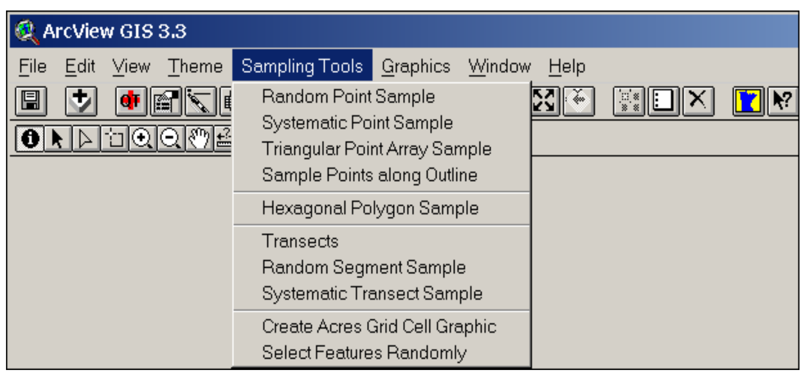
DNR Sampling Tool *(V2.8 November 09, 2005)*

The Sampling Tool was designed to assist biologists in using ArcView to generate spatially explicit random or systematic sampling schemes to support resource monitoring, mapping, and research needs. The tool works either with polygons in a theme or with graphics that have been added to a View. Samples can be entirely within a single polygon or shape, or distributed among several disjoint polygons or shapes. A number of user defined constraints and settings are offered as input options.

Installing and Activating the Extension
The DNR Sampling Tool is an extension that accessible through ArcView 3.2, 3.2a and 3.3. The Tool will not work in ArcView 8.1 or ArcGIS 8.1 suite of ESRI products. To install the DNR Sampling Tool copy the **dnrsample.avx** file into the \esri\av_gis30\arcview\ext32 directory. To use the tool in ArcView, go to the **Files**:*Extensions* menu option and check the box next to the DNR Sample option. When you open a View within ArcView, the Sampling Tools Menu should appear on the Menu Bar.

The Sampling Tool Menu
The Sampling Tool Menu offers eight options depending on the type of sampling scheme desired:

Random Point Sample
Systematic Point Sample
Triangular Point Array
Hexagonal Polygon Sample
Transects
Random Segment Sample
Systematic Segment Sample
Create Acres Grid Cell Graphic
Select Features Randomly



Selecting any of the eight Sampling Tool Menu options will activate sampling specific dialog boxes that allow the user to control the sample generation process.

How the Sampling Tool works
The placement of points or transects for any sampling operation is accomplished by first deriving a starting XY coordinate based on the minimum X and minimum Y of the polygon(s) or graphic(s) selected in a View. From the original XY, a random point is generated and its location is tested to determine if it falls outside the boundary formed by

the polygon or graphic, if it does, it is thrown out and another random point is selected. In the case of the Random Point Sample, if the point falls inside the polygon, then the user defined constraints for sample area and minimum distance from another point is tested. Depending on the outcome, the point is added to the set of sample points and the process is repeated until the user defined number of points is reached.

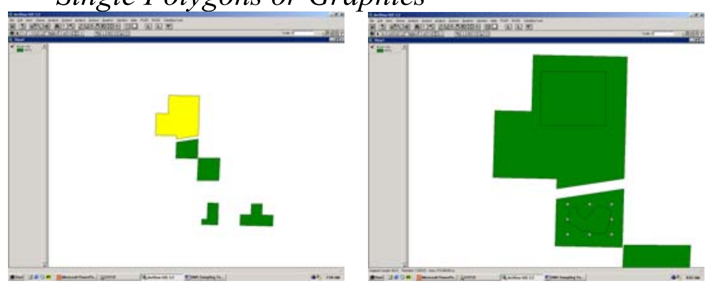
The Transect option takes the process one step further, after the random point is determined, a random bearing is generated and a line conforming to user defined transect length and sample width is created and tested for intersection with previously placed transects, and with the boundary of the polygon or graphic. If this test fails the user-defined constraints, the line is discarded and a new transect starting point is generated and the process is repeated. Transects are placed until the user defined number of transects or percent sample is met.

A Common Need For All The Options

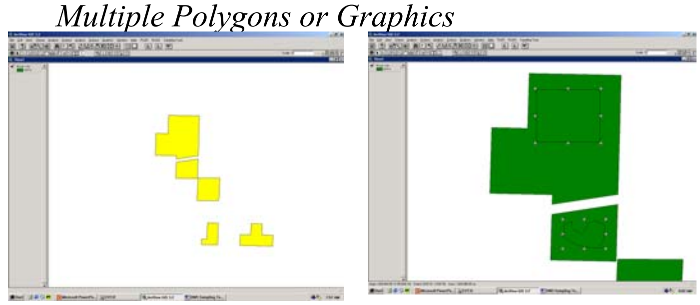
Polygons vs. Graphics

As stated above, the Sampling Tool places points and transects inside the bounds of polygons or graphics, consequently, either a polygon theme or graphics must be present in the view and one or more features must be selected. The ability to select multiple polygons or graphics is important because it allows points or transects to be distributed among disjoint tracts that may need to be sampled as a single unit. The ability to use graphics to constrain the distribution of sample locations, allows the user to sample a portion of a larger unit without having to either subdivide the large unit or create a new theme first.

Single Polygons or Graphics



Multiple Polygons or Graphics



User Input and Map Units

The units that are used for all user inputs are controlled by the properties of the View. The View Properties can be controlled by selecting the **View**:*Properties* from the Menu bar. The Map Units must be set appropriately. If the data being worked with is projected in UTM, it is likely that the Map Units is meters.

This tool only works on data that has been projected; such as UTM, State Plane or other locally define projection. Your data must not be in Geographic or Lat/Long coordinates. In addition, it does not work on geographic data that is displayed in a "Projected View" document. To check to see if you are using a projected View use the VIEW | Properties option to see if a Projection is listed above the **Projection…** button. If you see one, then you have a projected View.

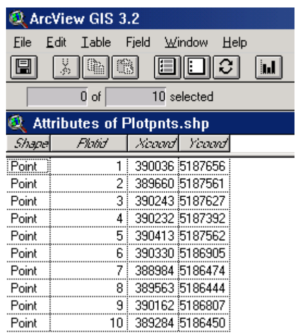
Tables of Coordinates

In addition to the spatially explicit lines and points created by the Sampling Tools, tables of coordinates that represent the point locations and starting and ending points of transects and the locations of point samples are stored in databases that specify the point or line id and the respective XY values. These databases can be exported and used with GPS equipment, and in the case of points to navigate to the center of the sample area. In the case of transects, GPS can be used to navigate to the starting point and then along the transect to the ending point. Row and Column number for systematic points are provided along with the XY values for the points with the origin in the upper left.

Databases can be accessed by making the sample theme of interest active and selecting the Open Table bu .

Examples of each of the databases are provided below.

Random Point Sample:


ArcView GIS 3.2

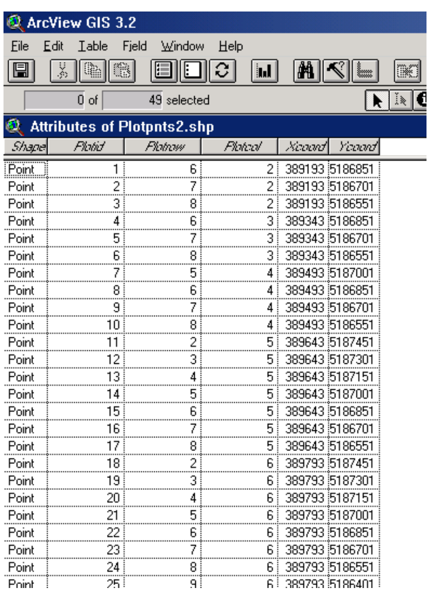
File Edit Table Field Window Help

0 of 10 selected

Attributes of Plotpnts.shp

Shape	Plotid	Xcoord	Ycoord
Point	1	390036	5187656
Point	2	389660	5187561
Point	3	390243	5187627
Point	4	390232	5187392
Point	5	390413	5187562
Point	6	390330	5186905
Point	7	388984	5186474
Point	8	389563	5186444
Point	9	390162	5186807
Point	10	389284	5186450

Systematic Point Sample:


ArcView GIS 3.2

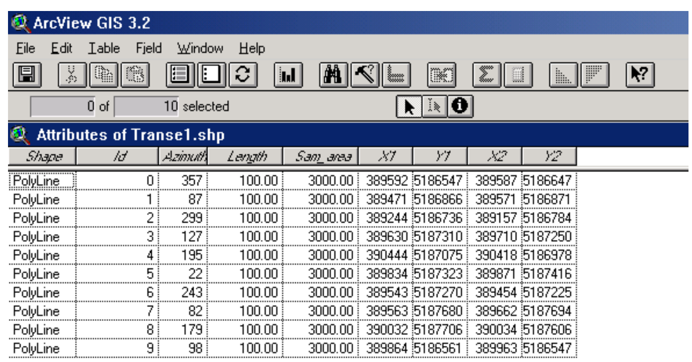
File Edit Table Field Window Help

0 of 49 selected

Attributes of Plotpnts2.shp

Shape	Plotid	Plotrow	Plotcol	Xcoord	Ycoord
Point	1	6	2	389193	5186851
Point	2	7	2	389193	5186701
Point	3	8	2	389193	5186551
Point	4	6	3	389343	5186851
Point	5	7	3	389343	5186701
Point	6	8	3	389343	5186551
Point	7	5	4	389493	5187001
Point	8	6	4	389493	5186851
Point	9	7	4	389493	5186701
Point	10	8	4	389493	5186551
Point	11	2	5	389643	5187451
Point	12	3	5	389643	5187301
Point	13	4	5	389643	5187151
Point	14	5	5	389643	5187001
Point	15	6	5	389643	5186851
Point	16	7	5	389643	5186701
Point	17	8	5	389643	5186551
Point	18	2	6	389793	5187451
Point	19	3	6	389793	5187301
Point	20	4	6	389793	5187151
Point	21	5	6	389793	5187001
Point	22	6	6	389793	5186851
Point	23	7	6	389793	5186701
Point	24	8	6	389793	5186551
Point	25	9	6	389793	5186401

Transect Sample:


ArcView GIS 3.2

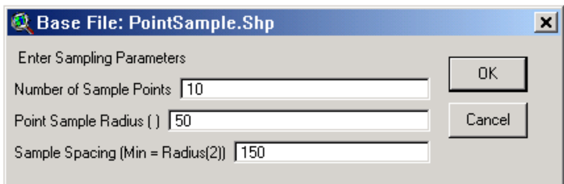
File Edit Table Field Window Help

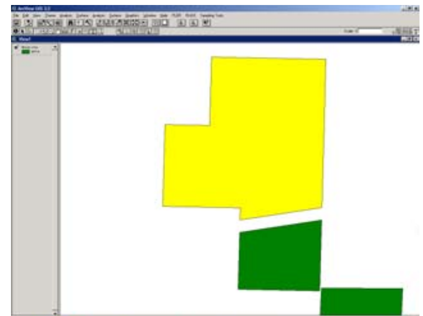
0 of 10 selected

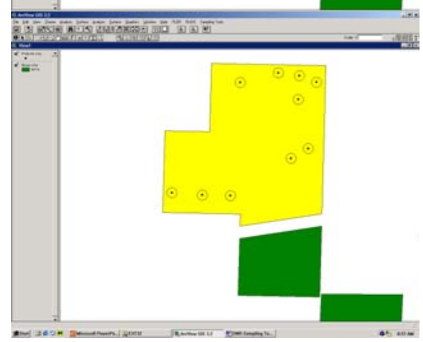
Attributes of Transe1.shp

Shape	Id	Azimuth	Length	Sam_area	X1	Y1	X2	Y2
PolyLine	0	357	100.00	3000.00	389592	5186547	389587	5186647
PolyLine	1	87	100.00	3000.00	389471	5186866	389571	5186871
PolyLine	2	299	100.00	3000.00	389244	5186736	389157	5186784
PolyLine	3	127	100.00	3000.00	389630	5187310	389710	5187250
PolyLine	4	195	100.00	3000.00	390444	5187075	390418	5186978
PolyLine	5	22	100.00	3000.00	389834	5187323	389871	5187416
PolyLine	6	243	100.00	3000.00	389543	5187270	389454	5187225
PolyLine	7	82	100.00	3000.00	389563	5187680	389662	5187694
PolyLine	8	179	100.00	3000.00	390032	5187706	390034	5187606
PolyLine	9	98	100.00	3000.00	389864	5186561	389963	5186547

Using The Random Point Sample Option
First open a View and select a polygon, polyline or graphic element that has been added to the View. If a theme polygon/polyline will be used to place the points, make sure the respective theme is active. Choose the **Sample Tool**:*Random* Point Sample option. Enter the user inputs, in this case:

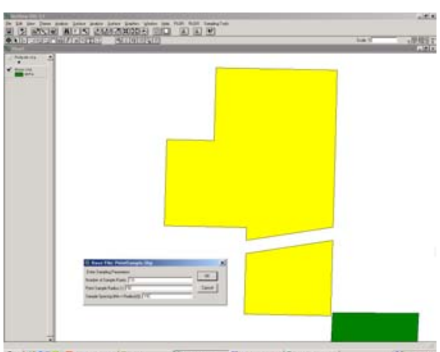


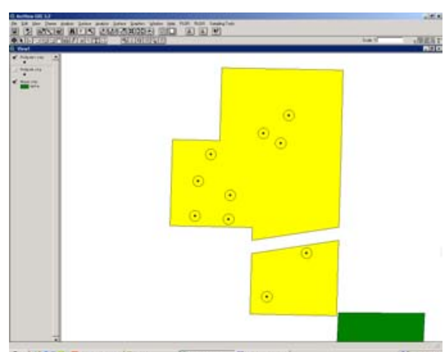




Click on OK, provide a output file name, and the new theme with 10 random points, along with a graphic representation of the sample area, is added to the View. A DOQ or other image can be displayed in the View to produce a field map for printing purposes.

Ten points distributed between 2 selected polygons might look like this.



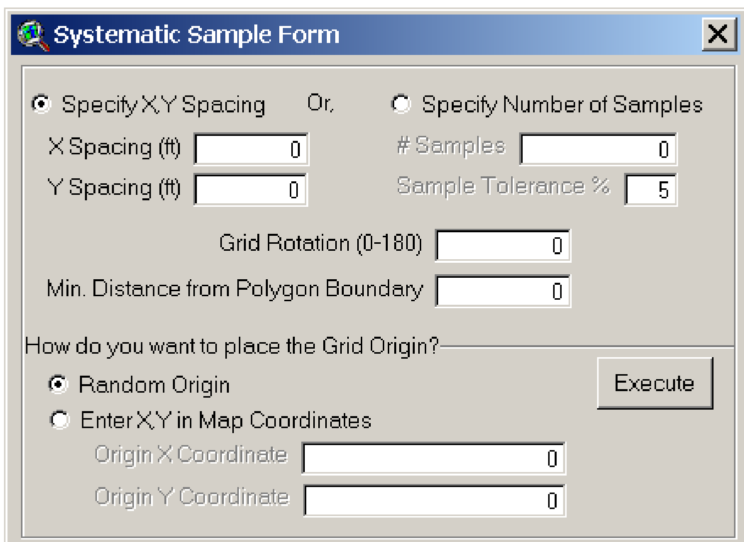


As of version 2.2 this option now works on polyline themes or graphics.

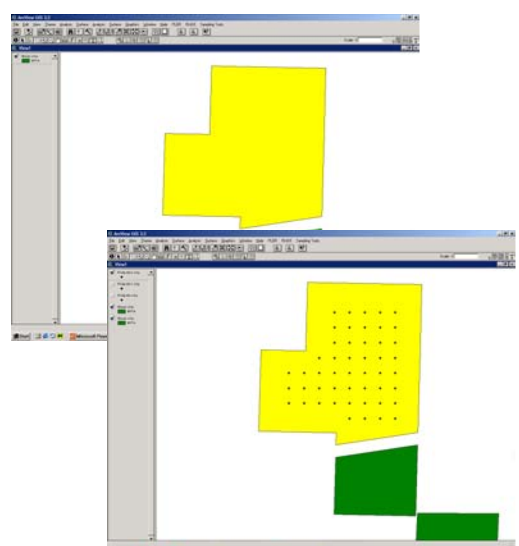
Using the Systematic Point Sample Option
The Systematic Point Sample option works very much like the Random Point Sample except it creates a systematic grid of points within the polygon(s) or graphic(s) selected. The user can either specify the X and Y spacing of the point grid or input the number of points desired in the sample and let the program figure out the spacing. The user can also specify a grid angle and how close the points can be to the polygon border.

This routine creates a grid of point features. The origin of the grid can be computed at random or you can specify a starting point for the grid based on a map coordinate.

Selection of the **Sampling Tool**:*Systematic* Point Sample option will initiate a dialog box where you can enter the various options you wish to use, the sample spacing and the starting grid location.


Systematic Sample Form
Specify X,Y Spacing Or, Specify Number of Samples
X Spacing (ft) 0
Y Spacing (ft) 0
Samples 0
Sample Tolerance % 5
Grid Rotation (0-180) 0
Min. Distance from Polygon Boundary 0
How do you want to place the Grid Origin?
Random Origin
Enter X,Y in Map Coordinates
Origin X Coordinate 0
Origin Y Coordinate 0
Execute

When you specify that you want to enter the number of samples, you need to enter a percent tolerance you are willing to deal with above and below your target number of samples. This is because the calculations might not be able to create the exact number of samples you desire.

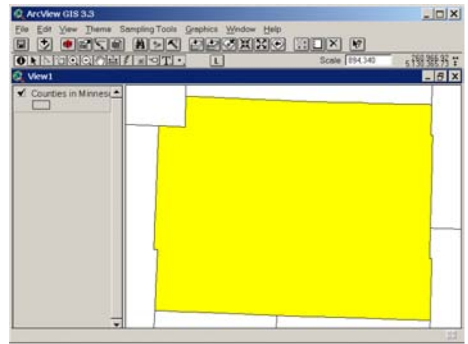


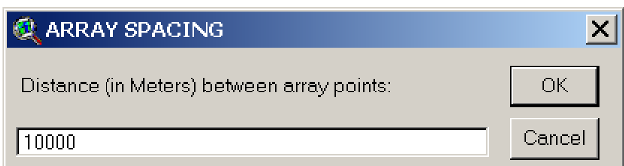
Click on OK, provide an output file name, and the new theme with the network of systematic points will be added to the View. Again, a DOQ or other image can be displayed in the View to produce a field map for printing purposes.

Although not shown here, as in the Random Point Sample example, systematic points can be generated for multiple polygon or graphic selections.

Using the Triangular Point Sample Option
The Triangular Point Array Sample works like the Systematic Point Sampling option except it offsets every other point by ½ the sampling distance. This results in a point arrangement that resembles triangles. The user supplies the sampling distance between points.

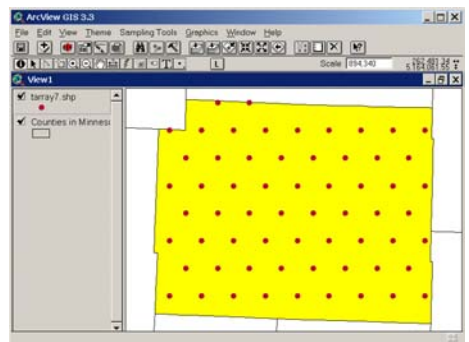
Selection of the **Sampling Tools**: *Triangular Point* Sample option will initiate a dialog box, where you enter the distance you want between the points in the output file.





Click on OK, provide an output file name, and the new theme with the triangular network of points will be added to the View.

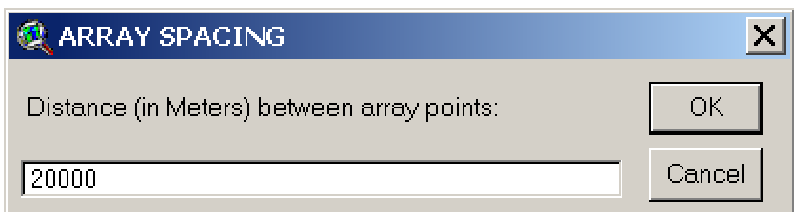
Unlike the other point sampling routines this option treats all selected polygons or graphics as a single shape.



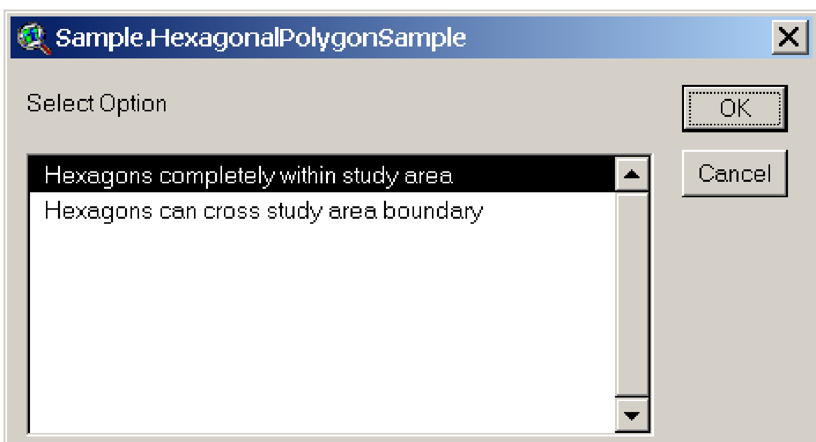
Using the Hexagonal Polygon Sample

This option allows the user to create hexagon shaped polygon sampling areas based on a set of points that are placed based on a set of triangular grid of points like those created with the Triangular Point Sample option. The user enters the sample point distance and the program will create the hexagons. This type of sampling is used for a wide variety of programs including EMAP and GAP.

Selection of the **Sampling Tools**: *Hexagonal Polygon Sample* will initiate a dialog box where you enter the distance you want between the points in the output file. These points will be the centers of the resulting output hexagons.

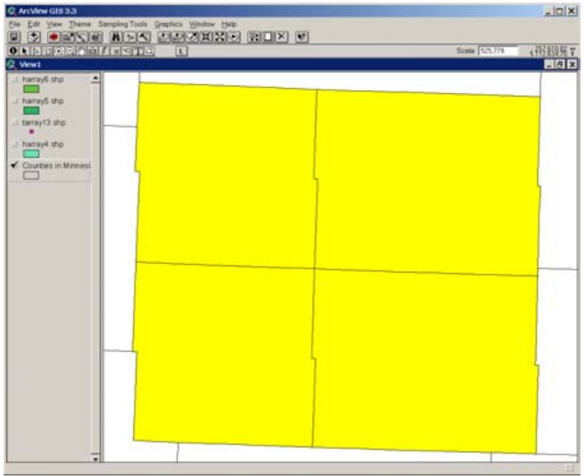


You also have the option of allowing hexagon's to cross over the study area boundary or only save those that are completely within the study area. You will be presented with the following dialog:

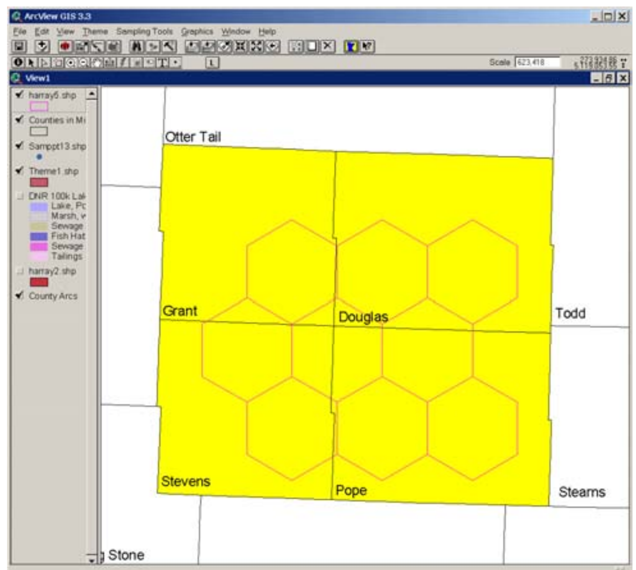


The first option "Hexagons completely within study area will verify that each hexagon is completely within the study area. If you select the second option, "Hexagons can cross study area boundary", The hexagons will cross the study area boundary.

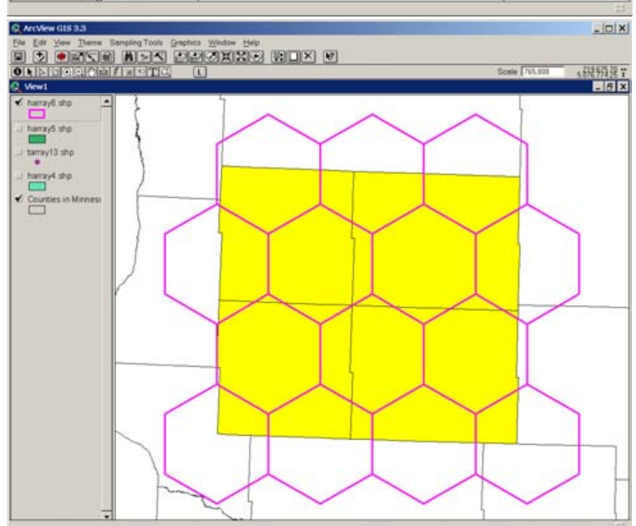
As you can see the graphic to the left, hexagons are built for the area of the selected set of polygons. In this case, four counties have been selected.



Option 1 – Hexagons completely within the study area.

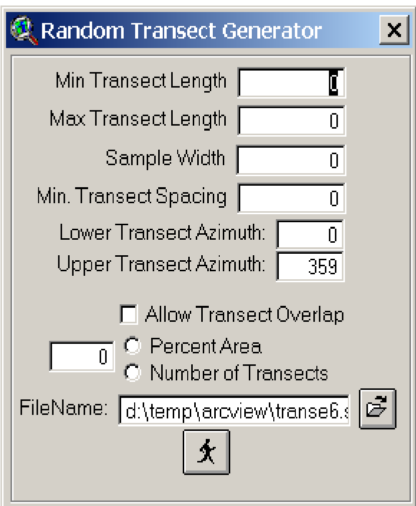


Option 2 – Hexagons can cross study area boundary.



Using the Transect Option

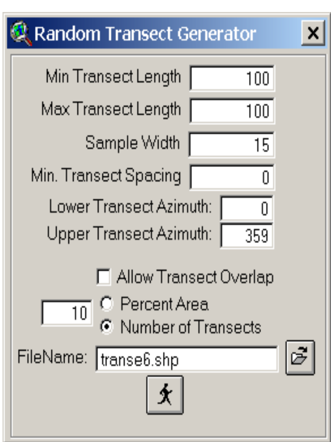
Placing random transects is a more complex operation and the opportunity for user inputs has been expanded to try and cover most of the user needs. All transects generated from this option are random both in the placement of the starting point and direction of the transect although transects can be constrained to be random within a specified direction by setting lower and upper azimuth limits for transects. Selecting the **Sampling Tools:***Transect* option will open the following dialog box for user inputs:



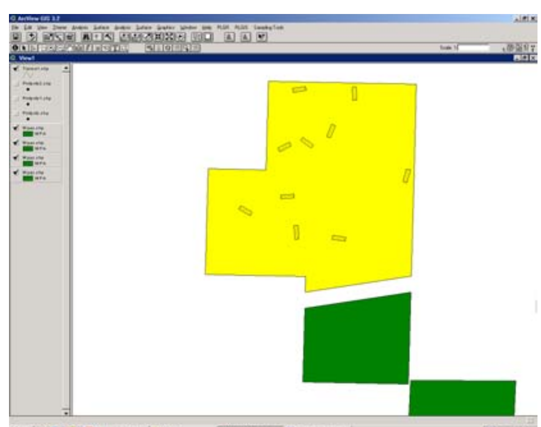
Where:
Min. and Max. Transect Length: If you want the transects to be the same length enter the same value for both entries.
Sample Width: width on 1 side of the transect
Allow Transect Overlap can be checked on to allow transects to overlap with one another
Min. Transect Spacing: the minimum distance between transects; this defaults to 2(sample width)
Minimum Transect Azimuth: Minimum transect azimuth
Maximum Transect Azimuth: Maximum transect azimuth
Percent Area or Number of Transects: select one or the other and enter the desired value
FileName: enter the output file name

Because the tool needs to “fit” transects in based on user inputs and constraints, this operation can take a while to complete, especially if the “percent area” option is chosen and the value is relatively high (> 10%)

As an example, the Transect Option inputs are as follows:



Click on the run button and the results are:



Like the Random Point Sample tool, transects that result from the process are automatically added to the view along with graphical representations of the bounds of the sample area. Images such as DOQs can be added for creating field maps.

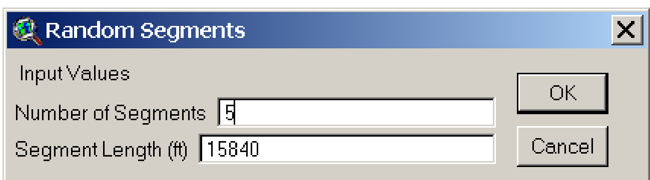
Although not shown here, as in the Random Point Sample example, transects can be generated for multiple polygon or graphic selections.

Using the Random Segment Sample option

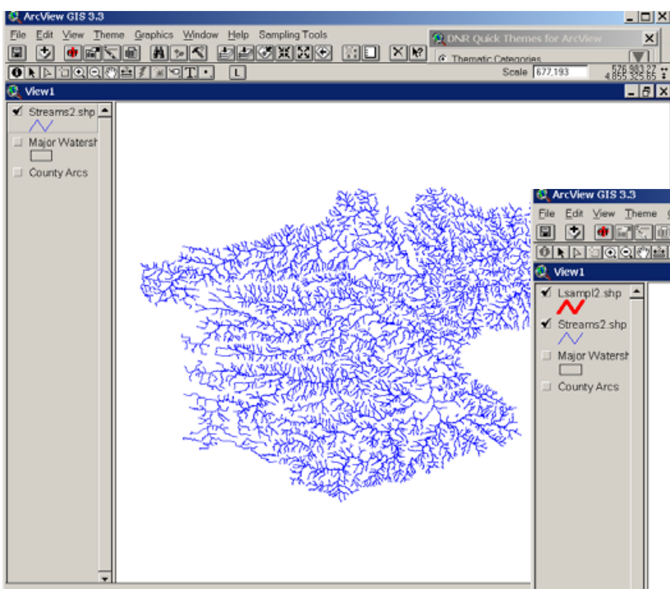
The Select Random Segments option is used to create a random selection set of arcs in a dataset of a specified length. One example is to select a random set of stream segments that are one mile long from an ArcView Shapefile of streams in a watershed.

To use this option you must have a PolyLine Shapefile in your View document. Initiate the command using the **Sampling Tools:***Random Segment Sample* option. Once you initiate the command you input values for the number of segments you wish to create and the length you want them to be.

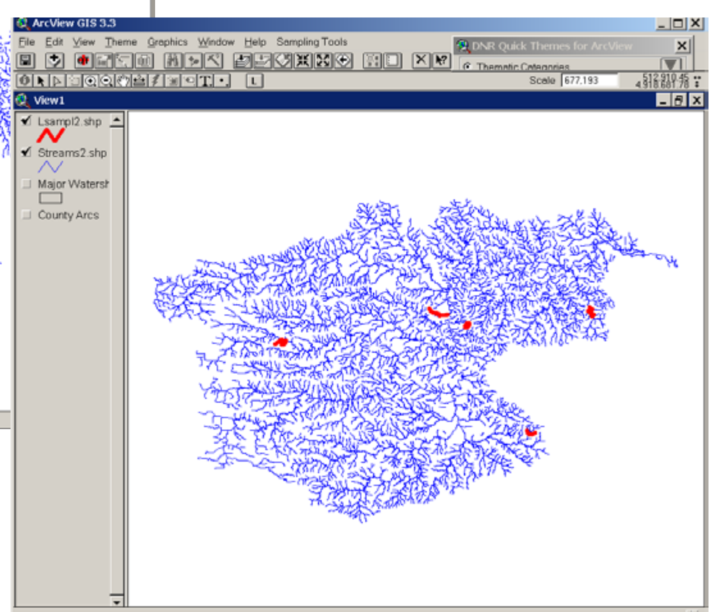
The following example creates five segments that are 5280 feet in length.



Before Selection

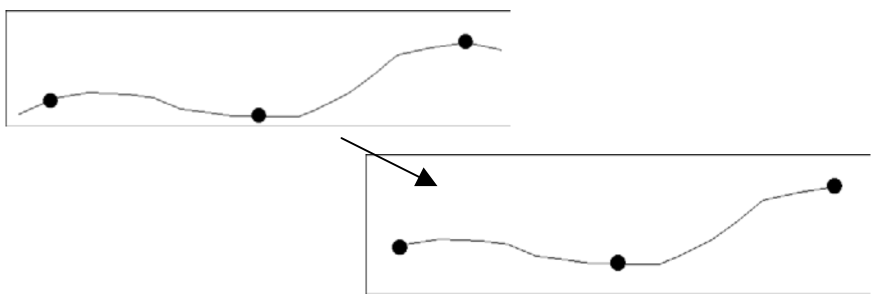


After Selection



Description of the Random Segment Process
The selection of random segments is done using the record number of the arcs in the input shapefile. A random number is selected between 0 - (n-1), where n is the number of records in the table. The polyline shape for this record is retrieved and at this point three scenarios arise:

Shape length = Desired segment length - Shape is written to the output shapefile,
Shape Length > Desired segment Length - The center of the line is determined and the line is clipped at ½ the desired segment distance on each side of the center.

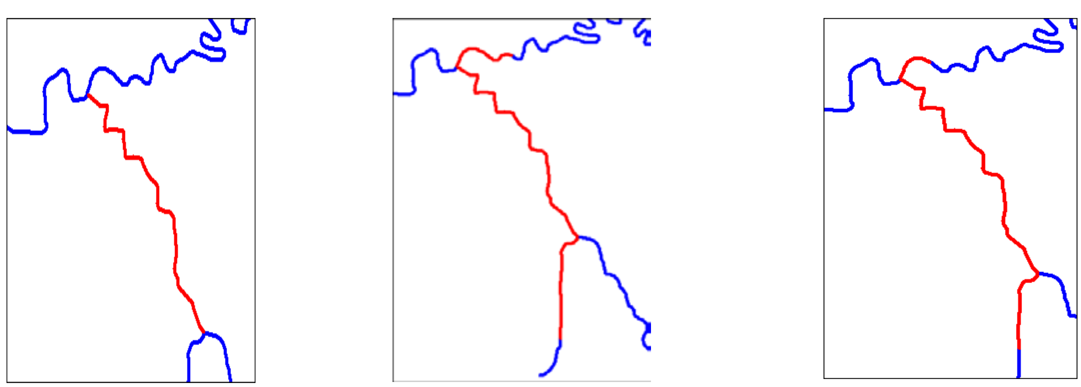


ShapeLength < Desired Length – When the selected line segment is shorter than the desired segment length the program attempts to create a longer line by selecting the segments that are adjacent to the currently selected arc. These arcs are then merged and if the resulting length is greater than the desired length the line clipped at ½ the desired segment length on either side of the center of the arc.

If an arc is connected to more than two arcs, two of those arcs are randomly selected to build the segment. In the example below, the center segment was selected at random and is shorter than the desired segment length.

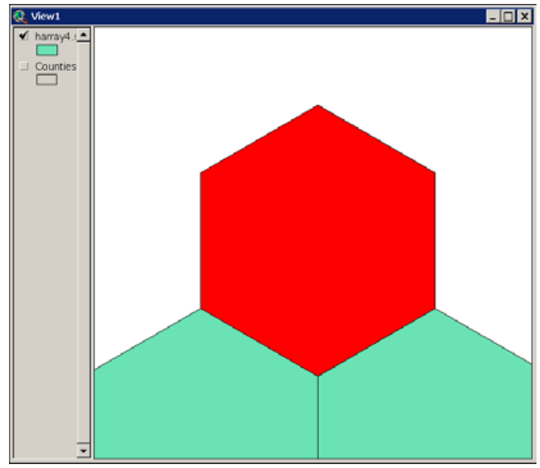
This line segment has four segments connected to it. At this point, two segments will be randomly selected from the four connecting arcs. This continues until a segment that is longer than the desired segment is reached. At this point the line clipped at ½ the desired segment length on either side of the center of the arc.

Step 1 Initial Select   Step 2 – Select Adjacent   Step 3 – Clip Ends



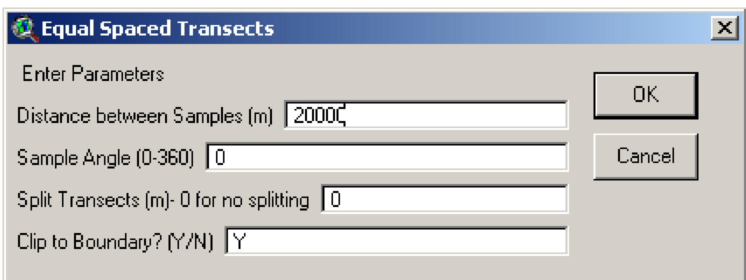
There are instances where getting enough lines of a certain length can be problematic. There is a safety counter in this program to help in these situations. The data you have will determine what you can do and this program relies on properly constructed data with good linear topology.

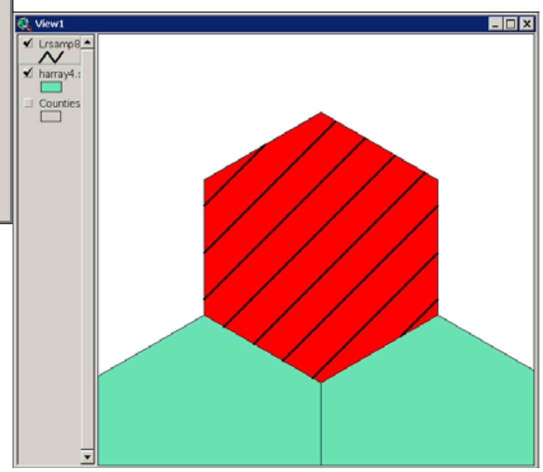
Using the Systematic Transect Sample



The Systematic Transect Sample option works very much like the Systematic Point Sample except it creates a set of transects that are systematically placed a distance apart from one another.

Selection of the **Sampling Tool**: *Systematic Transect Sample* option will initiate a dialog box, enter the user inputs, in this case the user enters the transect spacing, the angle of the transects (0-36), whether or not they want to split the transects into equal seqments and how long these segments should be and whether or not you want the transects clipped to the extent of the boundary of the shape you have selected





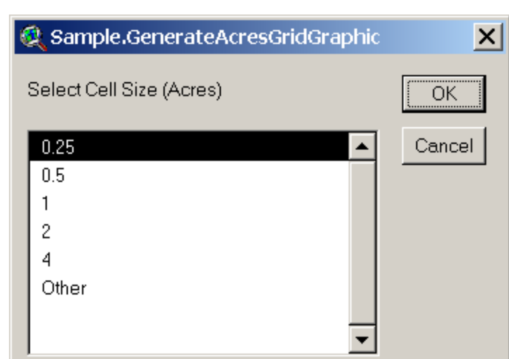
These inputs will result in an output file that contains regularly spaced transects that may or may not be clipped to the border of the selected polygon or graphic shape.

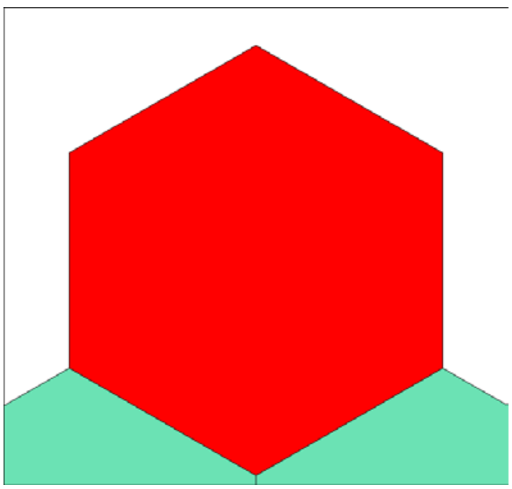
The output file has one field called ID which represents the order that the transects were created, left to right. They will be oriented to the direction you specified.

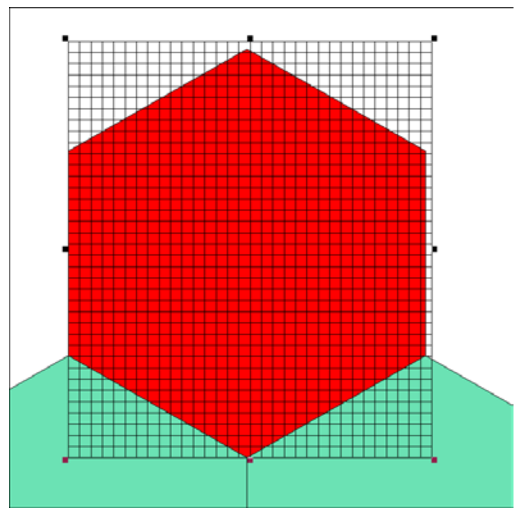
You can also choose to have each of the transects split on an equal interval. In this case, each individual transect will be split into segments based on the value entered. Use zero (0) for no splitting.

Using the Create Acres Grid Cell Graphic Option

This option creates graphic squares of a user supplied size for the selected graphic or polygon. Once selected, the user selects the desired size of the cells in acres and the graphic is created. There are a number of predetermined cell sizes but the user can select “Other” and create grid cells of user-supplied size.







These grid cells graphics are not polygons, they are constructed as a set of lines that are grouped together to create the lattice.

Using the Select Features Randomly Option

This option creates a selection set of records for a Point, Line, or Polygon theme. The user inputs the percentage of features the user wants to select from the current shapefile. To save these selected shapes to a shapefile use the THEME | Convert to Shapefile option. The user also has the option to only select features that don't overlap.

Credits

Many thanks to Chuck Loesch, the originator of this documentation. It may be hard to write code but it's harder to write documentation – especially if you write the code! Thanks again!

Thanks also to Nick Seigal at nick@nickseigal.com for the code to generate Triangular Point Array Samples and Hexagonal Polygon samples. These have been very useful additions to the toolbox. The contribution is much appreciated.

Thanks also to you, the user. If you would like to have additional sampling techniques or know of existing code that would be a good addition please contact me at Tim.Loesch@dnr.state.mn.us.