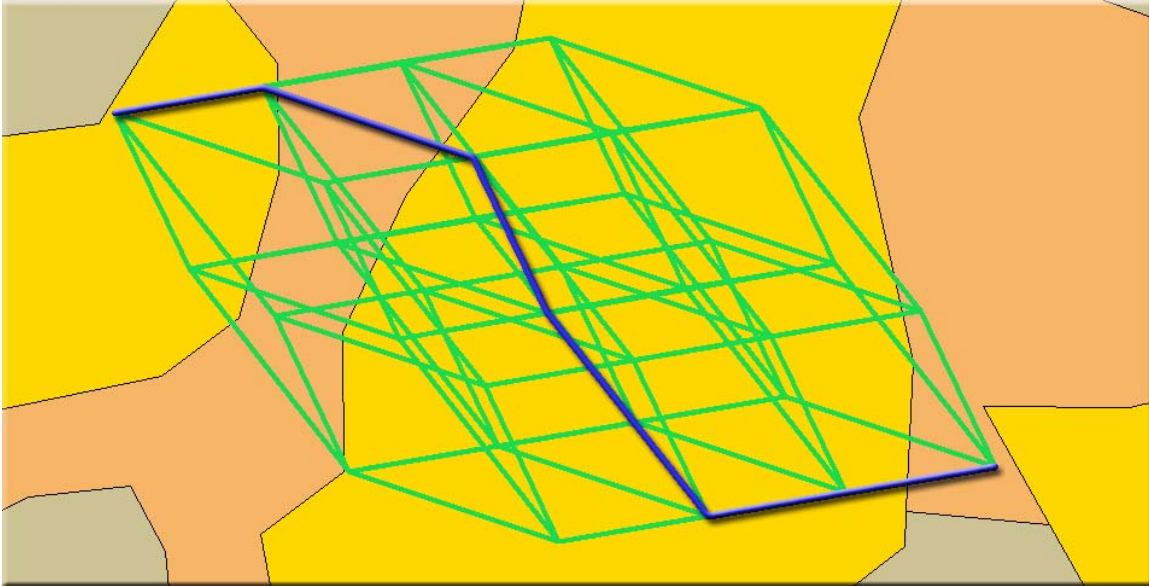# Alternate Animal Movement Routes v. 2.1

Aka: altroutes.avx

Last modified: April 12, 2005

TOPICS: ArcView 3.x, Animal Movement, Alternate, Route, Path, Proportion, Distance, Bearing, Azimuth, Angle, Point, Line, Polyline, Polygon, Shape, View, Analysis, Tools, Vertices, Random, Distribution

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DESCRIPTION: This extension is intended as an exploratory tool to help compare habitat features used by an animal with those habitat features that were available in a particular route. It works by developing a set of alternative routes based on the original route using a variety of potential methods, each with several options, including:

1) Randomly distributing the original route segments, such that all alternative routes start at the same point and end at the same point and all have the same set of route segments.

2) Making lists of the distances, bearings and internal angles defined by each segment of the original route, then randomly drawing from those lists.

3) Randomly relocating the entire route, with options to randomize either the origin point, the orientation or both.

You can compare characteristics of your random routes with characteristics of the actual route the animal used. This extension will derive several indices on each alternate route based on the geometry of that route, and more indices based on attributes of a polygon theme that the routes cross through (Land Cover types, for example). For users with Spatial Analyst and 3D Analyst, the author recommends his "Surface Tools" extension to derive topographic characteristics of the alternate routes (see http://www.jennessent.com/arcview/surface_tools.htm).

This extension includes additional tools to:

1) Combine route segments into complete routes.

2) Analyze habitat characteristics of routes by intersecting them with a habitat polygon theme and calculating the distances and proportions of each route that traverse each unique habitat type.

3) Analyze habitat characteristics of the buffered areas around the routes, again by intersecting them with habitat polygons and calculating the areas and proportions of each route buffer that overlays each unique habitat type.

4) Add a field containing record numbers to a table.

OUTPUT: This extension will generate polyline themes of alternate routes based on tables, point themes and polyline route themes. The alternate route themes include several indices describing geometric aspects of the route and how much they deviate from the original route.

The tools that analyze habitat characteristics will identify all unique polygon attributes in intersecting polygons, and then generate the length and the proportion of the route that lays within each habitat type. In these cases you also have the option to save your clipped polylines or polygons in a separate shapefile.

REQUIRES: This extension requires that the file "avdlog.dll" be present in the ArcView/BIN32 directory (or $AVBIN/avdlog.dll) and that the Dialog Designer extension be located in your ArcView/ext32 directory, which they usually are if you're running AV 3.1 or better. The Dialog Designer doesn't have to be loaded; it just has to be available. If you are running AV 3.0a, you can download the appropriate files for free from ESRI at:

http://support.esri.com/index.cfm?fa=downloads.patchesServicePacks.viewPatch&PID=25&MetaID=483

REVISIONS: Version 2 adds methods to generate random routes based on segment lengths and bearings independently, and to randomly relocate and rotate the entire route. Version 2 also includes several stand-alone tools to intersect routes with polygons, combine route segments and to add record number fields to datasets.

Version 2.1 (April 12, 2005) adds the option to randomize routes by randomly selecting from the original set of internal angles in the original route. This version also fixes bugs relating to sorting by date, attempting to randomize segments in a polyline with ≤ 1 segment, and intersecting polylines or polygons with background polygon themes or randomizing routes while not copying any of the original fields to the new theme.

Recommended Citation Format: For those who wish to cite this extension, the author recommends something similar to:

Jenness, J. 2005. Alternate animal movement routes (altroutes.avx) extension for ArcView 3.x, v. 2.1. Jenness Enterprises. Available at: http://www.jennessent.com/arcview/alternate_routes.htm.
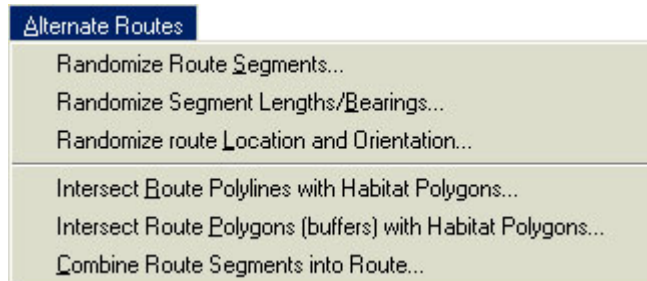
Please let me know if you cite this extension in a publication (jeffj@jennessent.com). I will update the citation list to include any publications that I am told about.

Table of Contents

General Instructions:

1) Begin by placing the "altroutes.avx" file into the ArcView extensions directory (../../Av_gis30/Arcview/ext32/).

2) After starting ArcView, load the extension by clicking on **File --> Extensions… ,** scrolling down through the list of available extensions, and then clicking on the checkbox next to the extension called "Alternate Animal Movement Routes."

3) Make sure your input themes and/or input tables are present in your project. This extension lets you select your input data from a list of themes/tables that are currently available in your project. It is not written to let you search the hard drive for your input data.

4) When loaded, the extension will add a new menu to your View menu bar named "Alternate Routes":
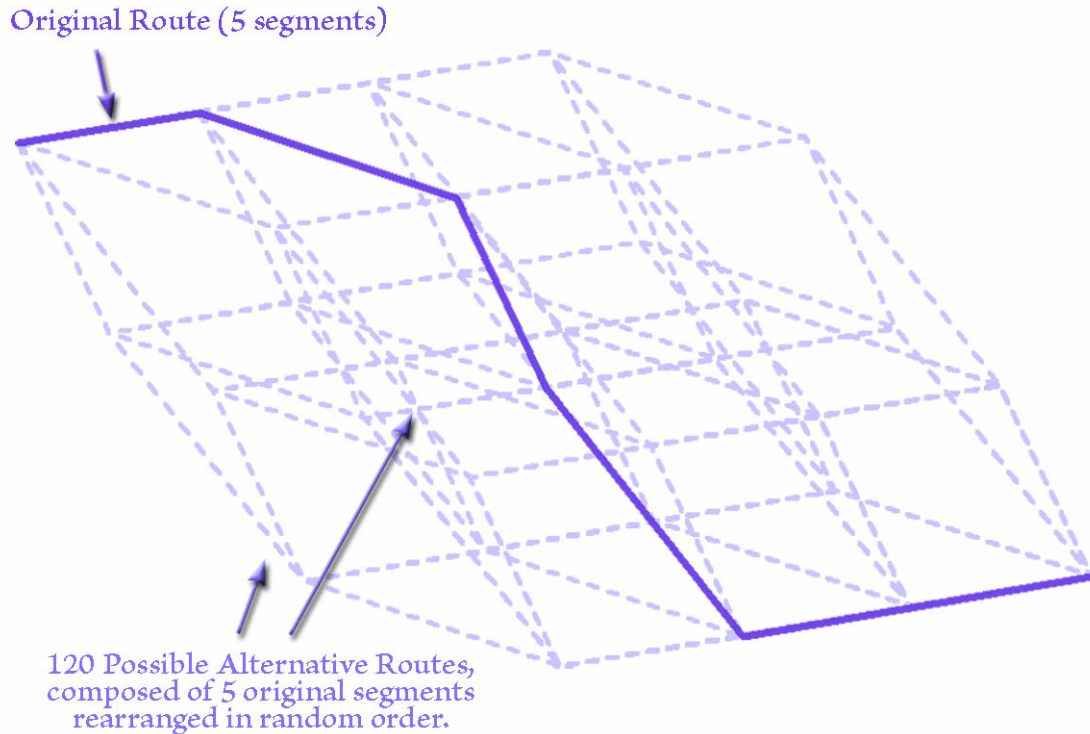

5) The extension will also add a menu item to your Table Edit menu labeled "Create Record Number Field":
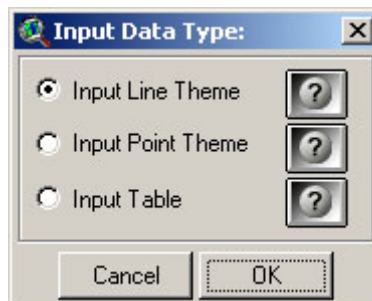
Randomize Route Segments:

This option will break each input route into a set of vertex-to-vertex segments, then randomly rearrange those segments into a new route. Each segment will be moved so that it starts at the end of the previous segment. The end result will be a new alternate route that starts and ends at the same place the previous route did, but which may go through entirely different areas and be much straighter or more crooked than the original route. There are options regarding how many routes to generate and whether a boundary polygon should be included.

Original Route (5 segments)

120 Possible Alternative Routes, composed of 5 original segments rearranged in random order.
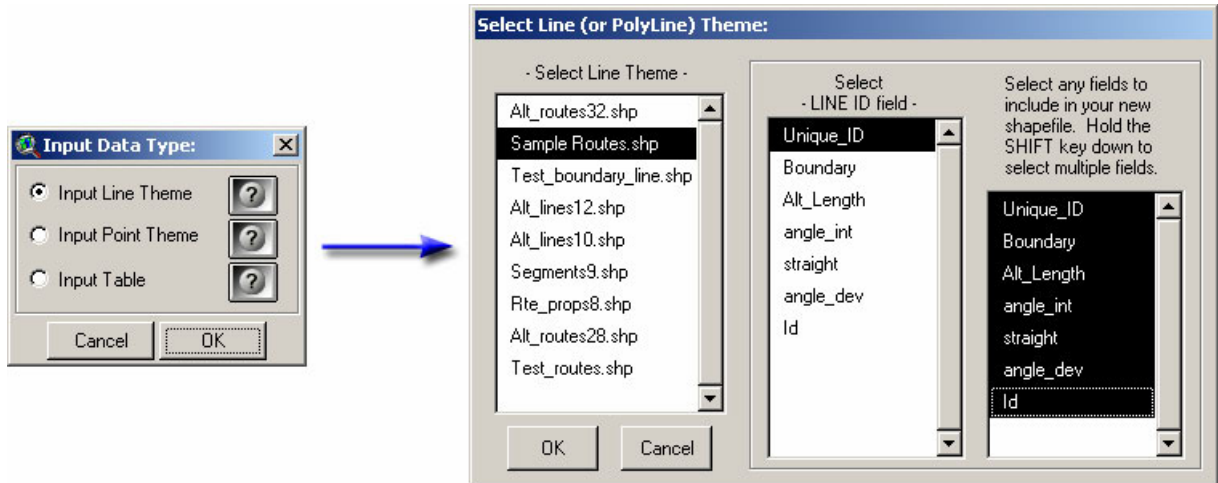
Instructions:

Identify Input Data Type: This tool can generate random routes based on polyline themes, point themes or tables. If the input dataset is a polyline theme, the tool will treat each line in the theme as a separate route. In this case, you have the option to include any of the original route attribute fields in the output shapefile of random routes. If the input dataset is a point theme or table, then the tool will assemble the routes from the points or the X- and Y-Coordinates. NOTE: If your dataset is a polyline theme of portions or segments of a route, you will need to combine those portions into complete route features before using this tool. See Combine Route Segments Into Route on page 25.

Start by clicking the "Randomize Route Segments…" menu item in the "Alternate Routes" menu. You will first be prompted to identify your input data type:
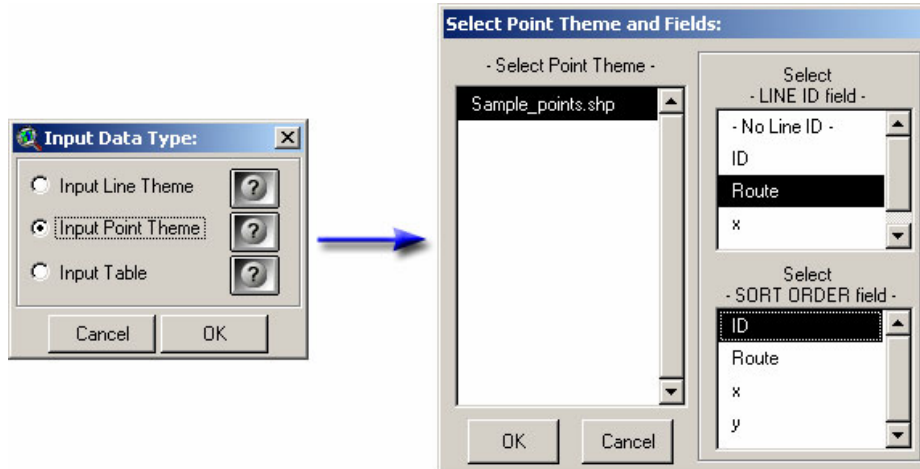

Each data type option will open a different dialog, prompting you for the necessary information to identify the route features in the data. The buttons with the question marks give details on the types and requirements of each data option:

1) INPUT LINE THEME: All lines in the theme represent complete separate routes you want to analyze. The Feature Attribute Table should include a field containing 'Line ID' values, and these ID values can be used to see which random routes correspond with which original route. Random routes will be generated for each of the input lines, and you have the option to specify which fields from the original line will be added to the random routes.
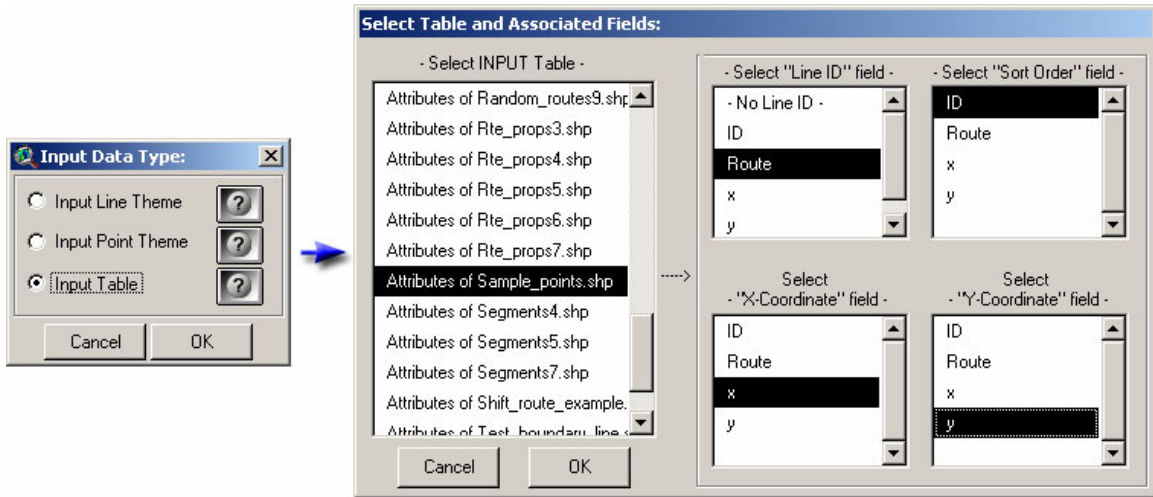

2) INPUT POINT THEME: Each point in the theme represents a vertex or point along the route. The Feature Attribute Table should include fields containing 'Line ID' and 'Sort Order' values (see the note on Sort Order below). The point theme can contain points for multiple routes. These points will be divided into separate routes according to their Line ID values, and sorted according to their Sort Order values. The sorted lists of points will then be assembled into complete routes, and these routes will form the basis for the random routes.

All random routes will include the respective Line ID values in the attribute table so you will know which original route is associated with each random route.

3) INPUT TABLE: Each record in the table reflects a single point (or vertex) in the route. The table should include fields containing 'Line ID', 'Sort Order', 'X-Coordinate' and 'Y-Coordinate values (see the note on Sort Order below). The table can contain records for multiple routes. Each record will be converted to a point based on the X- and Y-coordinates, and these points will be divided into separate routes according to their Line ID values and sorted according to their Sort Order values. The sorted lists of points will then be assembled into complete routes, and these routes will form the basis for the random routes.

All random routes will include the respective Line ID values in the attribute table so you will know which original route is associated with each random route.
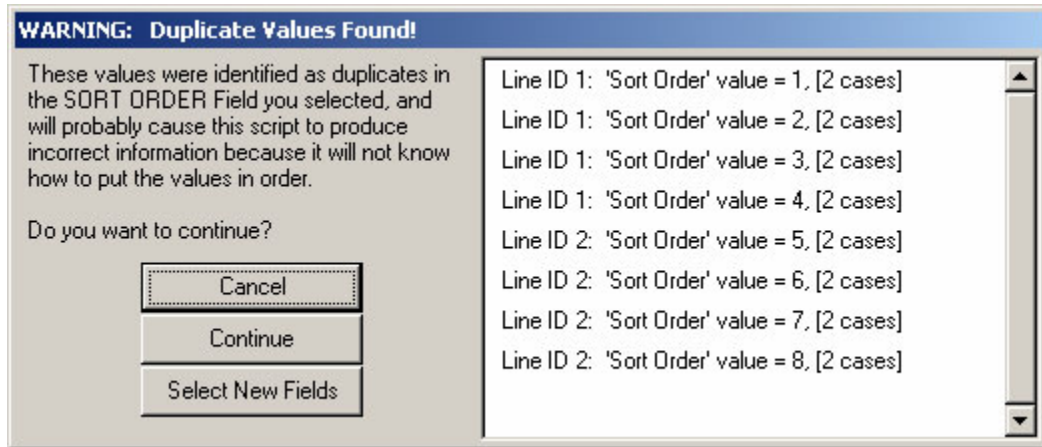
A NOTE REGARDING SORT ORDER: In cases where this extension requires that you specify the sorting order of your points or records, it is important to know if the values in your "SORT ORDER" field are in "String" format or "Numeric" format. The extension will sort the features based on the "SORT ORDER" field regardless of whether they are Strings or Numbers, but you should be aware that numbers in string format have a different sort order than numbers in numeric format. Strings are sorted alphabetically while numbers are sorted numerically. The numbers 1 through 21 are sorted in the following ways:

   A. **Numeric Format:** 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21

   B. **String Format:** 1, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2, 20, 21, 3, 4, 5, 6, 7, 8, 9

If you want to sort the points in the order they appear in the attribute table, the best option is to add a field to your attribute table containing record numbers (see Adding Record Numbers to Tables on page 25), or simply choose the option "– Use Record Order –" in the list.

It is important that you don't have duplicate sort values for any particular route, because the tool will probably sort the records incorrectly and might even crash. The extension will check for duplicate Sort values and alert you if it finds any:

Specify Randomization Parameters: After you have identified your data type, input theme and appropriate attribute fields, the tool will assemble the routes in memory and calculate how many potential alternate routes exist based on the number of possible permutations of segments for each route. You will then be prompted to identify the number of random alternative routes to generate and a few other parameters:

Output Information:

Possible Permutations:

```
Line ID: 1 (8 segments):  40,320 permutations
Line ID: 2 (6 segments):  720 permutations
----------------------------------------
Total:  41,040 possible alternate routes
```

○ Calculate all possible permutations (41,040)
◉ Limit Permutations: Max per Input Line = `45`

☑ Create Polyline Output Shapefile
    ☑ Original Line ID   ☑ Distance by Polygon Area
    ☑ Unique Numerical ID   └☐ Save Area Polygons?
    ☑ Line Length   ☑ Straightness Index
    ☑ Total Vertex Distance   ☑ Average Internal Angle
    ☑ Avg. Vertex Distance   ☑ Average Deviation Angle

☑ Create Point Output Shapefile
    ☑ Original Line ID   ☑ X-Coordinate
    ☑ Alternate Line ID   ☑ Y-Coordinate
    ☑ Unique Point ID   ☑ Distance from Original Line

☐ Constrain Routes Within Boundary Area:

[Cancel] [OK]

Number of Random Routes: First specify whether you would like to generate all possible random routes or if you would like to set a maximum number per input route. This extension will let you know the total number of random routes possible for each input route and give you the option to generate all possible alternatives.

Polyline Output Options: This option will create a polyline theme of random alternate routes with several potential fields describing each route. These fields include identifiers for each route, four measures of how much that alternate route deviates from the original route, and potentially data regarding how much each route crosses over some particular attribute of interest (see the discussion on intersecting routes with polygons on page 21). You have the option to select which of the following fields will be included:

- *Original Line ID:* This is the ID value of the Original Route. If you conduct an analysis on multiple routes simultaneously, this field will identify which original route that particular alternative route is associated with.

- *Alternate Line ID:* This field assigns a unique numerical value to each alternative line.

- *Line Length:* The length of that alternative route in map units. All alternative routes associated with a particular original route will have the same length.

- *Tot. Vertex Dist.:* This extension can calculate the distance from the original line to each vertex on that particular alternative route. This field contains the sum of all the distances.

- *Avg. Vertex Dist.:* This field takes the total vertex distance and divides it by the number of vertices. This field may be more appropriate for comparing routes with different numbers of route segments than the total vertex distance. Please see the discussion on Vertex Distances on page 28 for an illustration of this measure.
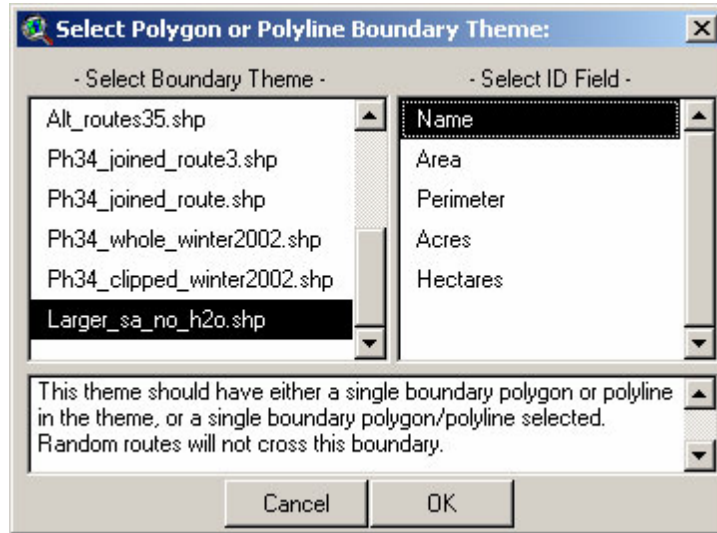
- *Polygon Area Dist.:* This is a measure of the land area bounded by the original route and the alternate route. Please see the discussion on Polygon Area Distances on page 29 for an illustration of this measure.

- *Straightness Index:* This is a measure of how straight the route is, calculated by dividing the total route length by the straight-line distance from the route beginning to the route end. These values will range from 0 to 1, where 1 means the route is perfectly straight and 0 means the route is infinitely crooked. All alternative routes derived from a single original route will have the same straightness index because they all are the exact same length and they all have the same beginning and ending points.

- *Average Internal Angle:* This is a measure of how much the line bends. Alternative routes may bend more or less than the original route. This measure reflects the average angle bound by each connected pair of line segments, and takes the average of all the bends in the line. Please see the discussion on Average Vertex Angles on page 26 for an illustration of this measure.

- *Average Deviation Angle:* This is another measure of how much the line bends, closely related to the average internal angle. This measure reflects how much the bearing of a segment deviates from the bearing of the segment before it, and takes the average of all the deviation angles in the line. Please see the discussion on Average Vertex Angles on page 26 for an illustration of this measure.

- *original:* A True/False field reflecting whether that particular route is the original route or not.

- *Fields containing Length and Proportion of Polylines that cross over Polygons:* This option will let you select a particular attribute field from a polygon theme and create separate fields for the length and proportion of the polylines that have each attribute. If any of the alternative routes go outside of the polygons completely, you will also get a field for the length and proportion of the route that falls outside of the polygons (see the discussion on intersecting routes with polygons on page 21). IMPORTANT: These fields will only be added if you choose to intersect your routes with a background polygon theme (see "Intersect with Polygon Theme:" below)

Point Output Options: You have the option to create a separate Point shapefile containing the vertices of each of the alternative lines. The Feature Attribute Table for these points can contain fields identifying each point by original route, by alternative route, or by a unique identifier for each point. The table can also include fields containing the X- and Y-Coordinates for each point and the distance from that point back to the original line. You also have the option to include a field containing the polygon attribute that the point overlays (see discussion below). You have the option to choose from the following fields:

- *Original Line ID:* This is the ID value of the Original Route. Multiple alternative routes may be derived from this same original route, and this field will allow you to identify which original route produced this particular alternative route.

- *Alternate Line ID:* This is the unique numeric value of each alternative route. This will tell you which alternative route contains this particular vertex point.

- *Point ID:* This assigns a unique numerical value to each individual vertex.

- *X-Coordinate:* The X-coordinate of the vertex, in map units.

- *Y-Coordinate:* The Y-coordinate of the vertex, in map units.

- *Distance from Line:* The Distance of the vertex from the original line, in map units. Please see the discussion on Vertex Distances on page 28 for an illustration of this measure.

- *original:* A True/False field reflecting whether that vertex comes from the original route or not.
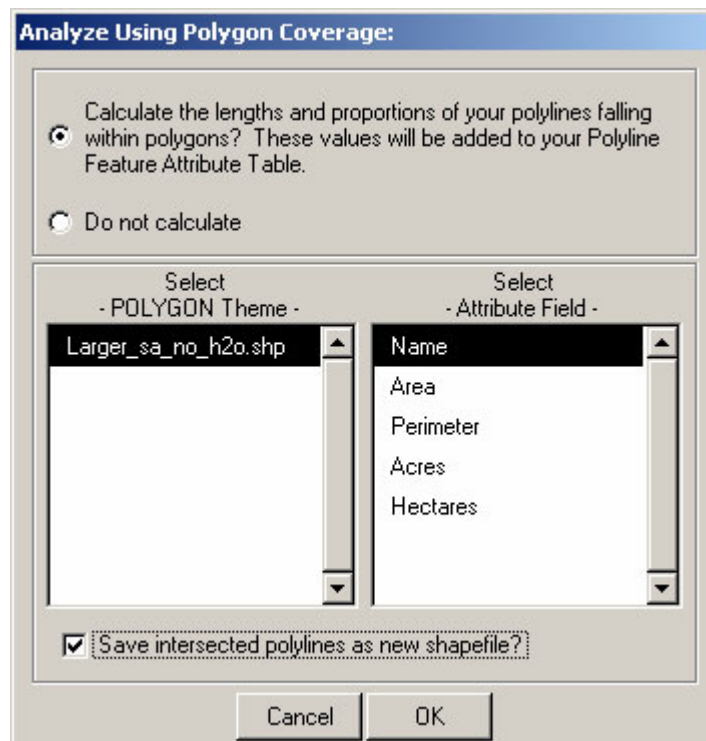
- *Polygon Attribute:* This is the attribute value of the background or habitat polygon the vertex sits in, based on the Polygon theme and the Attribute Field that you select. This field will only be added if you choose to intersect your routes with a background polygon theme (see "Intersect with Polygon Theme:" below).

Constrain Routes Within Polygon: If you have a theme containing a polygon or polyline boundary feature that you know your random routes should not cross, you can check the "Constrain Routes Within Boundary Area" option. IMPORTANT: This option will be disabled if you elect to generate all possible alternative routes for your input routes (see above). If you select this option, you will be asked to identify your boundary theme and ID field:

Intersect with Polygon Theme:

If you have any polygon themes available in your view, you will have to opportunity to calculate the length and proportion of each route that goes through each unique polygon type. Please refer to the discussion on intersecting routes with polygons on page 21 for details on this operation. You will only see the following dialog if you have polygon themes in your view:
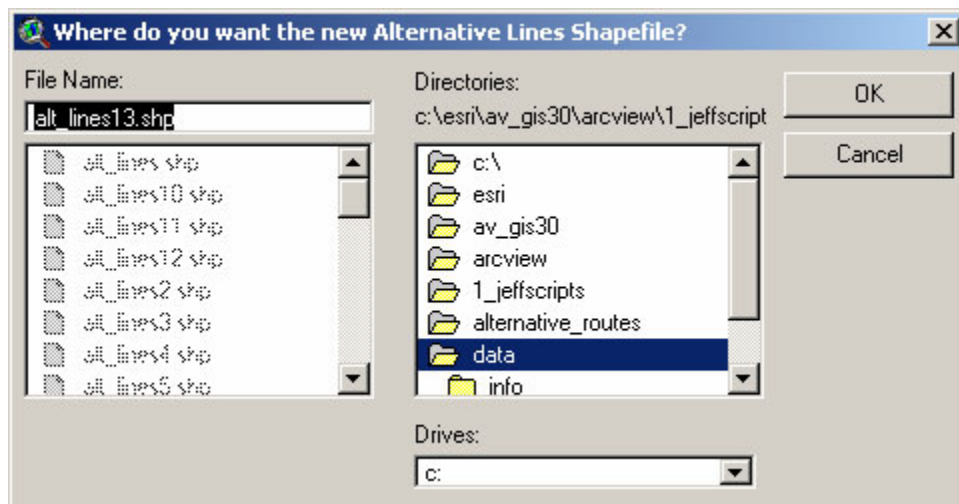
If you have elected to generate a point shapefile of your random route vertices, then this function will also add a polygon attribute field to your point shapefile. The final point theme will include polygon attribute values for all points, reflecting the attribute value of the polygon intersecting each point.

Saving Intersected Polylines: If you have elected to create a polyline shapefile of alternative routes, and you have designated a polygon theme with attribute values, then you have the option to create a new polyline shapefile containing all the individual polyline segments that have been clipped to the polygons, along with the polygon attribute values. The extension must clip the alternative routes to the polygon coverage in order to calculate the lengths and proportions described in the "POLYLINE OUTPUT" above, and this just gives you the option to save those clipped polylines to a separate shapefile. If you choose to save these line segments, your Line Segment Feature Attribute Table will contain the following fields:
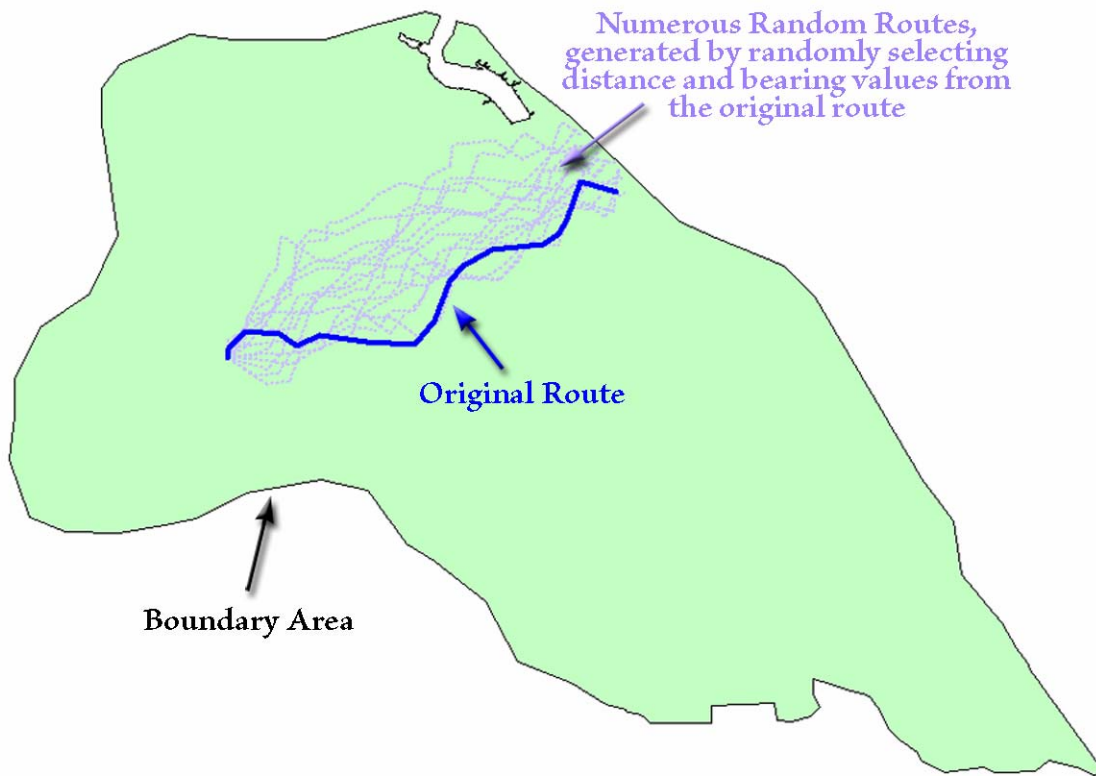
- *Length:* The length of the line segment, in map units

- *Proportion*: The percentage of the total line that the line segment comprises.

- *Original Line ID:* This is the ID value of the Original Route. Multiple alternative routes may be derived from this same original route, and this field allows you to identify which original route produced this particular alternative route.

- *Alternate Line ID:* This is the ID value of the particular alternative route that this line segment comes from.

- *Line Segment ID:* This assigns a unique numeric value to each line segment.

- *Polygon Attribute:* This is the attribute value of the polygon the line segment sits in. This attribute value is based on the polygon theme and the attribute field that you selected.

- *original:* A True/False field reflecting whether this line segment comes from the original route or not.

Finally, you will be asked where you would like to save any of your output shapefiles. These dialogs should be familiar to most ArcView users, and you will be asked for a separate name and location for each output shapefile you specified.
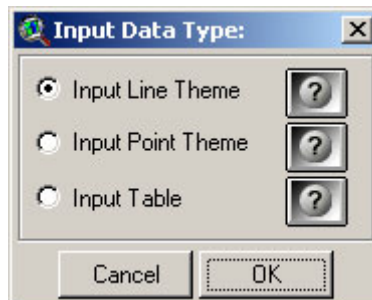
Randomize Segment Lengths and Bearings:

This option will examine each vertex-to-vertex segment along the original route and build separate lists of the distances and bearings traveled in that segment. The random routes are generated by starting at the original route origin and then randomly selecting from the lists of distances and bearings. There are several options regarding selecting with replacement, selecting from only one of the lists or applying a boundary feature.
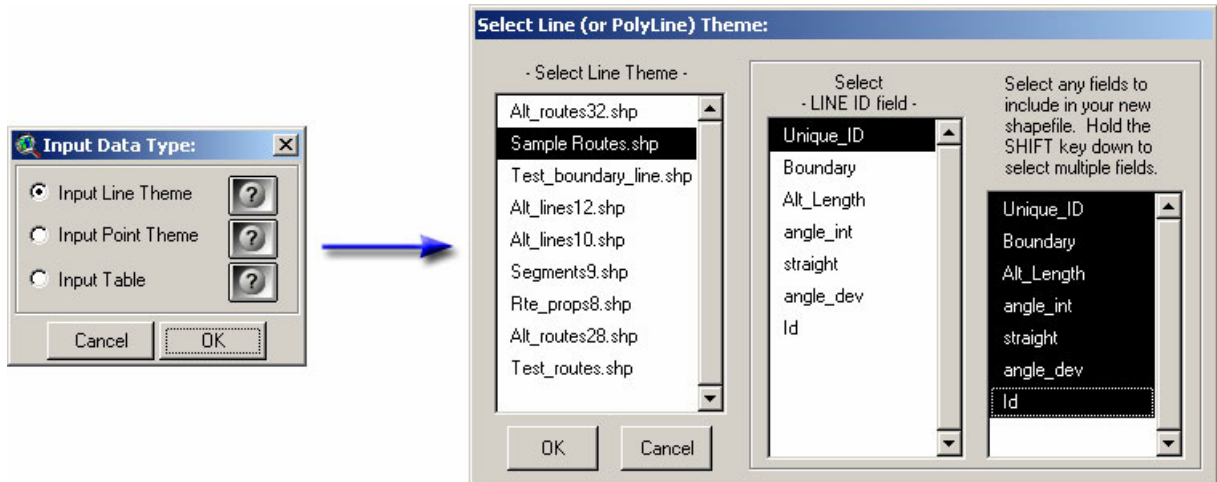

Instructions:

Identify Input Data Type: This tool can generate random routes based on polyline themes, point themes or tables. If the input dataset is a polyline theme, the tool will treat each line in the theme as a separate route. In this case, you have the option to include any of the original route attribute fields in the output shapefile of random routes. If the input dataset is a point theme or table, then the tool will assemble the routes from the points or the X- and Y-Coordinates. NOTE: If your dataset is a polyline theme of portions or segments of a route, you will need to combine those portions into complete route features before using this tool. See Combine Route Segments Into Route on page 25.

Start by clicking the "Randomize Segment Lengths/Bearings…" menu item in the "Alternate Routes" menu. You will first be prompted to identify your input data type:
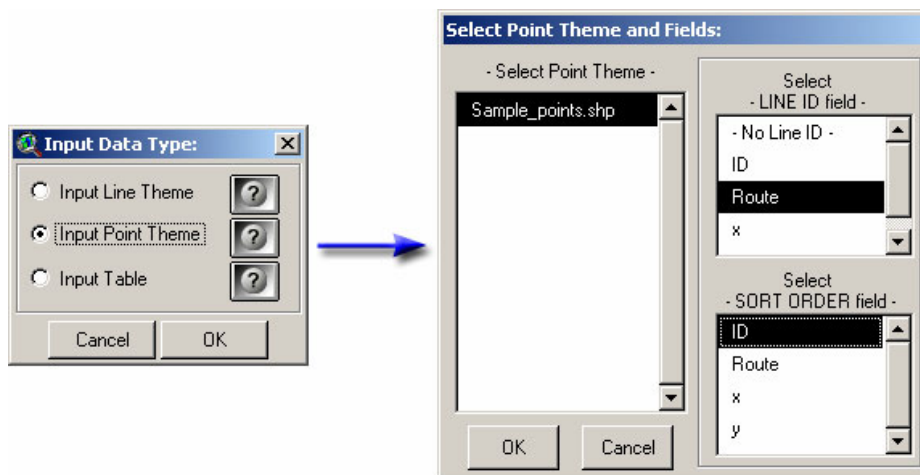
Each data type option will open a different dialog, prompting you for the necessary information to identify the route features in the data. The buttons with the question marks give details on the types and requirements of each data option:

4) INPUT LINE THEME: All lines in the theme represent complete separate routes you want to analyze. The Feature Attribute Table should include a field containing 'Line ID' values, and these ID values can be used to see which random routes correspond with which original route. Random routes will be generated for each of the input lines, and you have the option to specify which fields from the original line will be added to the random routes.
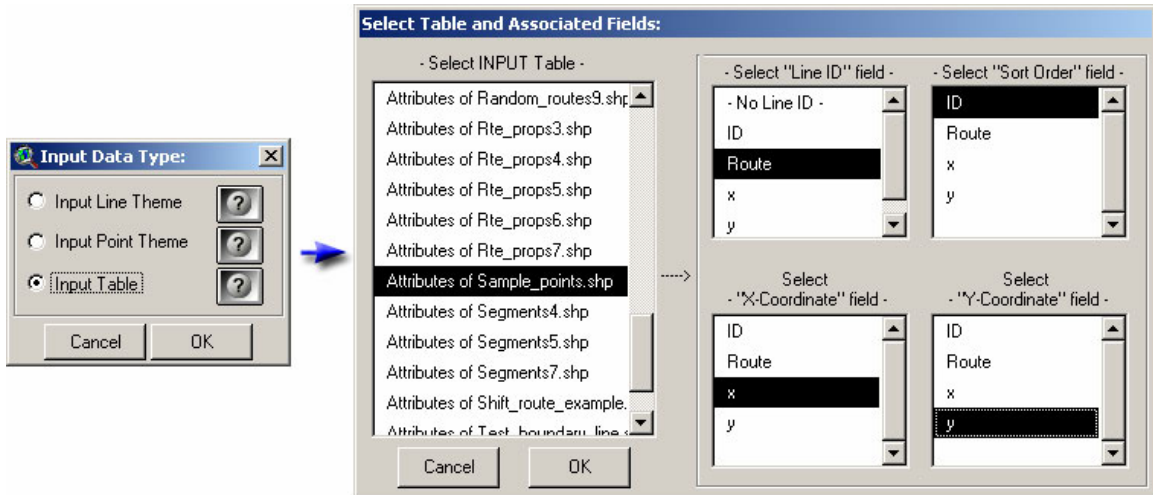

5) INPUT POINT THEME: Each point in the theme represents a vertex or point along the route. The Feature Attribute Table should include fields containing 'Line ID' and 'Sort Order' values (see the note on Sort Order below). The point theme can contain points for multiple routes. These points will be divided into separate routes according to their Line ID values, and sorted according to their Sort Order values. The sorted lists of points will then be assembled into complete routes, and these routes will form the basis for the random routes.

All random routes will include the respective Line ID values in the attribute table so you will know which original route is associated with each random route.

6) INPUT TABLE: Each record in the table reflects a single point (or vertex) in the route. The table should include fields containing 'Line ID', 'Sort Order', 'X-Coordinate' and 'Y-Coordinate' values (see the note on Sort Order below). The table can contain records for multiple routes. Each record will be converted to a point based on the X- and Y-coordinates, and these points will be divided into separate routes according to their Line ID values and sorted according to their Sort Order values. The sorted lists of points will then be assembled into complete routes, and these routes will form the basis for the random routes.

All random routes will include the respective Line ID values in the attribute table so you will know which original route is associated with each random route.
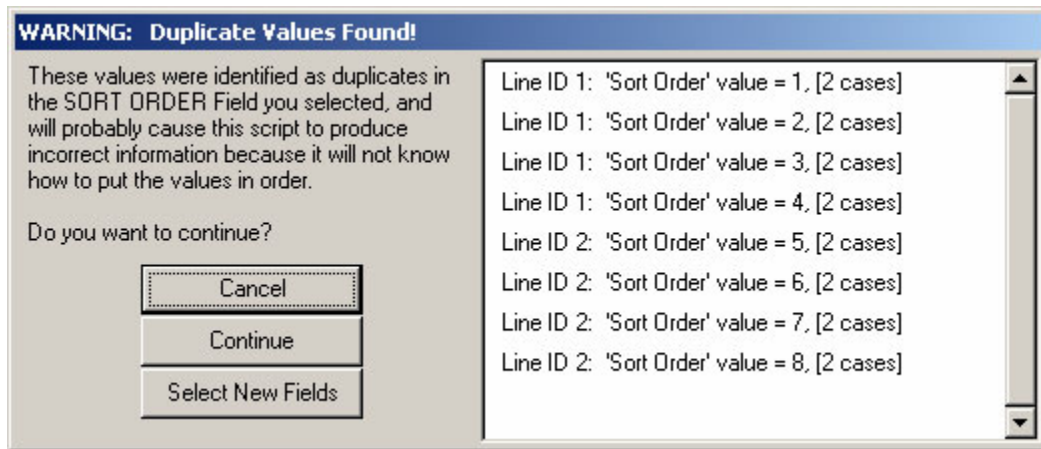
A NOTE REGARDING SORT ORDER: In cases where this extension requires that you specify the sorting order of your points or records, it is important to know if the values in your "SORT ORDER" field are in "String" format or "Numeric" format. The extension will sort the features based on the "SORT ORDER" field regardless of whether they are Strings or Numbers, but you should be aware that numbers in string format have a different sort order than numbers in numeric format. Strings are sorted alphabetically while numbers are sorted numerically. The numbers 1 through 21 are sorted in the following ways:
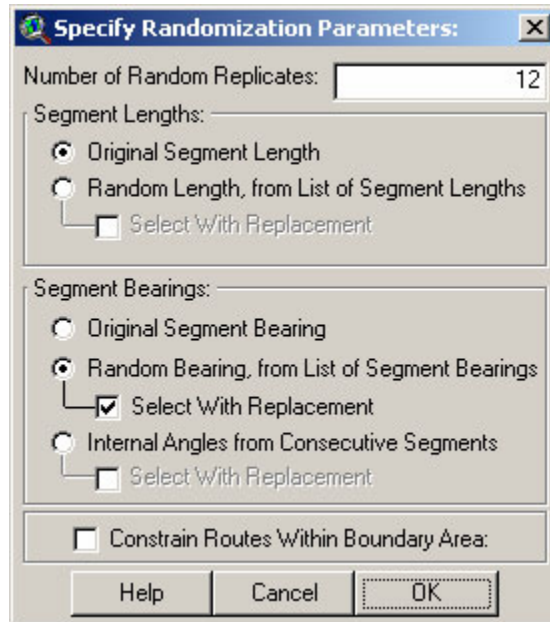
C. **Numeric Format:** 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21

D. **String Format:** 1, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2, 20, 21, 3, 4, 5, 6, 7, 8, 9

If you want to sort the points in the order they appear in the attribute table, the best option is to add a field to your attribute table containing record numbers (see Adding Record Numbers to Tables on page 25), or simply choose the option "– Use Record Order –" in the list.

It is important that you don't have duplicate sort values for any particular route, because the tool will probably sort the records incorrectly and might even crash. The extension will check for duplicate Sort values and alert you if it finds any:

Specify Randomization Parameters: After you have identified your data type, input theme and appropriate attribute fields, the tool will ask you how many random routes to generate and what aspect of the original routes you wish to randomize:
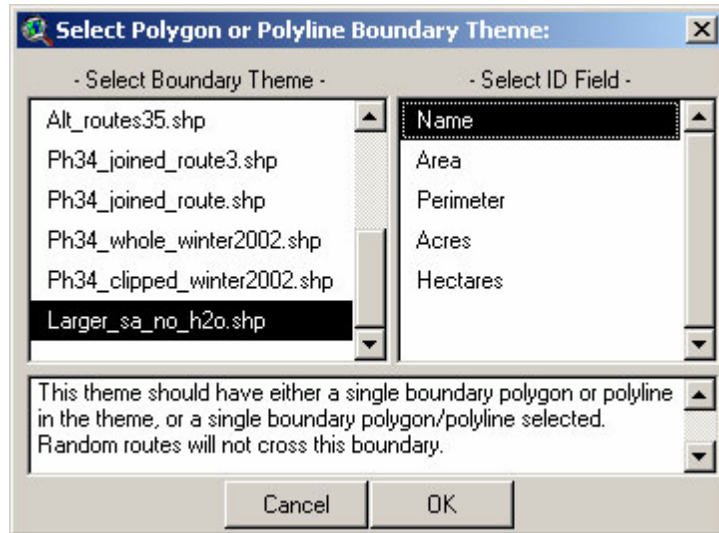
Random routes will be generated with the same number of segments as the original route and will all begin at the starting point of the original route. Optionally each segment can have the length, bearing, or internal angle between each pair of consecutive segments randomly drawn from the list of existing lengths, bearings and internal angles for that route, or it can keep the original length/bearing/internal angle of the original segment. If selecting randomly, you have the option to select with replacement, in which case the same length/bearing/internal angle might be selected multiple times, or without replacement, in which case all original bearings, lengths or internal angles will be included in the random routes.

If you choose to randomly select from the list of internal angles of the original route, then the first segment on each random route will have the same bearing as the first segment on the original route. The internal angle between that segment and the next segment, and then for each consecutive pair of segments thereafter, will be selected at random from the list of internal angles.

NOTE: Choosing "Original Segment Length" or "Original Segment Bearing" means that any particular segment in the new route will have the same length or bearing as it's respective segment in the original route. The nth segment in the random routes will have the same distance or bearing as the nth segment in the original route. If you set your options to both "Original Segment Length" and "Original Segment Bearing", then your "random" routes will all be identical to your original route.
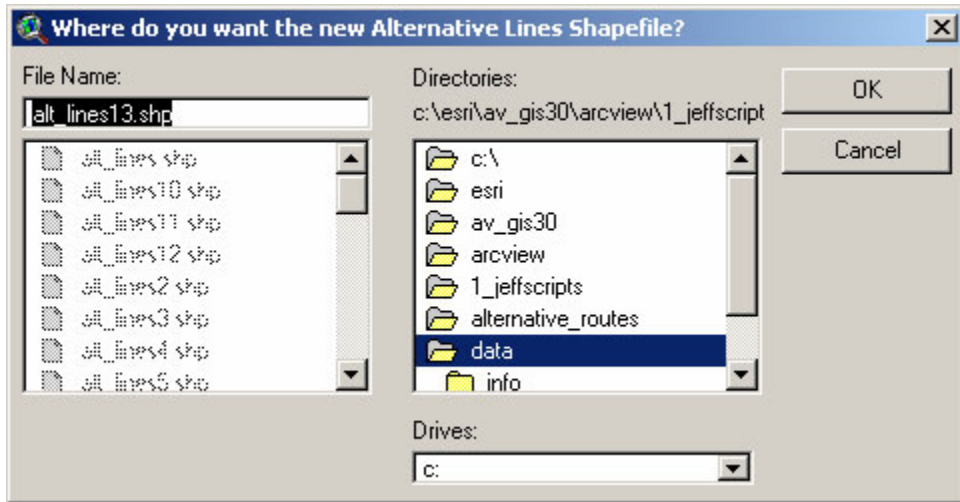
'Constrain Routes Within Boundary Area' means that the route will be prevented from going outside a particular polygon or across a polyline boundary. If you choose this option, you will be prompted to identify the polygon/polyline theme containing your boundary feature.

Output Fields: The attribute table of your new shapefile of random routes will automatically contain the following fields:
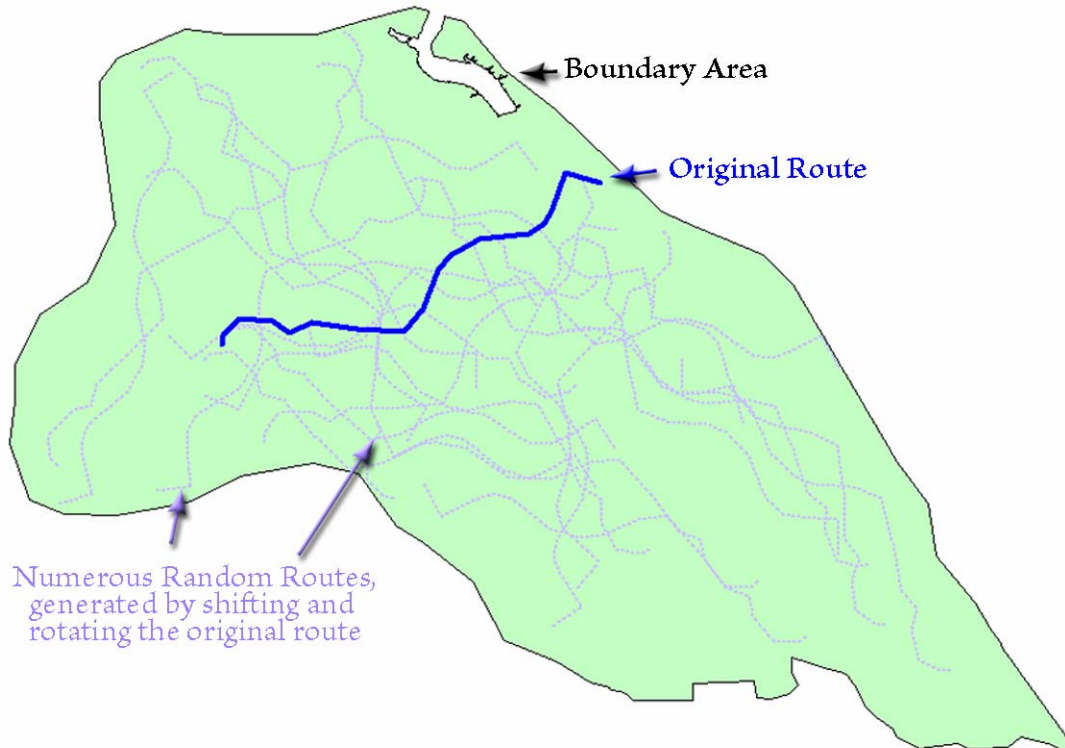
- *Unique_ID:* Just a unique ID value for each polyline in the shapefile.

- *Boundary:* The boundary ID value of any boundary polygon or polyline you may have specified. If you did not choose to constrain routes within some kind of boundary region, the [Boundary] field will contain the string "None Specified".

- *Alt_Length:* The length of the polyline.

- *Avg. Internal Angle:* A measure of how much the line bends. Alternative routes may bend more or less than the original route. This measure reflects the average angle bound by each connected pair of line segments, and takes the average of all the bends in the line. Please see the discussion on Average Vertex Angles on page 26 for an illustration of this measure.

- *Straightness:* A measure of how straight the route is, calculated by dividing the total route length by the straight-line distance from the route beginning to the route end. These values will range from 0 to 1, where 1 means the route is perfectly straight and 0 means the route is infinitely crooked.

- *Avg. Deviation Angle:* Another measure of how much the line bends, closely related to the average internal angle. This measure reflects how much the bearing of a segment deviates from the bearing of the segment before it, and takes the average of all the deviation angles in the line. Please see the discussion on Average Vertex Angles on page 26 for an illustration of this measure.

- *Possibly other fields:* If your input theme was a Polyline theme, then you had the option to select which fields to add to your new theme of random polylines (see above). All fields selected in the "Select Line (or Polyline) Theme:" dialog will be added.

In the last step, you will be asked where you would like to save your output shapefile. This dialog should be familiar to most ArcView users.

Where do you want the new Alternative Lines Shapefile?

File Name:

alt_lines13.shp

- all_lines.shp
- all_lines10.shp
- all_lines11.shp
- all_lines12.shp
- all_lines2.shp
- all_lines3.shp
- all_lines4.shp
- all_lines5.shp

Directories:

c:\esri\av_gis30\arcview\1_jeffscript

- c:\
- esri
- av_gis30
- arcview
- 1_jeffscripts
- alternative_routes
- data
- info

Drives:

c:

OK

Cancel

Randomize Route Location and Orientation:

This option will generate random routes by duplicating the original route and then randomly locating and rotating it within some pre-defined area. The tool includes several options regarding restricting the general orientation of the random lines to a range of values, randomizing only the orientation or the location, and whether to allow the random routes to pass outside the boundary polygon.

Boundary Area

Original Route

Numerous Random Routes, generated by shifting and rotating the original route
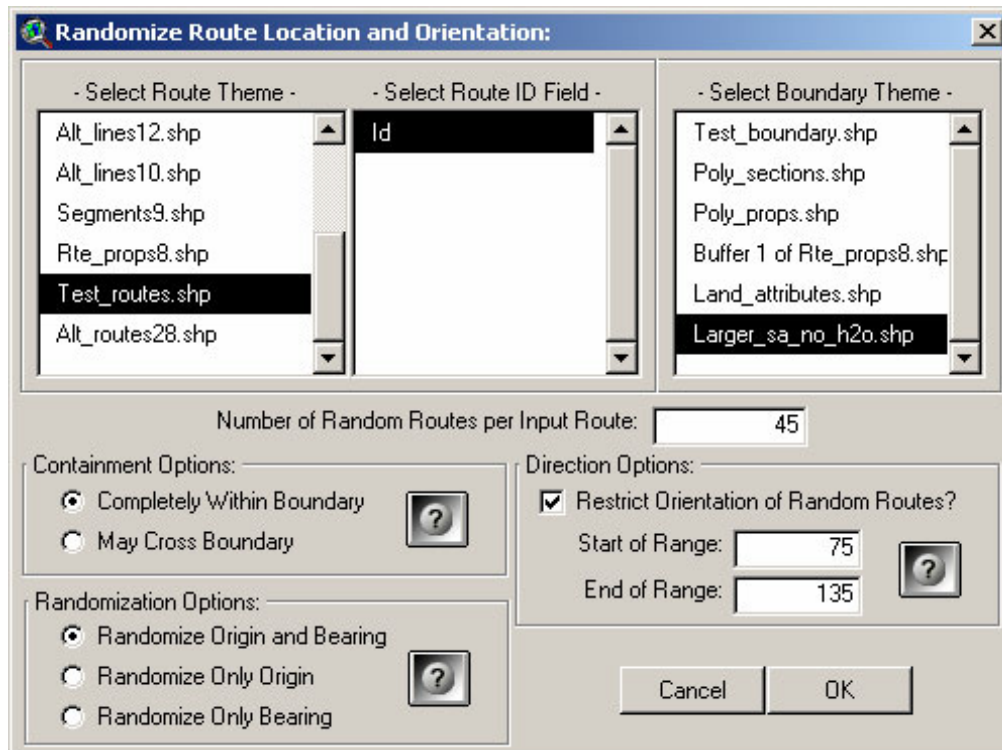
Instructions:

This tool can generate random routes based on polyline themes of complete routes. If your dataset is a polyline theme of portions or segments of a route, you will need to combine those portions into complete route features before using this tool. See Combine Route Segments Into Route on page 25.

Start by clicking the "Randomize Route Location and Orientation…" menu item in the "Alternate Routes" menu. You will first be prompted to identify your randomization parameters. Select your theme of original routes in the "- Select Route Theme -" listbox and then a Route ID field. This tool can generate random routes based on multiple input routes, so the Route ID fields will be useful in identifying which original route gave rise to any particular random route.

Next select the Boundary Theme containing either a single polygon or a single selected polygon. This boundary theme is important because all random routes will originate within the boundary polygon.

Containment Options: All random routes will be generated so that the starting point of the route lies within the specified boundary theme. Due to the randomization process, some of these random routes may cross outside the boundary. If you consider your boundary to be impenetrable to your species, choose the 'Completely Within Boundary' option to prevent routes being generated that cross that boundary. Otherwise, choose the 'May Cross Boundary' option to allow random routes to cross outside the boundary.

Randomization Options: Random routes may be generated at random locations, in random directions, or both.

- *Randomize Origin and Bearing:* Creates new routes in new locations and going in new directions.

- *Randomize Only Origin:* Creates new routes in new locations, but all oriented in exactly the same direction as the original route.

- *Randomize Only Bearing:* Creates new routes originating at the same starting point as the original route, but going in random directions.

  IMPORTANT: If you choose to randomize only the origin, then this will override any values you enter in the 'Direction Options' box. Choosing this option will force all routes to be oriented exactly the same regardless of any direction range you specify.

Direction Options: This option will restrict the general orientation of the randomly generated routes to a specified range of directions. The route orientation is defined as the bearing from the starting point of the route to the ending point of the route. Random routes will be rotated randomly, but this option will force the random routes to go in a general direction. This may be useful if you know, for example, that your species of interest always goes generally north or south at particular times of year.
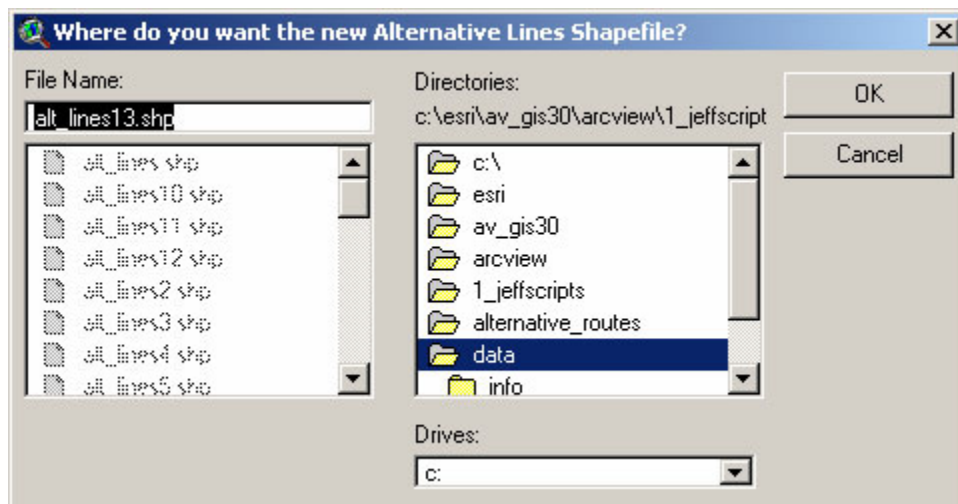
The range should be described in terms of degrees on a compass, going clockwise from the start to the end of the range. A range going from Northwest to Northeast would be entered as:

- [Start of Range = 315]

- [End of Range = 45]

Output Fields: The attribute table of your new shapefile of random routes will automatically contain the following fields:

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- *Unique_ID:* Just a unique ID value for each polyline in the shapefile.

- *Orig_Rte_ID:* The ID value of the original route that produced this particular random route.

- *Length:* The length of the polyline.

- *Rotation:* The amount that this particular random route was rotated..

- *Orig_Azmth:* The general orientation of the original route that produced this particular random route.

- *New_Azmth:* The general orientation of a route, defined as the bearing from the starting point to the ending point of that route.

- *Num_segs:* The number of route segments in the original route.
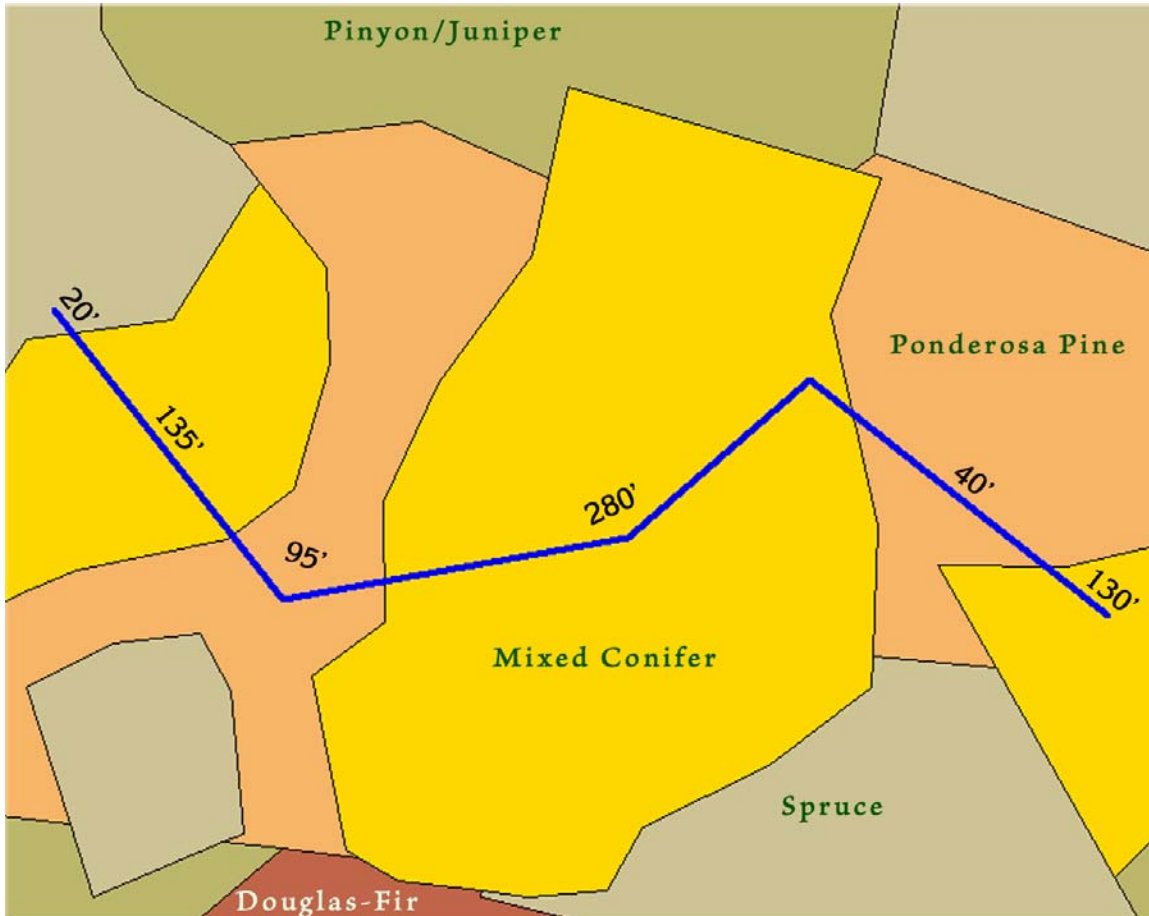
In the last step, you will be asked where you would like to save your output shapefile. This dialog should be familiar to most ArcView users.

Additional Tools:

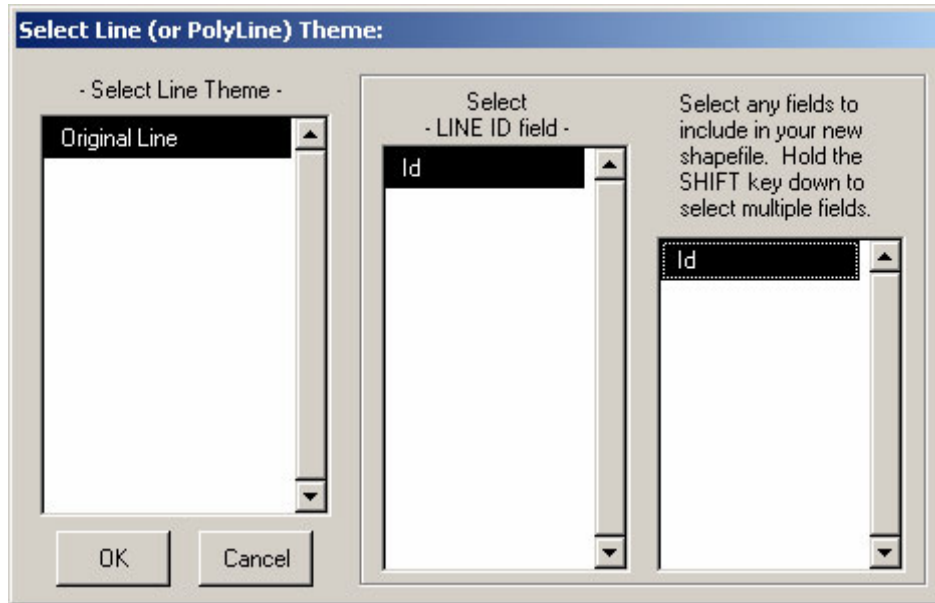***Intersect Route Polylines with Habitat Polygons:***

This extension will intersect a route polyline theme with a polygon theme and identify all the unique attribute values from that set of polygons. It will then create two new fields in your polyline shapefile for each attribute; one for the total length of that route which traverses polygons with that attribute, and one for the proportion of that route that is contained in those polygons. It will not necessarily create new fields for each polygon. If multiple polygons have the same attribute value, than the length and proportion values will reflect the sum of all the polygons with that attribute that the route passes over. For example, in the following illustration, the route passes through 6 separate Cover Type polygons, but only 3 actual Cover Types:
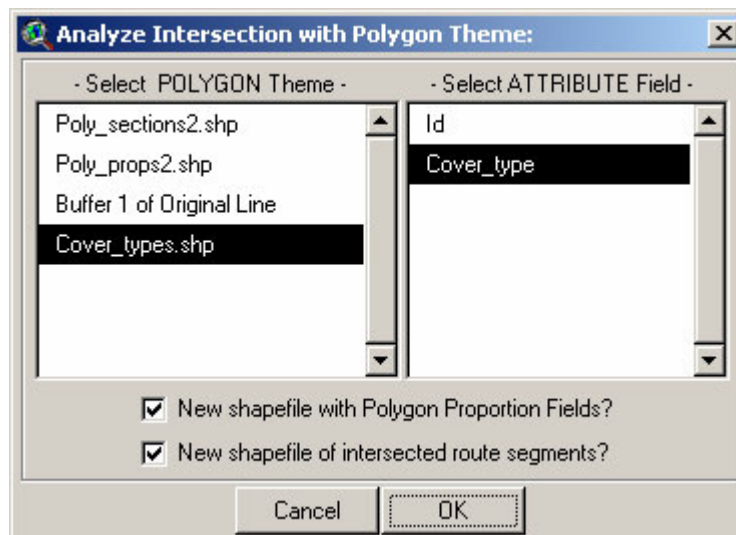

The total length of this route is 700'. It passes through 6 different polygons but only 3 unique cover types. Of the total 700' length, 20' (3%) passes through *Spruce*, 455' (65%) passes through *Mixed Conifer*, and 225' (32%) passes through *Ponderosa Pine*. This means that there would be at least six new fields in the feature attribute table for the alternate routes; 3 fields for the actual lengths of the routes within each cover type and 3 fields for the proportion of the routes that pass through each cover type. If any of your alternate routes pass entirely out of the polygon theme, you will also get fields for "Length Outside" and "Proportion Outside".

This function can be accessed through 2 tools:

1) **Menu item *Intersect Route Polylines with Habitat Polygons*:** This is a stand-alone application that can work with any polyline and polygon theme. Choose this menu item and you will be prompted first identify your Polyline route theme, ID Field and any additional fields you would like to add to your new shapefile:

Next select your polygon theme and attribute field:

Here you also have the option to specify what output you want. No changes will be made to your actual polyline shapefile.
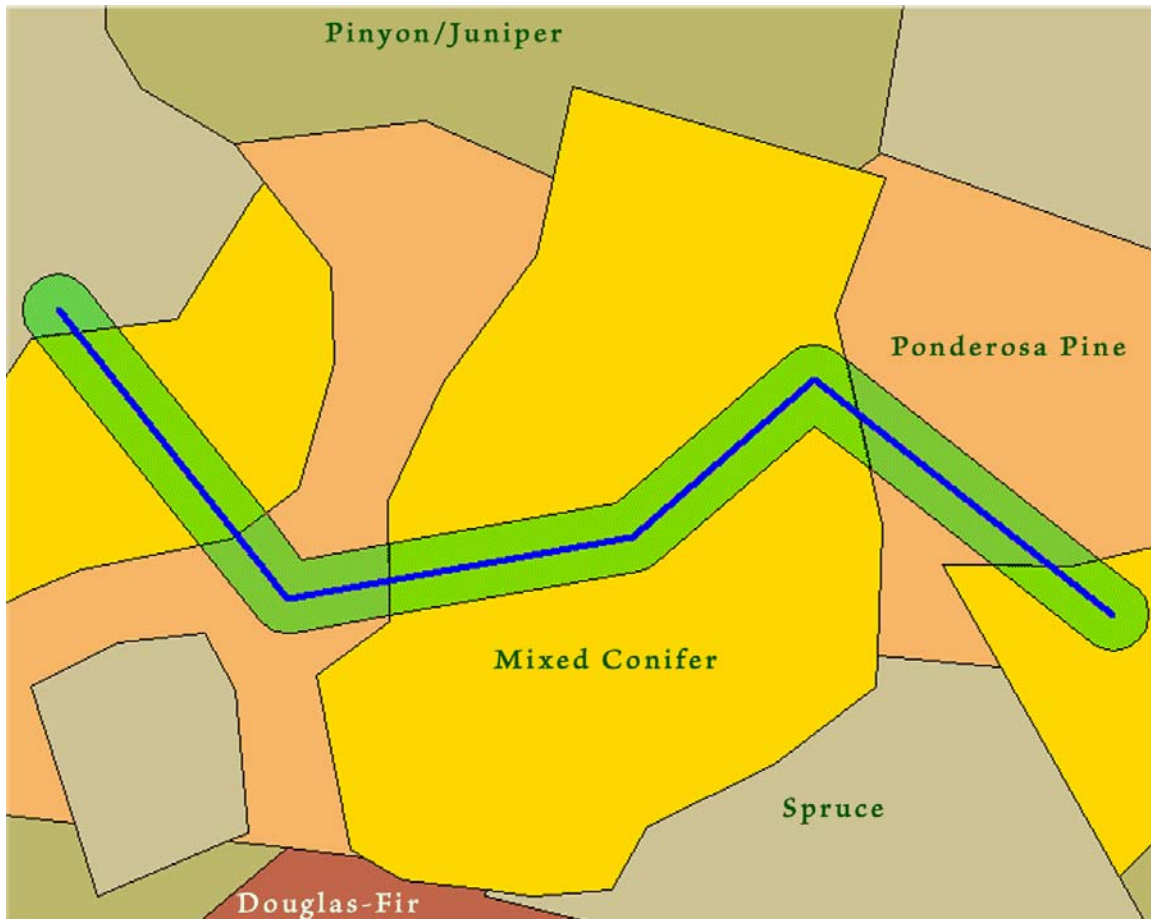
A. <u>New shapefile with Polygon Proportion Fields</u>: This will generate a new polyline shapefile containing all the fields you specified in the dialog box above, plus fields for the lengths and proportions of each unique habitat type traversed by the polylines.

B. <u>New shapefile of intersected route segments</u>: This will generate a new polyline shapefile where each polyline represents a portion of a route that was intersected by any particular polygon. It will contain the following fields:

- *Seg_length:* The length of the segment in map units.

- *Proportion*: The proportion of the original route represented by this segment.

- *Line Segment ID:* A unique numeric value for each record in the segment shapefile.

- *Polygon Attribute:* The attribute value contained in the specified polygon theme attribute field.

- All the original fields and values you specified in the "Select Line (or Polyline) Theme:" dialog (see above).

2) **Menu Item *Randomize Route Segments*:** This function is also accessible through the route randomization function *Randomize Route Segments* (page 5). That function allows you to generate a polyline shapefile of random routes and a point shapefile of route vertices. Both shapefiles can be intersected with a polygon theme to extract polygon attributes of routes and vertices.
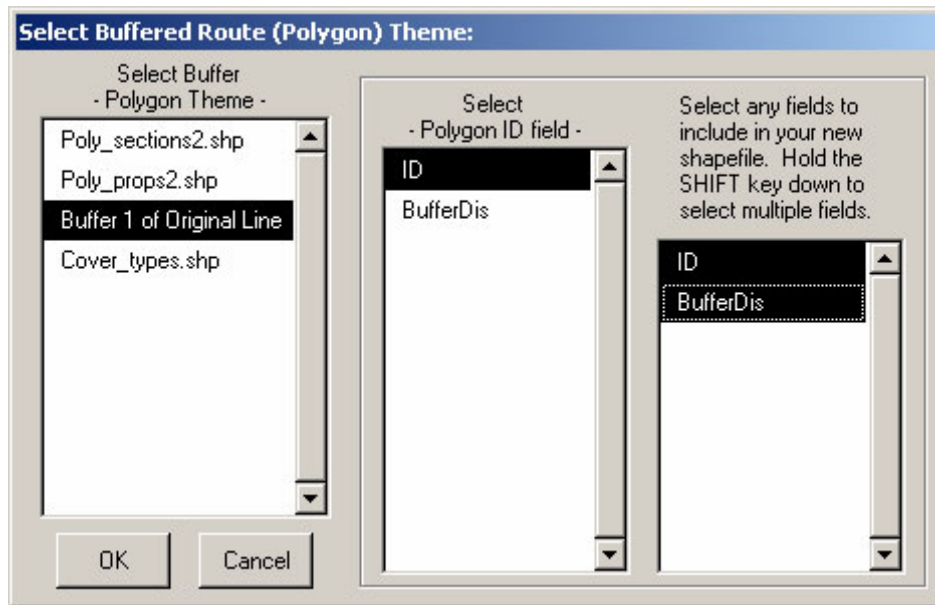
Intersect Route Polygons with Habitat Polygons:

This option is very similar to *Intersect Route Polylines with Habitat Polygons* above, except that it intersects polygons, not polylines, with a habitat polygon theme, and it reports area values instead of distance values. Any polygon theme can be analyzed this way, but the intention of the tool was really to analyze buffers around routes.
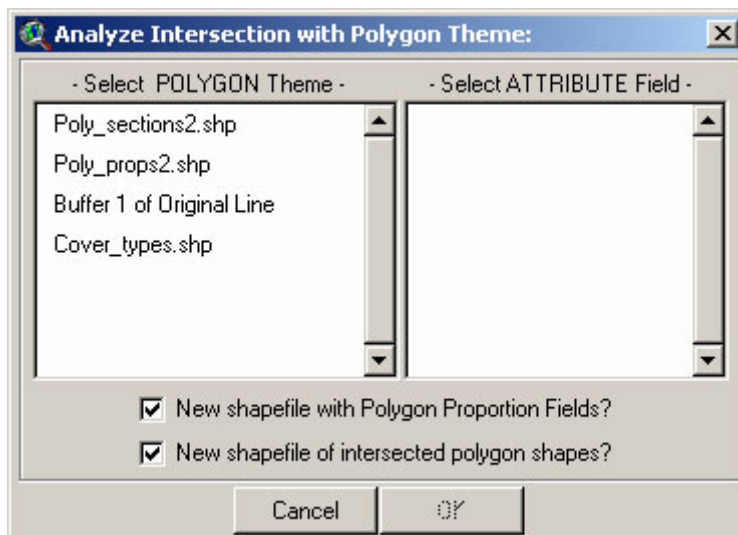

For example, we may not be completely certain of our route. We have a series of point locations, but it may not be reasonable to assume that our animal went directly from point to point. In most cases it is more likely that the animal wandered a bit in route, and therefore it would be more defensible to say that the animal traveled through a particular region rather than directly along a line. Therefore we can generate a buffer around our route to represent the probable area the animal traveled.

Use of this tool is almost identical to that of intersecting routes with polygons. First click the menu item *Intersect Route Polygons (buffers) with Habitat Polygons…* and select your buffer theme, ID field and any fields you want to add to your output:

Next identify your polygon habitat theme and specify the output you would like:
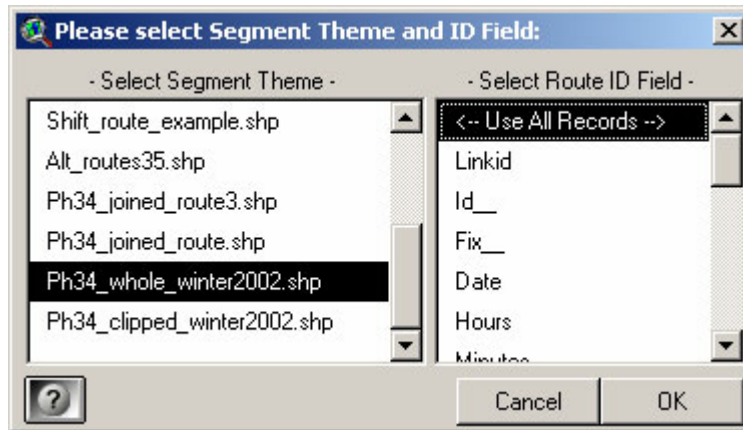
You can generate 2 types of output:

A. New shapefile with Polygon Proportion Fields: This will generate a new polygon shapefile containing all the fields you specified in the dialog box above, plus fields for the areas and proportions of each unique habitat type covered by the buffer polygons.

B. New shapefile of intersected route segments: This will generate a new polygon shapefile where each polygon represents a portion of a buffer polygon that intersected any particular habitat polygon. It will contain the following fields:

- Sect_area: The area of the segment in square map units.

- Proportion: The proportion of the original route represented by this section.

- Polygon Section ID: A unique numeric value for each record in the intersected buffer shapefile.

- Polygon Attribute: The attribute value contained in the specified polygon theme attribute field.

- All the original fields and values you specified in the "Select Buffered Route (Polygon) Theme:" dialog (see above).

Combine Route Segments into Route:

All of the tools in this extension are written to work on complete routes, where each polyline in a polyline theme represents the total route an animal traveled. Some tools are also written to accept point shapefiles or tables, in which case the tools assemble the routes internally prior to doing the final analysis. However, none of the tools are written to assemble route segments prior to doing the final analysis. If your input data are in a polyline dataset, where each polyline represents only a portion of the complete route you want to analyze, then you will need to combine those route segments into a final polyline theme before using any of the tools.

Click the *Combine Route Segments into Route…* menu item and select your Segment theme and Route ID field:

This segment theme can contain segments from multiple routes, so the Route ID field is used to separate segments into their respective routes. If all your segments come from a single route, and if you don't have a Route ID field available, click "<-- Use All Records -->". In this case the route polyline theme will use the segment theme name as the Route ID value.

This function will operate on either all features in a theme if no features are selected, or only the selected set of features if any are selected. In all cases, segments will be combined into routes in the order in which they appear in the attribute table.

Add Record Numbers to Table:

A few of the functions offered in this extension require that you specify a field containing values to be used to sort a set of points or records. The tools are written this way because the points or records may not be ordered correctly in the table, and the author wanted the tools to be useful regardless of the record order.
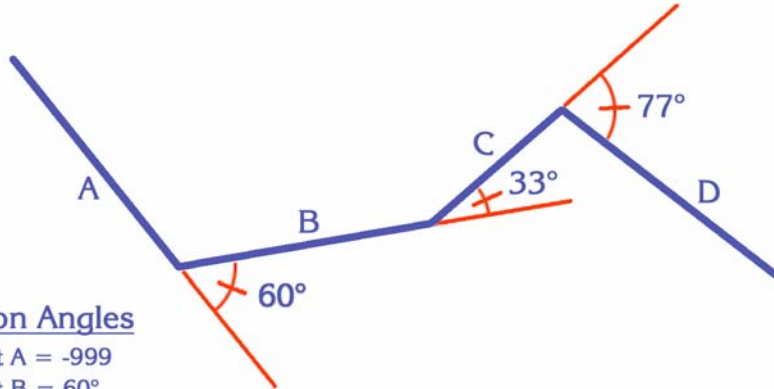
Unfortunately, this is not helpful if your records are sorted correctly and if you don't have a Sort Order field available. Therefore the author added this function to create a "Record Number" field to your table, which can be used as the sort order field in cases where the records are already sorted correctly. IMPORTANT: This function will modify your existing table and the change will be permanent. There is no UNDO operation for this. The modification is minor, though, and none of your current data will be changed. Any selection you have set will still be there after the operation.

All you need to do is open your table, click the "Edit" menu, and then click "Create Record Number Field". The table does NOT need to be set to Editable prior to this. The tool will add a field named [rec_num] and populate it with record number values. If a field named [rec_num] already exists in your table, the tool will append an index number to the name until it finds a name that does not exist in your table (i.e. [rec_num_1], [rec_num_2], etc.)

Additional Topics

Average Vertex Angles

Deviation Angle: This value reflects how much the bearing (in degrees) of a particular segment deviates from the bearing of the segment prior to it. High deviation angles indicate that the path changes direction a lot. This deviation value will be equal to 0° if the segment continues on the exact same bearing as the segment before it, and 180° if the path doubles back and goes in exactly the opposite direction.
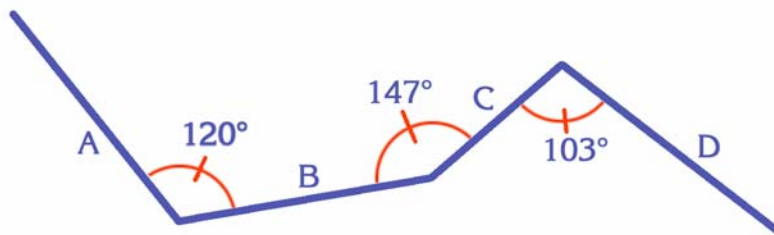

Deviation Angles
Segment A = -999
Segment B = 60°
Segment C = 33°
Segment D = 77°

$$\text{Average Deviation Angle} = \left(\frac{60+33+77}{3}\right) = 56.7°$$

Internal Angle: This value reflects the internal angle (in degrees) formed by the two route segments and will always be less than or equal to 180°. This value will be equal to 180° if the segment continues on the exact same bearing as the segment before it, and 0° if the path doubles back and goes in exactly the opposite direction.
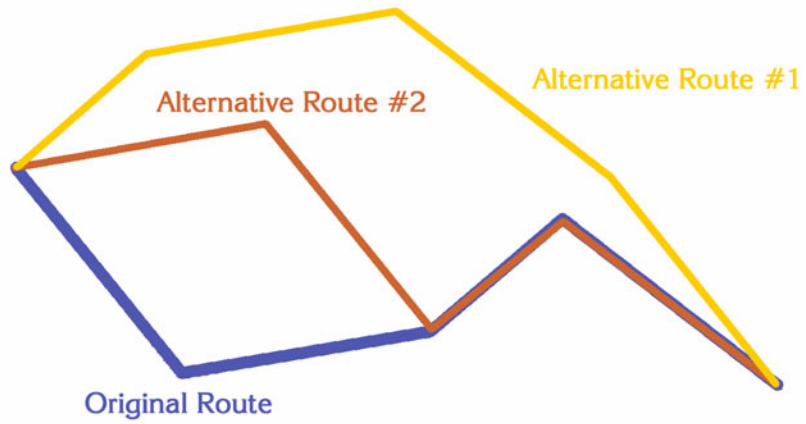

Internal Angles
Segment A = -999
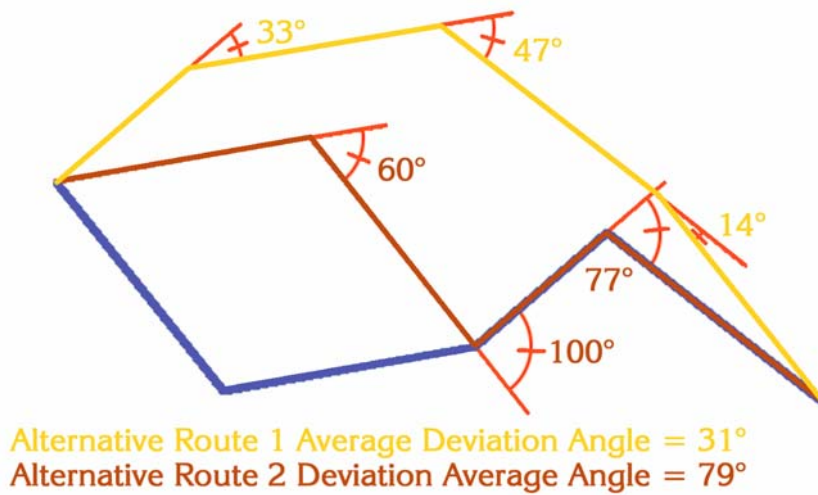Segment B = 120°
Segment C = 147°
Segment D = 103°

$$\text{Average Internal Angle} = \left(\frac{120+147+103}{3}\right) = 123.3°$$

Deviation and Internal angles are supplementary so the values for each will sum to 180°.

In general, alternative routes can have considerably different average angles than the original line, which would likely indicate different styles of movement. For example, given 2 alternative routes derived from the route illustrated above:

We can calculate the average deviation of both alternative routes and see that Alternative Route #1 is considerably straighter than the original route, while Alternative Route #2 is more crooked:
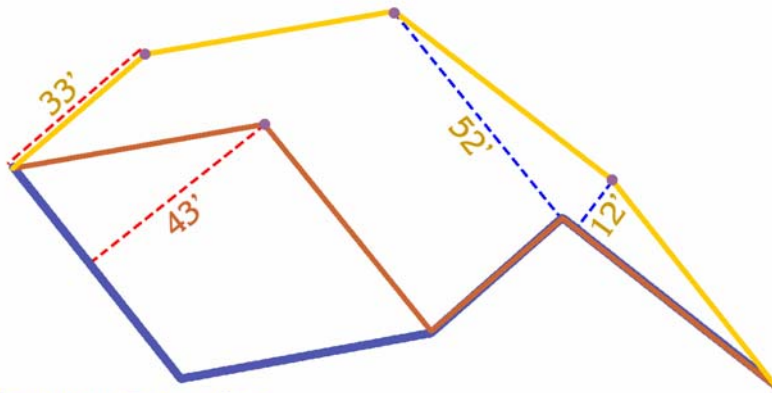

Alternative Route 1 Average Deviation Angle = 31°
Alternative Route 2 Deviation Average Angle = 79°

Vertex Distances:

The "Total Vertex Distance" and the "Average Vertex Distance" fields simply measure the distance from each vertex of the alternate lines to the closest point on the original line, and either summing up all the distances or taking the average distance per vertex.

Vertex Distances

Each Alternative Route has 5 vertices.
The first and last vertices always overlay the original line.

Alternative Route #1:
Total Vertex Distance = 0 + 33 + 52 + 12 + 0 = 97
Average Vertex Distance = 97/5 = 19.4

Alternative Route #2:
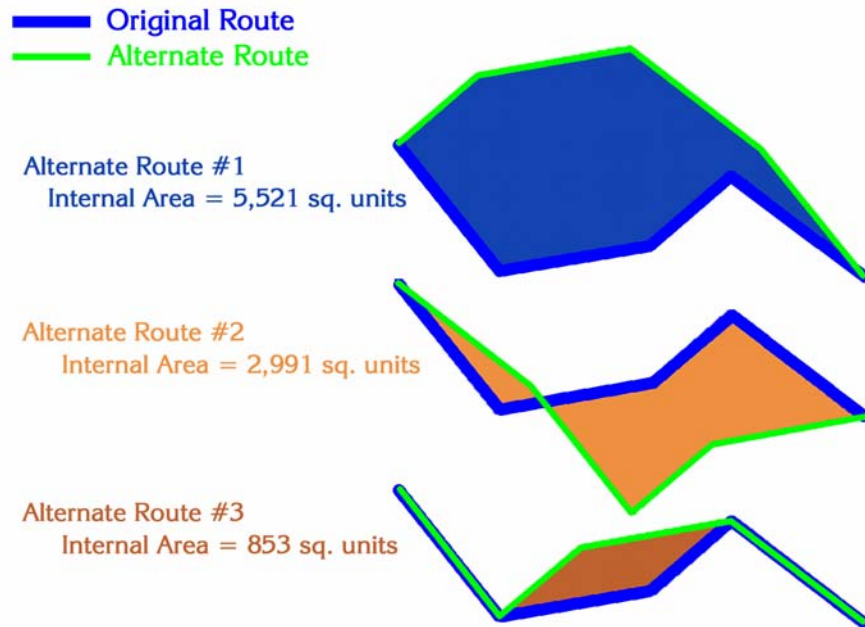Total Vertex Distance = 0 + 43 + 0 + 0 + 0 = 43
Average Vertex Distance = 43/5 = 8.6

Polygon Area Distances:

The "Distance by Polygon Area" measures the area of the polygon bounded by the alternate route and the original route. In this measure, alternate routes can be considered farther away if the land area between that route and the original route is large. If you like, you can save these polygons into a separate shapefile. They are hard to view because they overlay each other, but the polygon feature attribute table will include fields for the Polygon Area, the Original Line ID (if you've selected it), the Alternate Line ID (if you've selected it), Unique Polygon IDs, and a True/False field called "original" indicating whether this polygon is bounded by two copies of the Original Route.

Enjoy! Please contact the author if you have problems or find bugs.

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Updates to this extension and an on-line version of this manual are available at

http://www.jennessent.com/arcview/alternate_routes.htm

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