Calculating Proportion of Habitat within a Polygon Wedge Based on Point Locations and Bearings (Turning Angles)

In the analysis of animal movement data, it may be desired to calculate landscape characteristics associated with each movement step in a path. Here, a *path* is defined as the segments connecting each pair of points (i.e. the *step*) collected. The *turning angle* is the actual bearing (in degrees out of 360) at which the animal's direction changes from point to point. To help determine one possible factor as to why an animal may deviate from a straight-line path, the proportion of habitat can be measured and compared for two wedges associated with the turning angle: actual bearing (direction of turn) and previous bearing (if animal never turned). The *wedge* is analogous to a 2-dimensional cone that radiates within an angle from a point by a "buffer" distance.

These instructions enable you to create polygon shapefiles of a wedge-shaped buffer around points. Using ESRI ArcView 3.x software, you perform the following:

- Calculate bearings of turning angles along a path defined by point locations; optionally, create shapefiles for each path segment
- Create a wedge-shaped "buffer" around each point, first by radiating endpoints around each, and then by closing them into wedge-shaped polygons
- Split and then intersect each wedge with a habitat layer; join and merge
- Calculate the proportion of habitat classes available
- Repeat most of the above steps with some modification to generate wedges based on the previous bearing

You need to install **XTools** and several extensions created by Jeff Jenness: **Path of Series of Features, with Distances and Bearings**, **Split Shapefiles**, and **Convex Hulls from Points** (available at http://arcscripts.esri.com/). Download and see the "read me" files for installation instructions. Also required is the **bearing_scripts.apr** project.

ORIGINAL DATA

Points.shp	Shapefile of point locations with a unique ID field
Habitat.shp	Shapefile of polygons with a habitat class field

CREATED DATA

Result.dbf	DBase table of the bearing angles between each pair of points
Endpoints.shp	Shapefiles resulting from radiating endpoints about each central point to outline the wedge
Wedges.shp	Shapefile of all the wedges created from convex hulls around each set of points
HabitatWedges.shp	All shapefiles from a batch overlay of each wedge intersected with Habitat.shp
Proportion.dbf	Dbase table summarizing area of each class

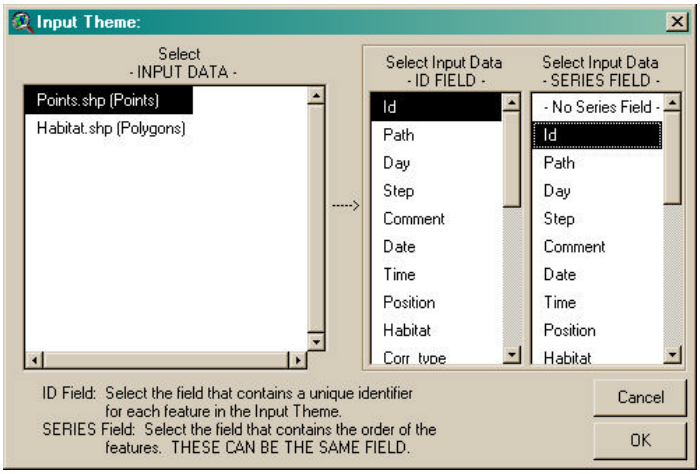
Steps in ArcView 3.2:

1. Start ArcView 3.2
2. Open the **bearing_scripts.apr** project

If you get dialog boxes asking for the location of particular files, it means you need to install the extensions indicated above.

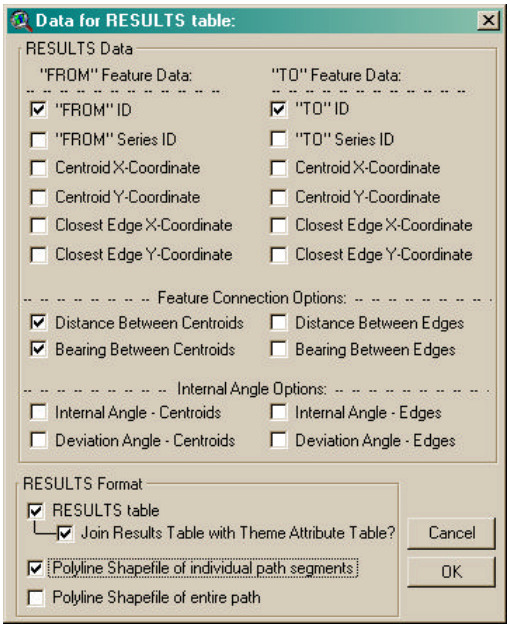
3. Open a new view (*XTools defaults may need to be set*)
4. Click the ADD DATA button and select **Points.shp** and **Habitat.shp** 
5. Choose FILE >>> SET WORKING DIRECTORY to specify the output path and then save the project

Calculating the Bearing and Creating Path Segments:



6. Click on the FIND PATH button 
7. Select **Points.shp** as the input
8. Select the ID and Series fields and click OK
9. Select the desired output DATA to be calculated by clicking a check in each box:
   - From ID
   - To ID
   - Bearing between centroids
   - Distance between centroids

As you can see, this extension has a lot of functionality. The specifications indicated here are the minimums required for this analysis.



10. Select the desired output FORMAT by clicking a check in each box:
    - Results table
    - Joined Results Table with Theme Attribute Table
    - Polyline Shapefile of individual path segments
11. Click OK
12. Click NO in the next box if your data is projected (i.e. NOT geographic in units of decimal degrees)
13. Click Ok in the next box to ignore it
14. Navigate to where you want to save the outputs and specify the output names as prompted; e.g. **Result.dbf** and **Segments.shp**
15. Click OK

16. In the table of contents, click on **Points.shp** to make it the active theme 
17. Click on the OPEN THEME TABLE button to open the attribute table
18. In the **'Attributes of Points.shp' table**, scroll over to inspect the joined fields from the **Result.dbf** table
19. Click on the ADD FIELDS button 

The script attached to this button will automatically code each point with the previous ID to use in a later join of the previous angle for analyzing the wedge if the animal never deviated from the path, and to correct any empty values in the bearing field. The Radiate Shapes around Points script will not accept values outside the range of 0 to 360 (including nulls). It also adds X and Y coordinates.

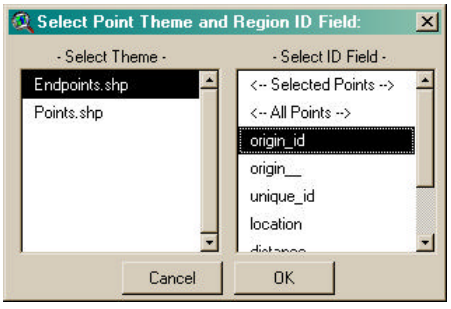
20. Select the ID, BEARING, and DISTANCE fields as prompted and set BUFFER
21. Click YES to save edits
22. Scroll to the right to inspect the new fields (*Note: [PreBEARING] is empty and waiting for a table join and calculation later on.*)

Creating the Wedge-Shaped "Buffers":

1. Activate the View with the Points.shp theme
2. Click on the RADIATE SHAPES AROUND POINTS button 
3. Select **Points.shp** as the feature theme to work on and click OK
4. Select **[ID]** as the ID Field and click OK
5. Select **[BEARING]** as the original bearing field and click OK
6. Select the **[DISTANCE]** OR the **[BUFFER]** field as the segment length to radiate outward from the center points
7. Enter a positive numeric value (within 0-360 degrees) to adjust the angle of rotation about the center points; e.g. **45**
8. Select **POINT** as the output shapefile feature type and click OK
9. Navigate to where you want to save the output and specify a name as prompted; e.g. **Endpoints.shp**
10. Click OK
11. Turn on the new theme once it is added to the view

The new shapefile approximates the outline of a wedge centered along the turning angle as if the point was buffered between angles. To create the actual wedge polygon "buffer," simply connect the dots.

12. Click on the CONVEX HULL AROUND POINTS button 



13. Select **Endpoints.shp** as the input theme
14. Select **[origin_id]** as the ID field
15. Click OK
16. Navigate to where you want to save the output and specify a name as prompted; e.g. **Wedges.shp**
17. Click OK

You now have polygon areas representing the buffer by angle area around each point in the path. Join this to the original point attribute table to retain important field values.

18. In the table of contents, highlight both **Points.shp** and **Wedges.shp** by holding the SHIFT key on the keyboard and clicking on each with a left click of the mouse
19. Click the OPEN THEME TABLE button
20. Activate the **'Attributes of Point.shp' table**
21. Choose TABLE >>> REMOVE ALL JOINS
22. Highlight the **[ID]** field by clicking on the heading
23. Activate the **'Attributes of Wedges.shp' table**
24. Highlight the **[origin_id]** field by clicking on the heading 
25. Choose TABLE >>> JOIN or click on the JOIN button

The above steps must be completed in the order that they are presented to get the correct table join of original point attributes associated with the corresponding wedges. The attributes will be retained during the split and subsequent intersection procedures – very useful for identification purposes later on.

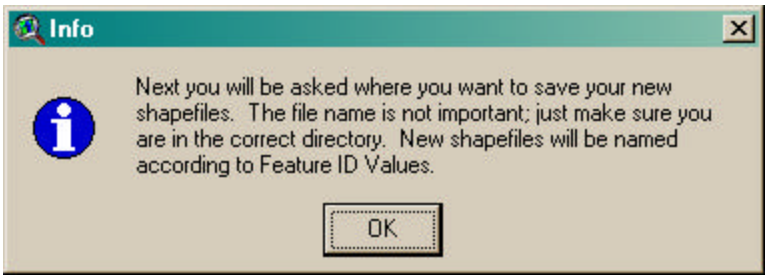
Splitting and Intersecting Wedges with Habitat:

The result of the Convex Hull around Points extension is a merged shapefile of all wedges. If you were to simply intersect this merged file with the habitat theme, you would not get the exact results needed; i.e. habitat within each complete wedge where wedges overlap one another. The Split Shapefile extension, Overlay Batch Script Writer script, and XTools extension fixes the overlap problem.

1. Close any open tables
2. Return to the View window 
3. Click on the SPLIT SHAPEFILE button
4. Select **Wedges.shp** as the feature theme to split apart and click OK
5. Select **[origin_id]** as the unique identification field

If your joined table includes a more descriptive field then you may use that; e.g. a text field that identifies the path and step from your original field data.

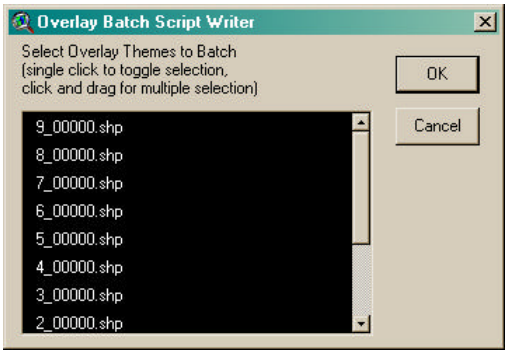
6. Click OK twice – *take note of the Info Box message*



7. Navigate to the directory to save the split shapefile outputs and click OK

TIP: It's a good idea to create a separate folder in your working directory to organize your files – especially if you will be analyzing several paths!

8. Click OK to dismiss the window once you have read the report indicating how many new shapefile have been created
9. Open a **new** view – **View2**
10. Click the ADD DATA button to add all the split shapefiles to View2
11. Click on the OVERLAY BATCH SCRIPT WRITER button 
12. Select **INTERSECT** as the overlay method and click OK
13. Hold the SHIFT key on the keyboard while clicking and dragging the mouse in the list box to **select <u>all</u> themes** to overlay – or hold down SHIFT and click each

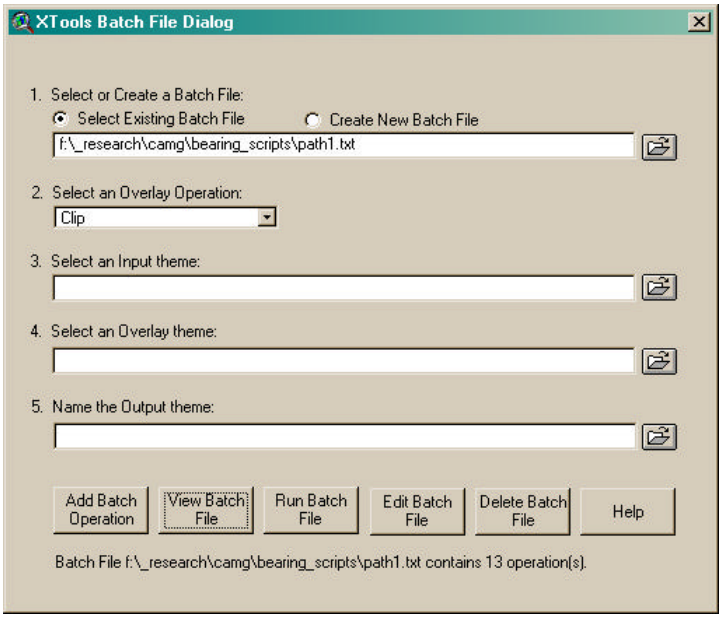


14. Click OK
15. Navigate to the directory containing the INPUT theme to select it; e.g. **Habitat.shp**
16. Type an output name for the text file; e.g. **path1.txt** – the extension is important!
17. Click OK

You should get a success message, which means you can use the script in XTools Batch Overlay tool to automatically intersect.

*ALL THEME INPUT/OUTPUT PATHS ARE ASSUMED TO BE THE **WORKING DIRECTORY**! Edit Batchscript in Notepad.*

18. Choose XTOOLS >>> XTOOLS BATCH OVERLAY
19. Click the BROWSE button to select the existing **path1.txt** batch script – *this interface also enables you to create batch scripts by selecting one file at a time*
20. Optionally, click on the VIEW BATCH FILE button to see what the file looks like; CLOSE when done
21. Click on the RUN BATCH FILE button
22. Click OK when the process finishes
23. CLOSE the XTools Batch File Dialog (click on the X button in the upper right corner)



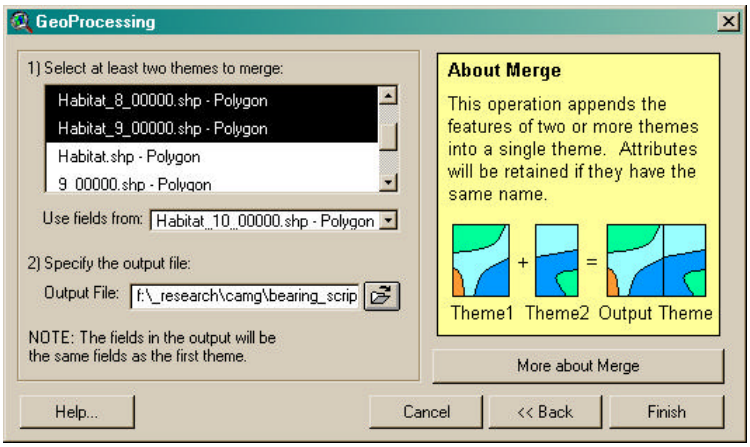
24. Hold the CTRL key on the keyboard and click in one of the empty check boxes to turn ON all themes at once – *you now have individual **habitat wedges**!*
25. Scroll through the table of contents to inspect the new theme names

The Overlay Batch Script Writer defaults to naming all outputs with the INPUT shapefile name concatenated with a "_" and the overlay shapefile name. Use this name to uniquely identify each wedge before merging and summarizing class areas.

26. Click on the SOURCE NAME button – *to automatically add a new field called "Source_Name" to all themes in the View*

27. Click on the FETCH GEOPROCESSING WIZARD button

28. Select MERGE as the operation and click NEXT
29. At step 1's selection list box, scroll down until you see the last split shapefile ("habitat_*" concatenated with the ID number)
30. Hold the SHIFT key on the keyboard while clicking and dragging the mouse UP the list box to **select <u>all</u> intersected themes** to merge – or hold down SHIFT and click each



31. Make sure that one of the "habitat_*" themes is selected in the 'Use fields from' selection box
32. At step 2, specify an output directory and shapefile name; e.g. **HabitatWedges.shp**
33. Click FINISH
34. Hold the CTRL key on the keyboard and click in one of the check boxes to turn OFF all themes at once
35. Turn on the new **HabitatWedges.shp** theme to examine it
36. Activate the theme and click on the OPEN THEME TABLE button

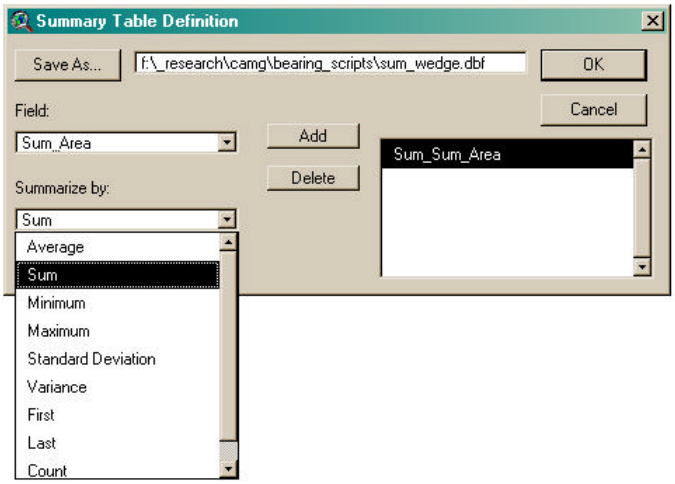
Calculating Proportion of Habitat:

37. With the **'Attributes of HabitatWedges.shp' table** active, choose XTOOLS >>> CALCULATE AREA, PERIMETER, LENGTH, ACRES, HECTARES
38. Scroll to the furthest right column to see the newly added fields

NOTE: If you need to change the units, choose XTOOLS >>> VIEW/CHANGE XTOOLS DEFAULTS.

39. Choose XTOOLS >>> SUMMARIZE MULTIPLE FIELDS
40. Select **[Landcov_]** (*or the habitat class field name*) and **[Source_Name]** by holding the SHIFT key as you click on each – *you may need to scroll if the list is long*
41. Click OK
42. Select **[Area]** and **[Perimeter]** for the summarization fields
43. Click OK
44. Specify and output directory and file name for the resulting table; e.g. **Proportion.dbf**
45. Click OK
46. Enlarge and examine the table

XTools nests the statistics by habitat class AND wedge name. The summarized area, perimeter, and count fields can be used for calculating simple proportion and landscape patch metrics.



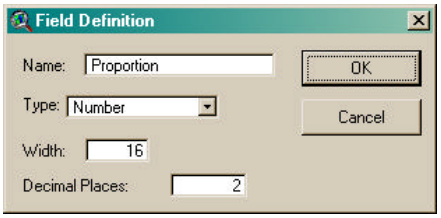
47. Click on the **[Source_Name]** heading to select it

Quickly calculate the total area for each wedge.

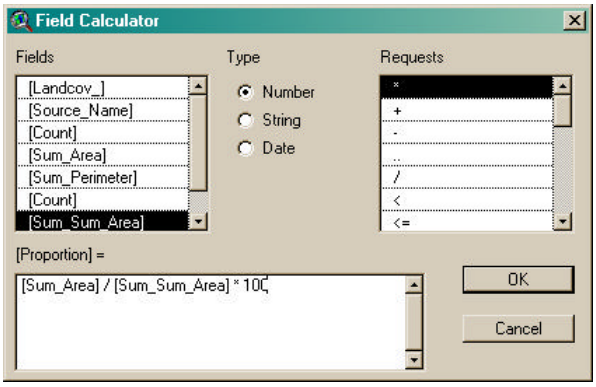
48. Choose FIELD >>> SUMMARIZE – *this is ArcView's original version of table summarization*
49. Select the field **[Sum_Area]** and summarize by **[Sum]**

50. Click the ADD button
51. Specify an output name; e.g. **sum_wedge.dbf**
52. Click OK – *all the records in the output have the same values; not surprising since each wedge was created equally!*
53. In the new table, click on the **[Source_Name]** heading to select it
54. Activate the **Proportion.dbf** table – it's **[Source_Name]** heading should still be selected from before

Now join this table with Proportion.dbf to facilitate the proportion calculation.



55. Click the JOIN TABLES button
56. Choose TABLE >>> START EDITING
57. Choose EDIT >>> ADD FIELD
58. Name the new field "**Proportion**" and specify **2** decimal places for the Number type
59. Click OK



60. Choose FIELD >>> CALCULATE or click on the CALCULATE button
61. Enter the following expression:

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[Sum_Area] / [Sum_Sum_Area] * 100
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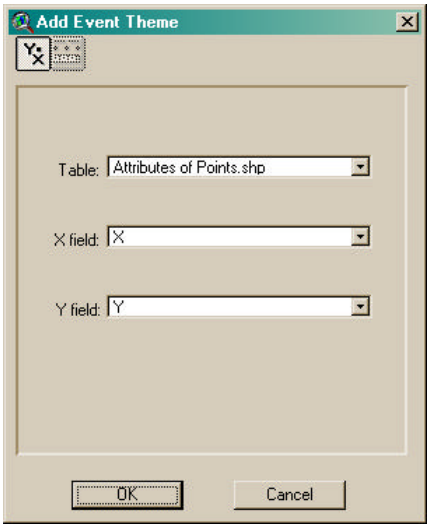
62. Click OK
63. Optionally, add more fields and calculate more landscape patch metrics
64. Choose TABLE >>> STOP EDITING
65. Click YES to save edits

The Proportion.dbf table contains percent composition of classes within each wedge!

Repeating the Analysis for Wedges Based on the Previous Bearing:

1. Close all the tables and open a **new** view – **View3**
2. ADD the **Points.shp** theme
3. Choose VIEW >>> ADD EVENT THEME
4. Select **'Attributes of Points.shp'** as the table
5. Select the X and Y fields then click OK

The event theme that is added is identical to the original Points.shp theme. This is a quick and dirty way to make a duplicate table available for joining and calculating attributes based on the [preID].

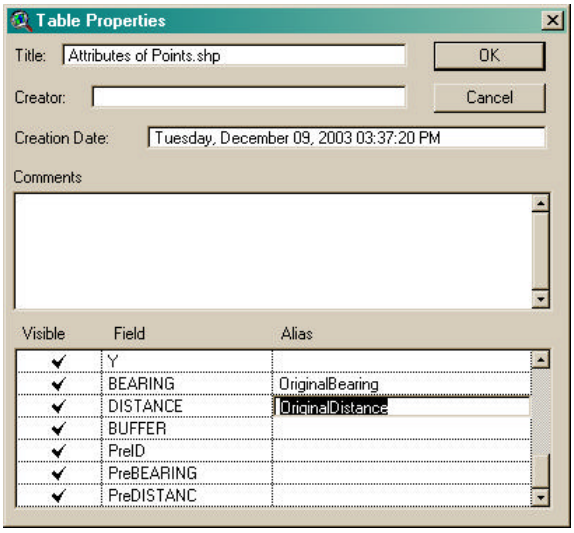


6. In the table of contents, highlight only **'Attributes of Points.shp'**
7. Choose THEME >>> PROPERTIES
8. Change the name to **Original Points.shp**
9. In the table of contents, hold the SHIFT key to highlight both themes
10. Click the OPEN THEME TABLE button

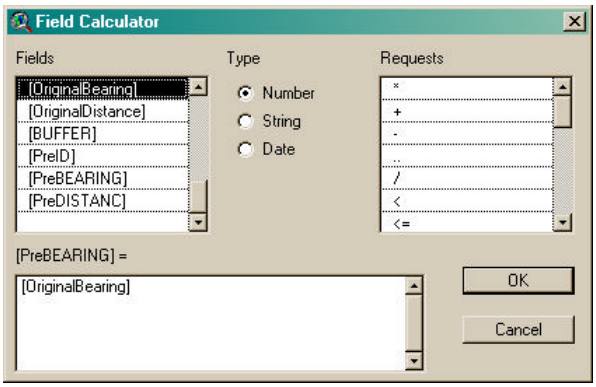
Now, join by [preID] field and calculate the [prevBearing] and [preDISTANCE]. Follow the order of steps exactly.

11. In the **'Attributes of Original Points.shp'** table highlight the **[ID]** field
12. In the **'Attributes of Points.shp'** table, highlight the **[preID]** field
13. Click the JOIN TABLE button

Notice that the various headings are duplicates. You need to set an Alias name for the second [BEARING] and [DISTANCE] fields, to access them in the calculation.



14. Choose TABLE >>> PROPERTIES
15. Scroll down to select the *last* **[BEARING]**
16. Type '**OriginalBearing'** in the Alias column
17. Scroll down to select the *last* **[DISTANCE]**
18. Type '**OriginalDistance'** in the Alias column
19. Click OK
20. Choose TABLE >>> START EDITING



21. Highlight the **[PreBEARING]** heading
22. Click on the CALCULATE button
23. Double click on the **[OriginalBearing]** field name then click OK
24. Highlight the **[PreDISTANCE]** heading
25. Click on the CALCULATE button
26. Double click on the **[OriginalDistance]** field name then click OK
27. EDIT the empty records by entering '**0**' in both **[PreBEARING]** and **[PreDISTANCE]**
28. Choose TABLE >>> STOP EDITING
29. Click YES to save edits

The previous bearing is nowassigned to each point location.

30. Choose TABLE >>> REMOVE ALL JOINS
31. Close all tables and return to **View3**
32. REPEAT the following steps, but SUBSTITUTE **[preBEARING]** and **[preDISTANCE]** in the instructions and use new output file names:
    - Creating the Wedge-Shaped "Buffers"
    - Splitting and Intersecting Wedges with Habitat
    - Calculating Proportion of Habitat
33. JOIN the final proportion table with the first by the origin_id or source name fields to easily compare differences in habitat class

Note: you may need to discard the first and last steps because there are no known previous and original turning angles respectively.