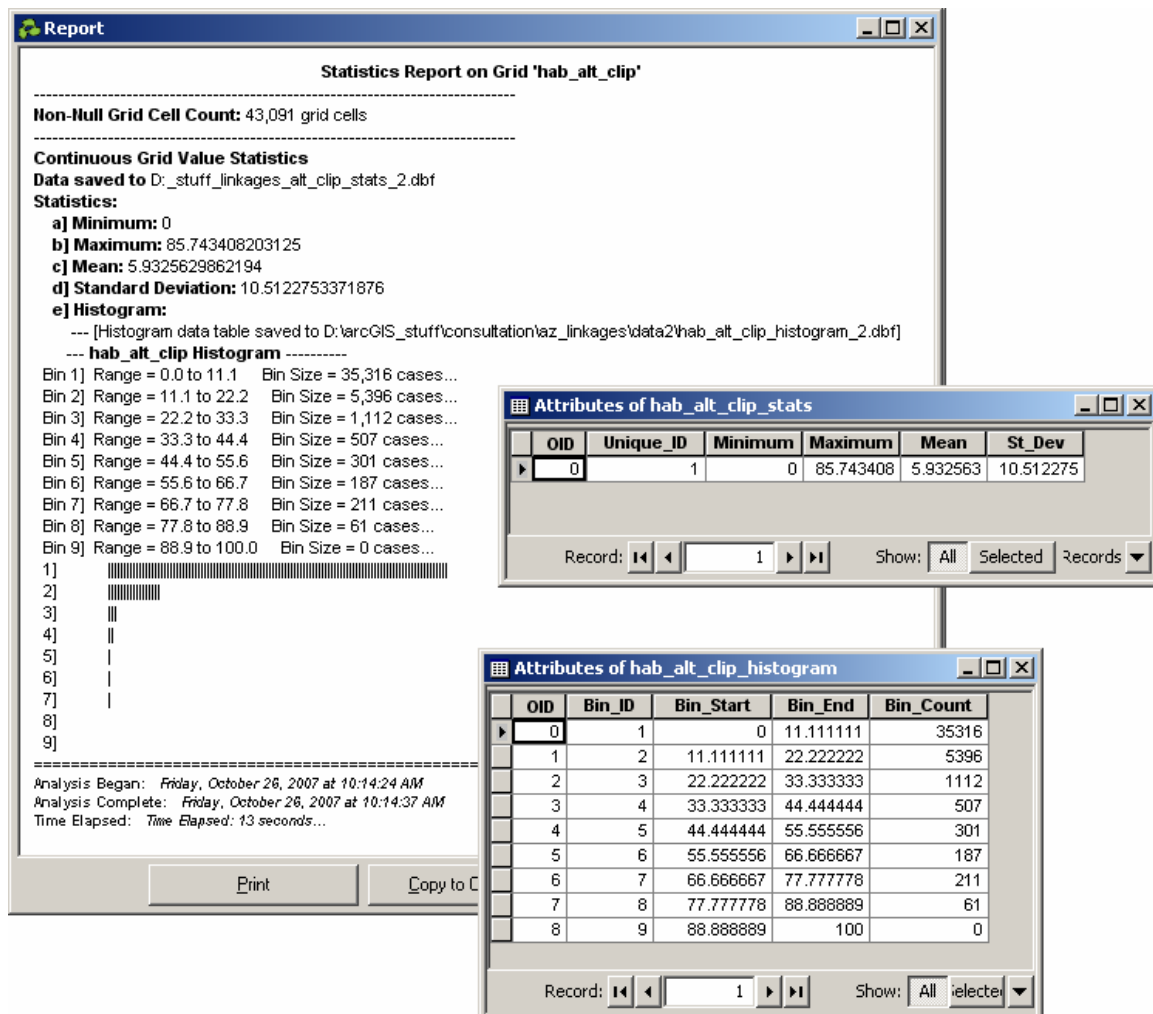
This function will be most useful when comparing the habitat suitability between different alternative corridor polygons. In general, the corridor polygon developed by the Corridor Designer tools will always have the best habitat values. It has to; the polygon is drawn around the habitat with the highest values.

The question for managers is then how much worse would an alternative corridor be? This tool provides a simple method to compare the distributions of habitat values between the primary and alternative corridor. For example, consider a situation where we wish to consider the alternative corridor illustrated below:

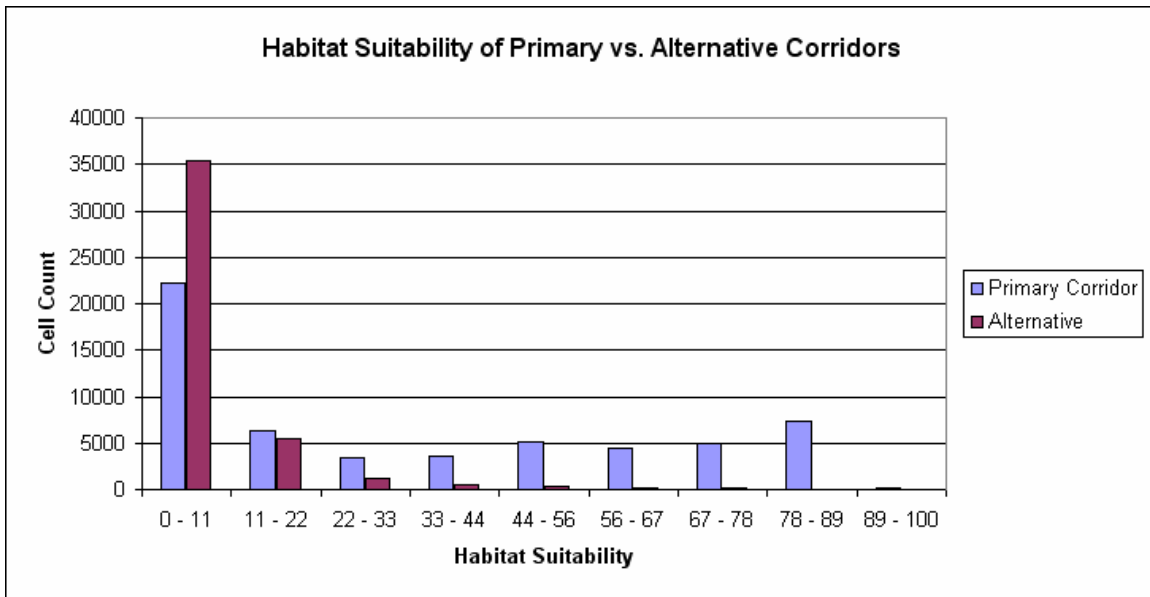


We first use the Clip Tool (see p. 40) to clip the habitat suitability model to the alternate corridor polygon illustrated above. We then use the habitat suitability statistics tool to generate statistics on this clipped grid. **NOTE:** It is a good idea to use the same number of histogram bins as we did when analyzing the primary corridor polygon, because we can then compare the histograms directly in Excel:



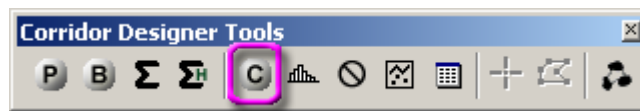


Note that the histogram always ranges between 0 and 100, regardless of the actual range of the data. Because of this fact, and because the histogram statistics are provided in a dBASE table, we can easily open both histogram tables in Excel, combine the data, and generate a paired bar chart that clearly illustrates the differences between the two corridors:




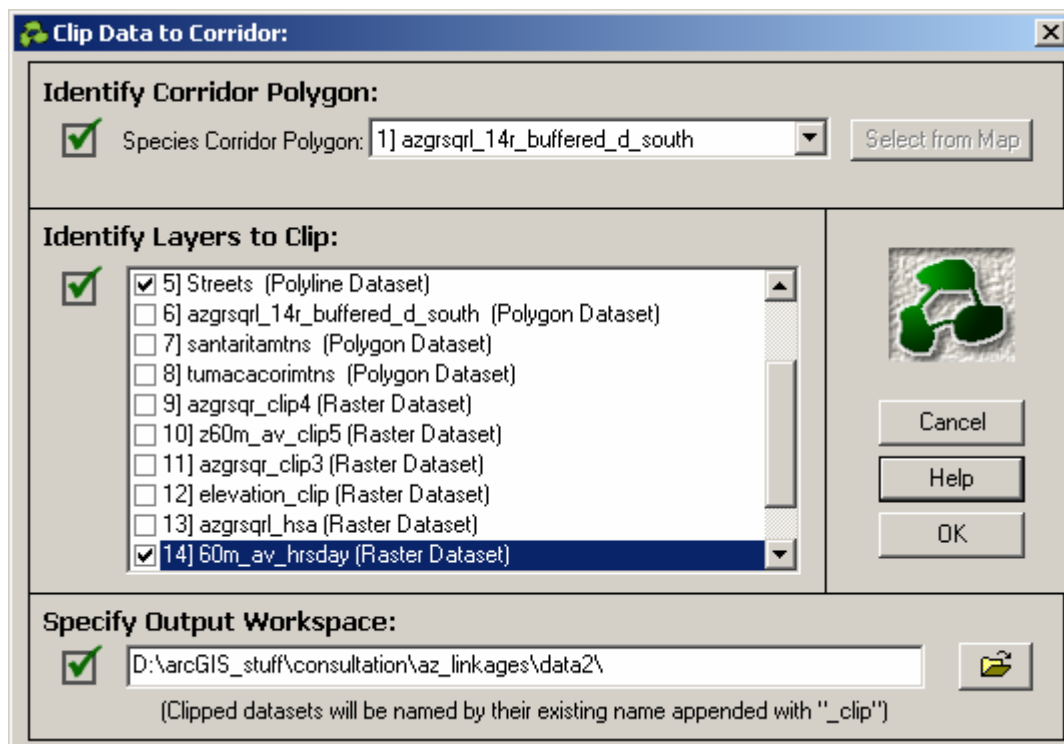
Ancillary Tools

Using the Clip Tool



The Corridor Designer Evaluation tools include functions to calculate a large variety of statistics on vector and raster data, including a specialized tool intended specifically for habitat suitability grids. However, these tools require that the vector or raster datasets be clipped to the polygon or area of interest before using them. The statistical tools themselves analyze the entire dataset and do not automatically clip the datasets as part of the analysis. Therefore we have provided a tool specifically designed to clip both raster and vector datasets to polygons.

Click the  button to open the “Clip Data to Corridor” dialog:



You must identify 3 parameters before the “OK” button will become enabled:

- 1) The polygon to clip to,
- 2) The layers to clip, and
- 3) The folder to save the new clipped datasets to.

As you identify each parameter, you will see green checkmarks appear in the respective boxes.

SELECTING THE CLIPPING POLYGON:

You have several options for selecting a corridor to clip to. You may:

- 1) Select a polygon layer from the map, IF that layer contains only a single polygon feature.

- 2) Select a single polygon from an existing polygon layer.
- 3) Select an existing polygon graphic.
- 4) Draw a new polygon graphic.

The drop-down list box at the top of the dialog lists all polygon layers currently in the active frame of your map document. If any of these contains only a single polygon, then you may simply select that layer and be done. However, the clipping tool is designed to work with a single polygon so you will receive an error message if you have multiple polygons in that polygon layer.

If you need to select a single polygon from a polygon layer, or if you need to select or draw a polygon graphic, then choose the option “Select by clicking on map”. This will enable the button “Select from Map”, from which you can access an interactive tool to directly select or draw your polygon. For more information on using the interactive polygon selection tool, please refer to “Selecting or Drawing Polygons” (see p. 47).

NOTE: This tool will not let you use several separate polygons for your clipping boundary. If you wish to use several polygons for this purpose, you will need to combine them into a single entity first. We have a separate stand-alone tool available which will do this function, available for free download at http://www.jennessent.com/arcgis/shapes_graphics.htm (see especially the discussion of the “Combine Features” tool).


IDENTIFYING THE LAYERS TO CLIP:

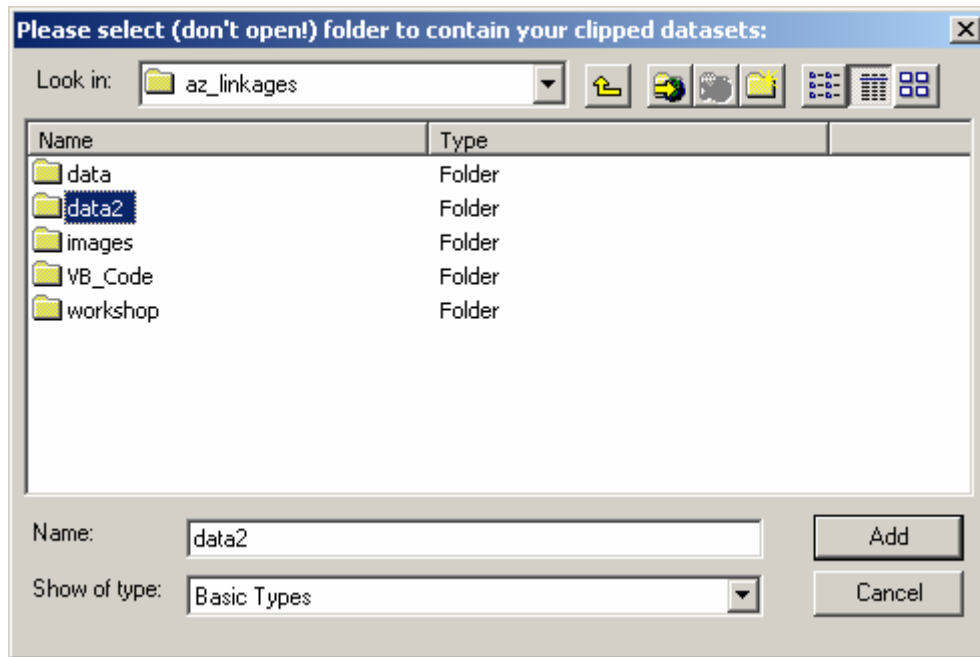
Select one or more layers to clip. Layers should be selected by clicking the check boxes to the left of each layer name.

This function will check to make sure the layers actually intersect the polygon before clipping them, and will also make sure the polygon is projected to the same coordinate system as the clip layer before the clip is executed. Therefore all clipped datasets will be in the same projection as the original dataset.

SPECIFY OUTPUT WORKSPACE:

Finally, make sure the clipped datasets are saved to the correct workspace. All clipped datasets will be named according to the layer name, appended with “_clip”. In the case of clipping grids, new grid dataset names will also conform to grid naming rules (i.e. ≤ 13 characters, no spaces and does not start with a number).

If you need to select a different folder to save clipped datasets to, then click the  button to open the standard ArcGIS file browser folder:

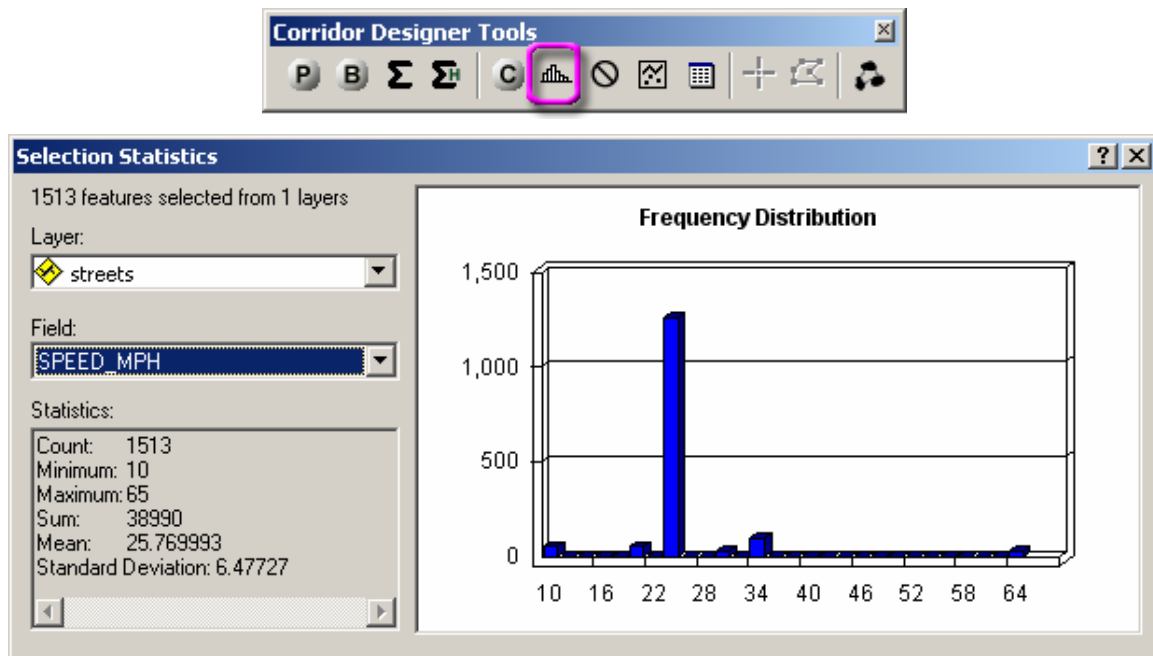


IMPORTANT: Do not open the folder you wish to select. Simply click on it once to select it, then click the “Add” button.

NOTE: This tool is an improvement over the standard ArcGIS clipping tools, in that it works equally well on raster and vector data and handles multipart polygons and polygons with holes or islands, or even multiply nested holes and islands. When clipping grids, it also maintains the full raster attribute table provided that there was one to start with. Finally, it will clip to non-standard shapes such as circles, ellipses and polygons containing curved segments.

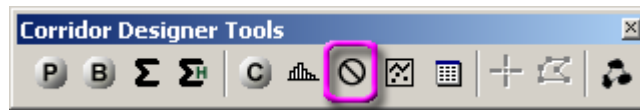
NOTE: If you used a graphic polygon to clip with, and if you wish to save your graphic into a new polygon shapefile, you can use the “Create Shapefile” tool to do so (see p. 45)

General ArcGIS Stats Tool:



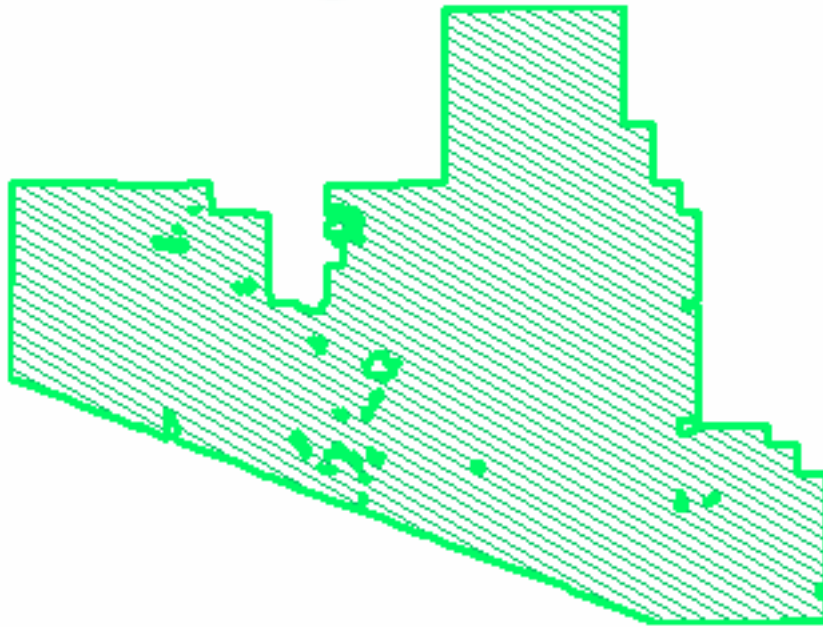
This tool is a standard ArcGIS function and provides a quick way to view general statistics and a nice histogram on selected features of a feature layer. It doesn't work if no features are selected and it only handles numeric data, but it is still useful for some purposes.

Delete Corridor Designer Graphics:



Several of the Corridor Designer Evaluation functions create graphics on the screen. For example, the Clip tool and the Polygon Selection tool both produce polygons with a particular fill pattern:

**Selected Polygon will turn green
with diagonal crosshatch:**



The bottleneck and patch distance tools will also produce distinctive graphics.

This button simply clears out any CorridorDesigner-produced graphics, leaving any other user-created graphics untouched.

Create New Shapefile:



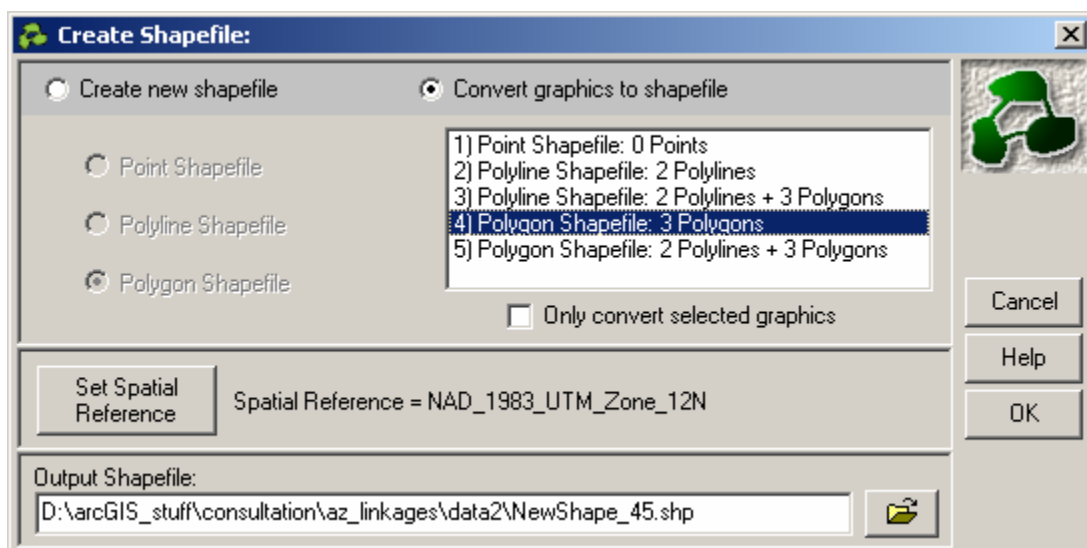
This function allows you to either create a new empty shapefile or convert graphic shapes to a shapefile. You may create either point, polyline or polygon shapefiles with this tool.

- Polygon shapefiles will include attribute fields for [Unique_ID] and [Area].
- Polyline shapefiles will include attribute fields for [Unique_ID] and [Length]
- Point shapefiles will include attribute fields for [Unique_ID], [X_Coord] and [Y_Coord].

NOTE: If you are converting graphics to a shapefile, and if those graphics have names (right-click the graphic and check the properties to see if it has a name), then these names will also be added to the attribute table in a [Name] field.

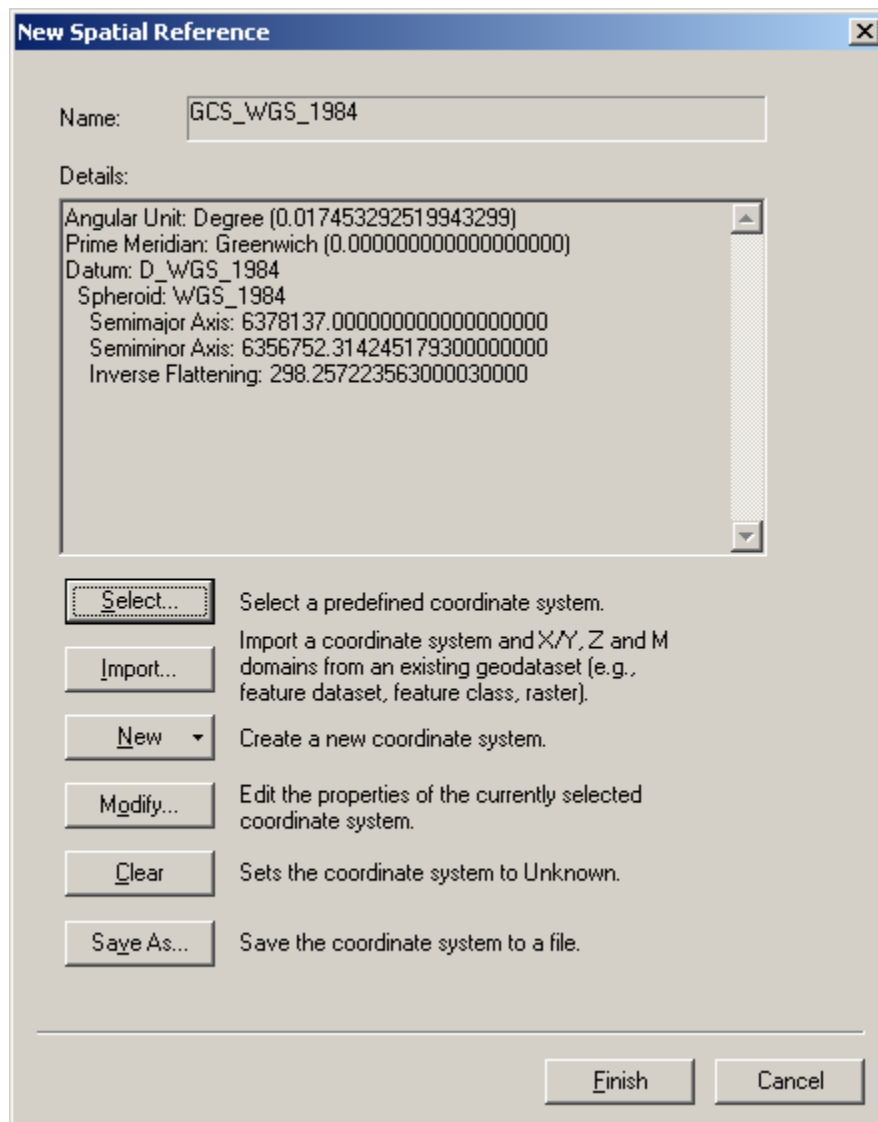
This function also allows you to convert polyline graphics to polygons, or polygon graphics to polylines, if you wish. When opened, the tool will examine your map to see how many point, polyline or polygon graphics are available, and whether any of them are selected. The tool will show you how many of each type are available to convert. If you attempt to create a shapefile from existing graphics when there are no graphics to convert, you will be notified of this and asked if you would like to try a different shape type.

NOTE: Certain linear or areal graphic shapes are not technically polylines or polygons. Polygons that are defined by a circle or elliptic arc are not really “polygons” in the sense that they are not composed of a series of straight-line segments. This is also true for linear features that are constructed of Bezier curves. It is not possible to add true curves such as circles, ellipses or Bezier curves to a polyline or polygon shapefile, so this function will convert these shapes to standard polygons or polylines before adding them to the shapefile. It does this by generating 200 evenly-spaced points along the length or perimeter of the curve, and connecting these points with straight segments. Therefore, if the original graphic feature is composed of true curves, then the actual shape in the shapefile will be slightly different than the original feature.



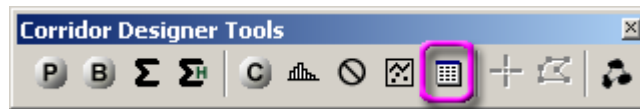
You must set a spatial reference for the new shapefile. If your map has a spatial reference set, then the map spatial reference will be the default value. You may easily change the spatial

reference by clicking the “Set Spatial Reference” button and identifying the spatial reference you want:



NOTE: This function adds the new shapefile to map, but does not delete existing graphics so you may not see the new shapefile when the shapes lie behind the graphics.

Open Tables:

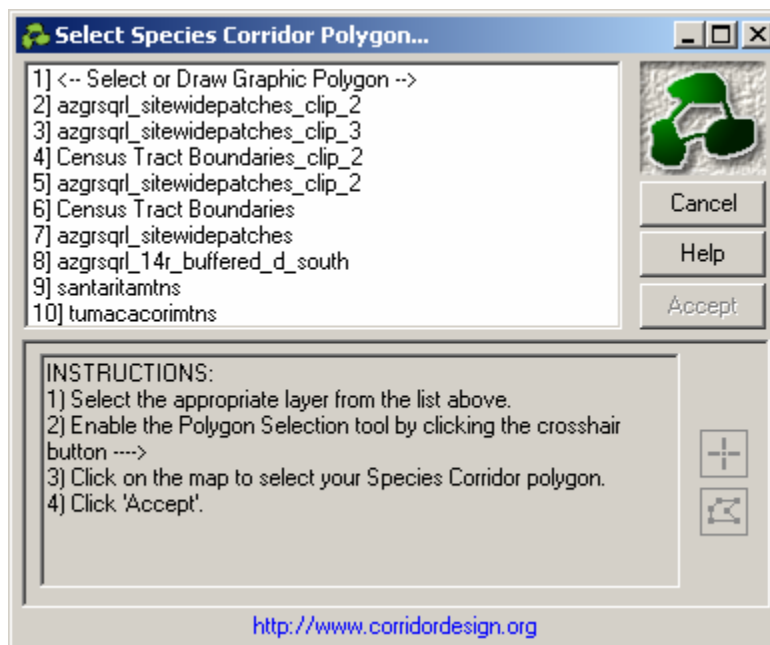


This button will automatically open tables for any selected layers that have tables. It only works on layers that are selected.

You can also open tables by right-clicking on each layer individually and selecting “Open Table” from the menu, but this button makes it a bit easier and allows you to open multiple tables at once.

Selecting or Drawing Polygons:

Three functions allow the user to do something based on a selected polygon graphic or polygon feature, and therefore all three tools needed a way to select or draw that polygon. The Patch Analysis, Bottleneck Analysis and Clip tools all provide access to the following dialog:




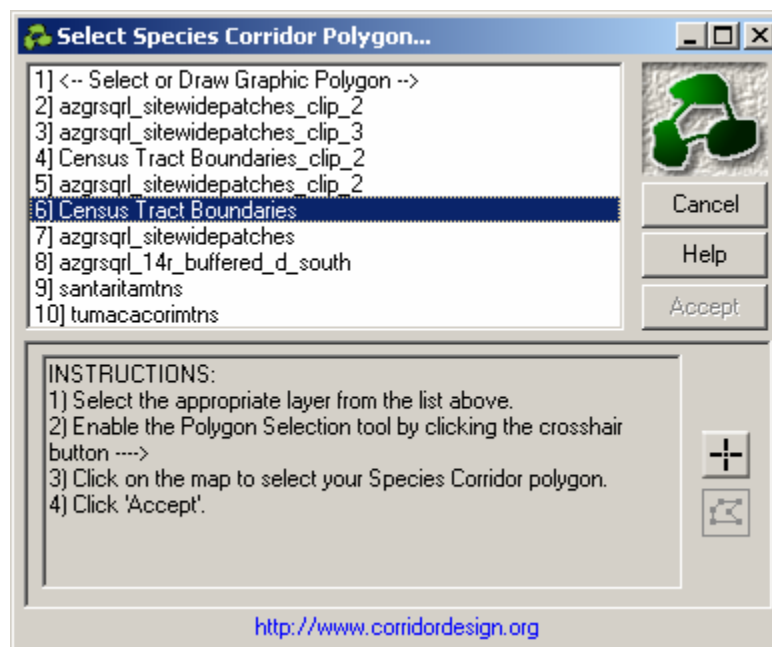
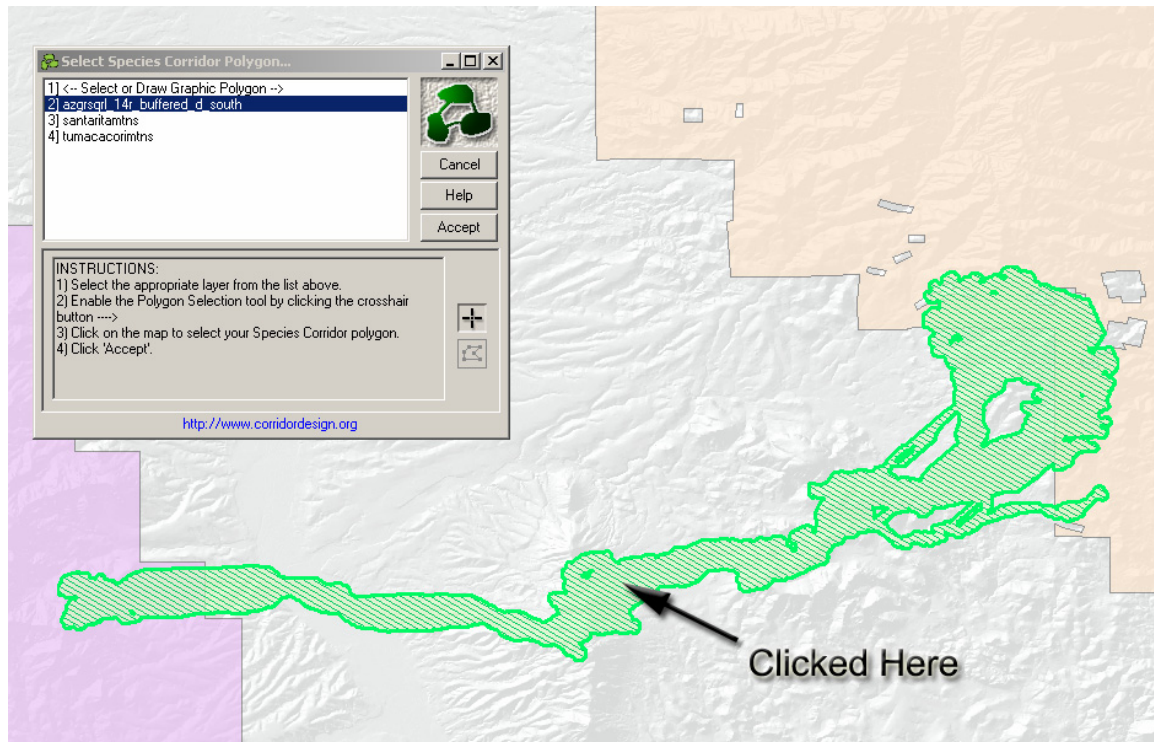
NOTE: The title of this dialog will change depending on whether the user is searching for a corridor polygon or a wildland block.



This dialog allows you to:

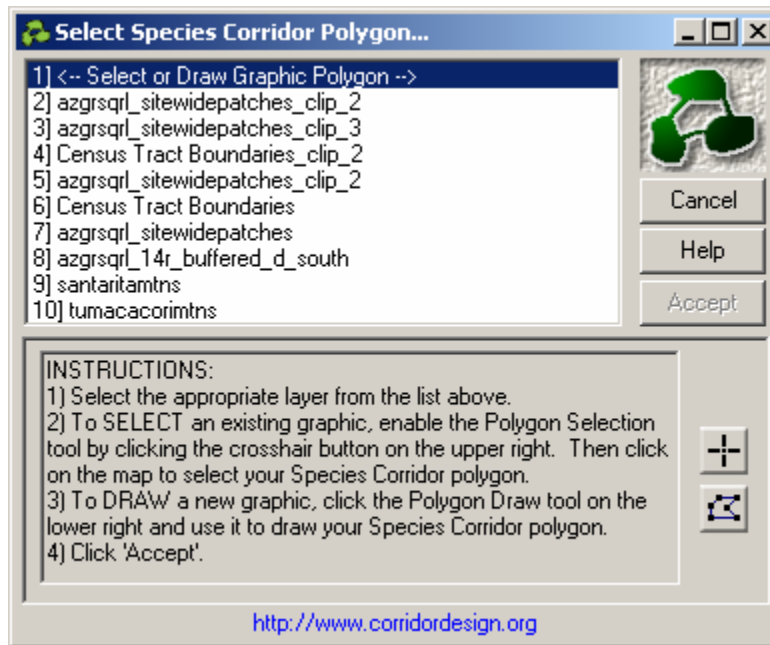
1. Select a single polygon from a polygon feature layer, or
2. Select a single graphic polygon, or
3. Manually draw a graphic polygon on the screen.

If you select a polygon theme from the list at the top of the dialog, then the “Select Polygon”

button  will become enabled and the corresponding tool will become enabled on the Corridor Designer toolbar. Click this button and then select a polygon from the theme. After you click on a polygon, it will turn a green color with a crosshatch fill:



You may also select or draw graphic polygons, rather than selecting polygons from a polygon layer. If you select the first item in the list, “Draw or select graphic polygon”, then both the “Select Polygon”  and “Draw Polygon”  buttons will become enabled. Use the appropriate button to either select or draw a graphic polygon. Note that the instructions change if you select this option:



In all cases, selected polygons will be shaded green with a crosshatch pattern. If any of these graphics remain in your view after you no longer need them, you can quickly clear them out using the “Delete Corridor Designer Graphics” tool (p. 44). You may also convert any graphics to a shapefile using the “Create Shapefile” tool (p. 45).

About Corridor Designer and Manual



The “About” dialog includes links to the Corridor Designer website, as well as email links to all the authors. The full Evaluation Tools manual (in PDF format) is available by clicking the “Open Manual” button.