



Exercise 1

Spatial Statistics

Measuring Geographic Distributions

Upon completion of this exercise, you will be familiar with:

The Measuring Geographic Distributions toolset

Examining and interpreting the locations and distribution of spatial data

Exploring spatial relationships within your spatial data





Table of Contents

Introduction to Exercise 1.....	3
Part 1 – Open the ArcMap project and explore the project data.....	3
Launch ArcMap and open the 1MeasuringGeographicDistributions.mxd.	3
Calculate the total yearly count and averages for BigFoot Sightings.	3
Part 2 – Explore the Spatial Statistics Toolset.....	4
Launch ArcToolbox and expand the Spatial Statistics Tools toolset.....	4
Part 3 – Explore the Spatial Distribution of the data.....	5
Set up your analysis environment.	6
Locate the average lat/long of all BigFoot sightings.	7
Locate the average location of BigFoot sightings based on the Class of the sightings.	8
Locate the average location of BigFoot sightings based on the Year of the sightings.	10
Locate the most centrally located BigFoot sighting.	12
Determine how BigFoot sightings are dispersed around the mean.....	14
Determine how BigFoot sightings are dispersed around the mean over time.....	15
What is the distribution and orientation of recent BigFoot sightings?.....	20
Monitor the seasonal movement of a radio collared BigFoot.	23




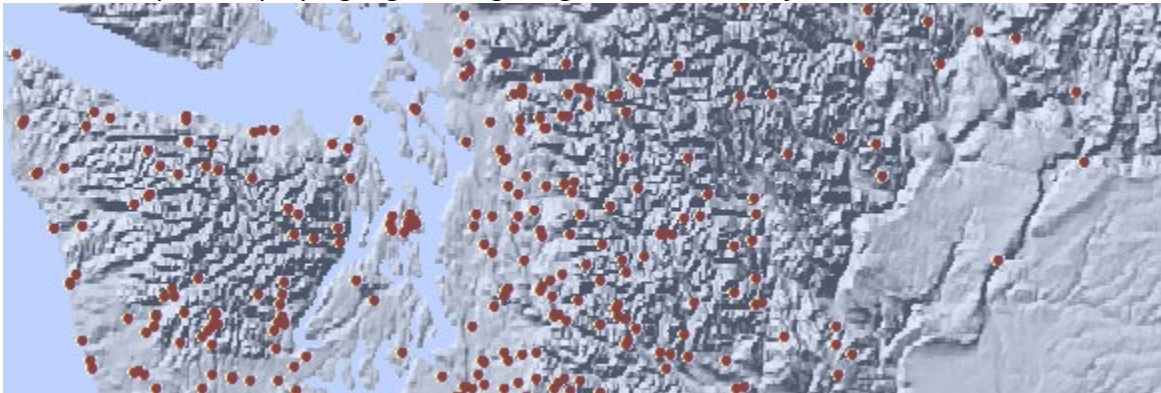
Introduction to Exercise 1

In this exercise, you will become familiar with the Spatial Statistics toolset by exploring the spatial distribution of your data. Measuring the geographic distribution of your data will enable you to identify any spatial patterns or clusters that exist.

Part 1 – Open the ArcMap project and explore the project data

Launch ArcMap and open the 1MeasuringGeographicDistributions.mxd.

1. Start ArcMap by selecting **Start | Programs | ArcGIS | ArcMap**.
2. Browse to the **..\Data** folder. 
3. Select the **Ex1_MeasuringGeographicDistributions.mxd** and click **Open**. *The map document opens displaying BigFoot Sightings across the Pacific NW.*



Calculate the total yearly count and averages for BigFoot Sightings.

1. From the *Table of Contents*, right click **BigFoot_Sightings** then select **Open Attribute Table**.

Table						
R6_BigFoot_Sightings						
	Class	Weight	Year	Count	Latitude (DD)	Longitude (DD)
▶	A	3	1861	1	-122.1062	46.32119
	A	3	1885	1	-122.9061	44.53686
	A	3	1885	1	-122.8088	44.49785
	A	3	1890	1	-124.1278	42.18827
	A	3	1897	1	-118.7133	43.52303
	A	3	1899	1	-124.3345	42.75639
	A	3	1900	1	-118.1072	46.28729

(0 out of 1439 Selected)

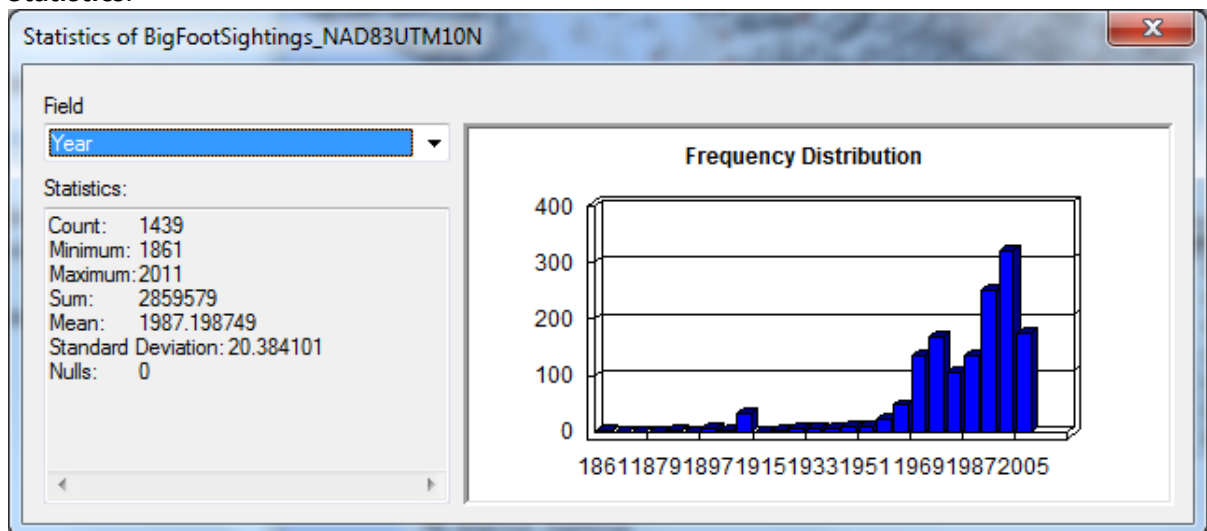
The attribute table contains information on the type or class of the sighting, the year and how many were seen and/or heard at each location. Their classes and weights include:

Type	Class	Weight
Physical	A	3
Audio	B	2
Footprint	C	1

Descriptive Statistics in ArcGIS are information that can be mathematically calculated based on data values. These tools quantify or identify characteristics of features and answer questions like, where is the center or how are the features distributed around the center? They help us summarize the spatial characteristics for a set of features.

NOTE: You can easily get descriptive statistics about your data by opening the attribute table, right clicking a column heading... and choosing Statistics

- From the attribute table, *right-click* the column heading **Year**, and then choose **Statistics**.



QUESTION - What is the total amount of sightings for all years? _____

QUESTION - Is there a trend such as an increase or decrease of sightings over time? _____

- Close the *Statistics* and *Attribute* windows.

Part 2 – Explore the Spatial Statistics Toolset

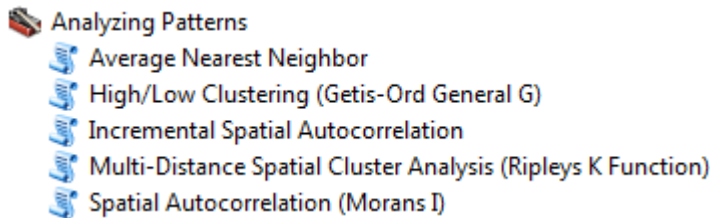
The Spatial Statistics toolbox contains statistical tools for analyzing spatial distributions, patterns, processes, and relationships. These tools incorporate space (proximity, area, connectivity, and/or other spatial relationships) directly into their mathematics.

Launch ArcToolbox and expand the Spatial Statistics Tools toolset.

- Click the **ArcToolbox** icon on the standard toolbar or from the main menu, select **Geoprocessing | ArcToolbox**.
- Scroll down to *Spatial Statistics* tools and click the **plus (+)** sign to expand the toolset.

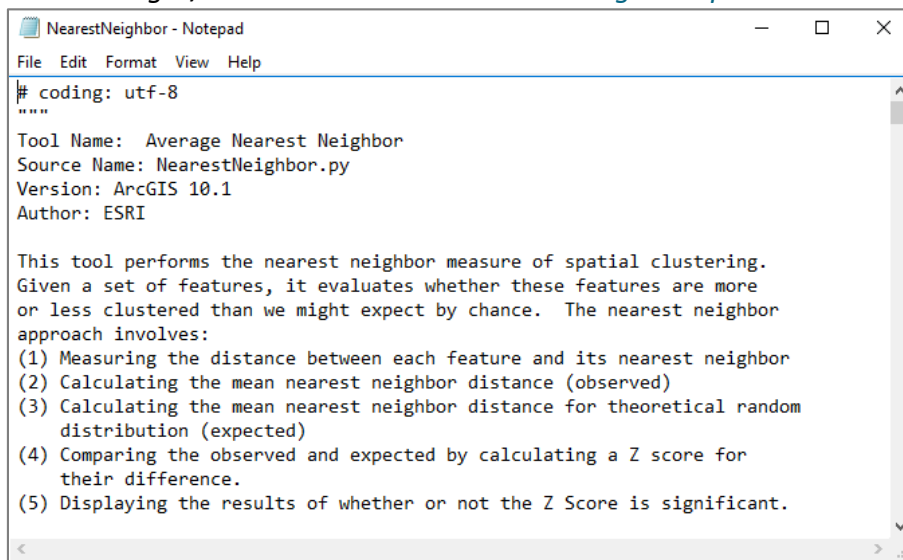


- Expand the *Analyzing Patterns* toolset. Notice the Python Script Symbol located next to each tool.



NOTE: Most of the tools in the Spatial Statistics toolbox are actually delivered as Python Scripts.

- Right-Click* the **Average Nearest Neighbor** tool and choose **Edit** from the available menu; *this will open up the underlying code that was written in Python allowing you to make changes/edits to it.* **NOTE:** Double-clicking will open the tool.



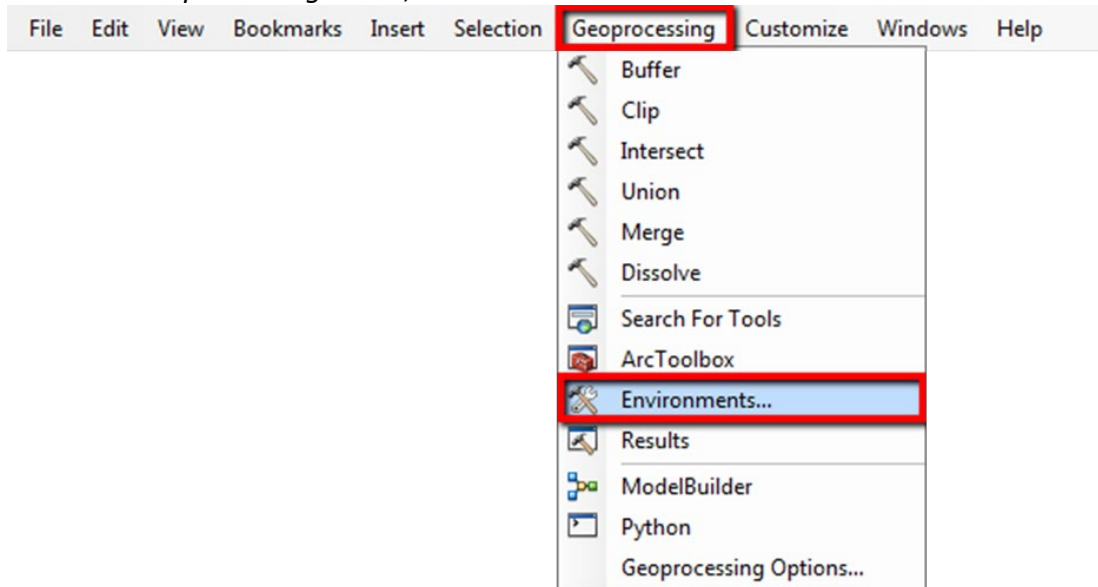
- Close** the Python window.

Part 3 – Explore the Spatial Distribution of the data

NOTE: Before you begin using tools within the Spatial Statistics toolbox, you should always set up your analysis environment. The analysis environment includes specifying a working directory, establishing an analysis mask and selecting an output coordinate system among other things.

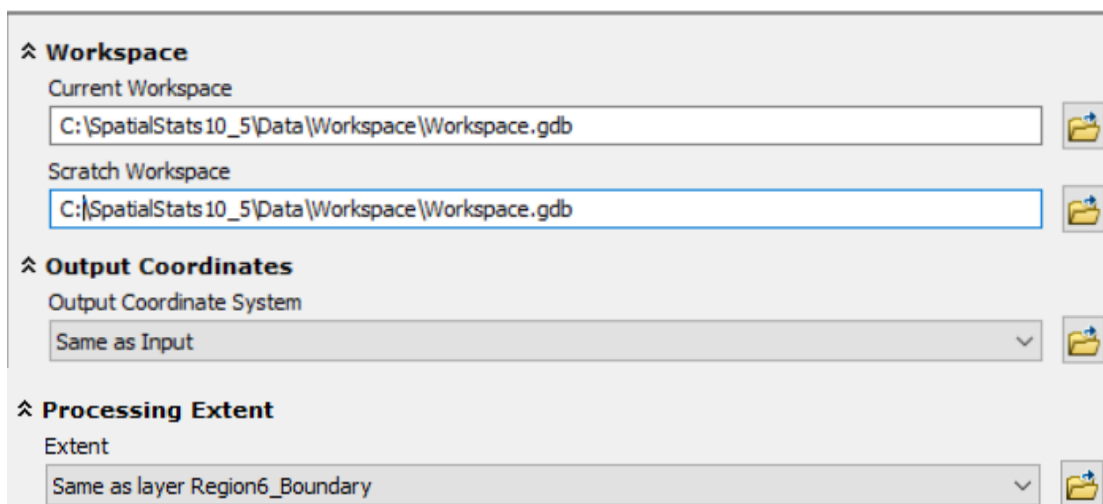
Set up your analysis environment.

1. From the *Geoprocessing* menu, choose **Environments**.



2. Set the *Current Workspace* and the *Scratch Workspace* both to **..\SpatialStats\Data\Workspace\Workspace.gdb**.
(Save the data to your own workspace location.)
3. Expand the *Output Coordinates* section.
4. Choose **Same as Input** for the *Output Coordinate System*.
5. *Processing Extent*: **Same as layer Region6_Boudary**.

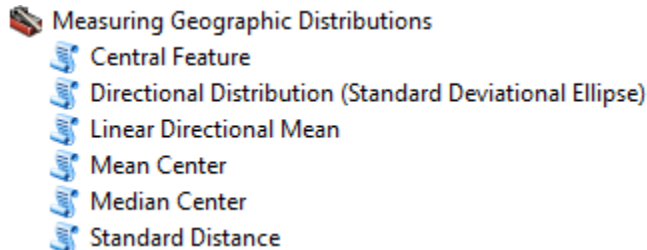
Environment Settings



6. Click **OK** to accept the changes
7. **Save** the map document. *The environment settings do not take until the map is saved!*

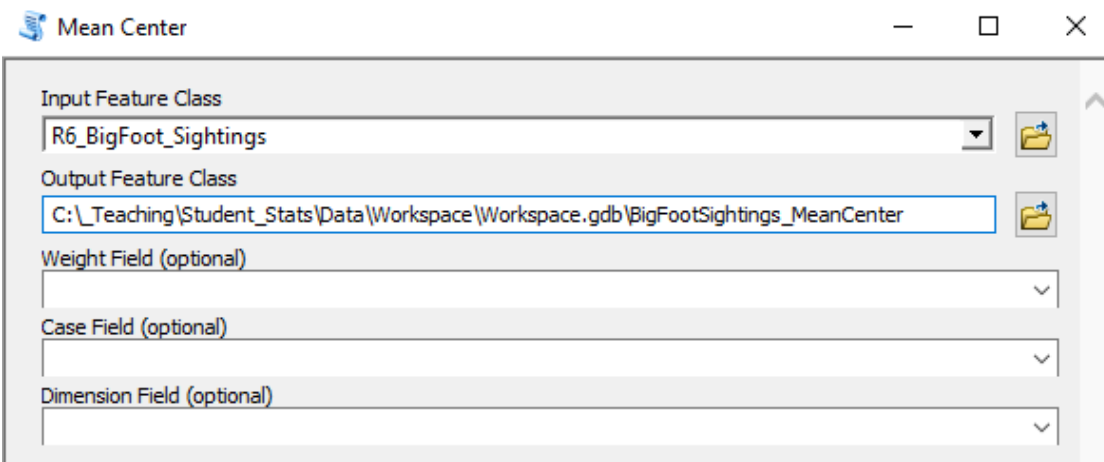
Locate the average lat/long of all BigFoot sightings.

1. From *ArcToolbox | Spatial Statistics Tools*, expand the **Measuring Geographic Distributions** toolset.



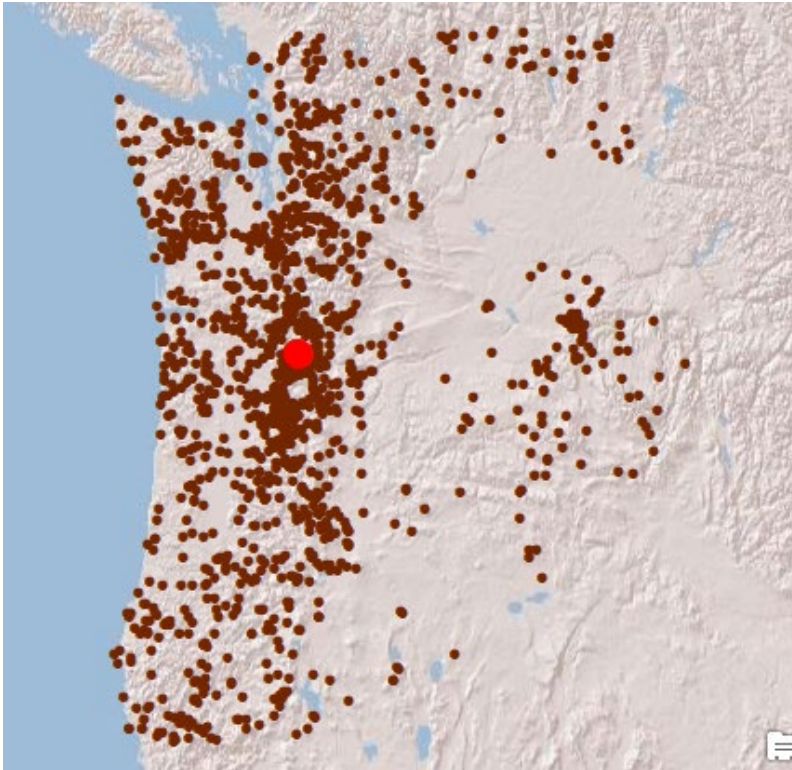
NOTE: The Measuring Geographic Distributions toolset helps summarize characteristics of spatial distribution and are useful for answering questions like: *Where's the center? Is there a directional trend to the spatial distribution of a disease outbreak? How are the features dispersed around the center?*

2. Double-click **Mean Center**. The Mean Center tool identifies the geographic center of the features in a dataset.
3. For *Input Feature Class*: select **R6_BigFoot_Sightings** from the dropdown. This layer includes BigFoot sightings from 1861-2011.
4. Enter **BigFoot_Sightings_MeanCenter** for *Output Feature Class*.



5. Accept the other defaults. Click **OK** to run the tool.

6. In ArcMap's Table of Contents, *change the symbology* of BigFoot_Sightings_Mean Center to a **large red dot**.



The average center of the distribution of all sightings is located where you see the red point. This indicates that the mean center of the sightings is west of the center of the study area and that the sightings are clustered or closer together, to the west of the study area.

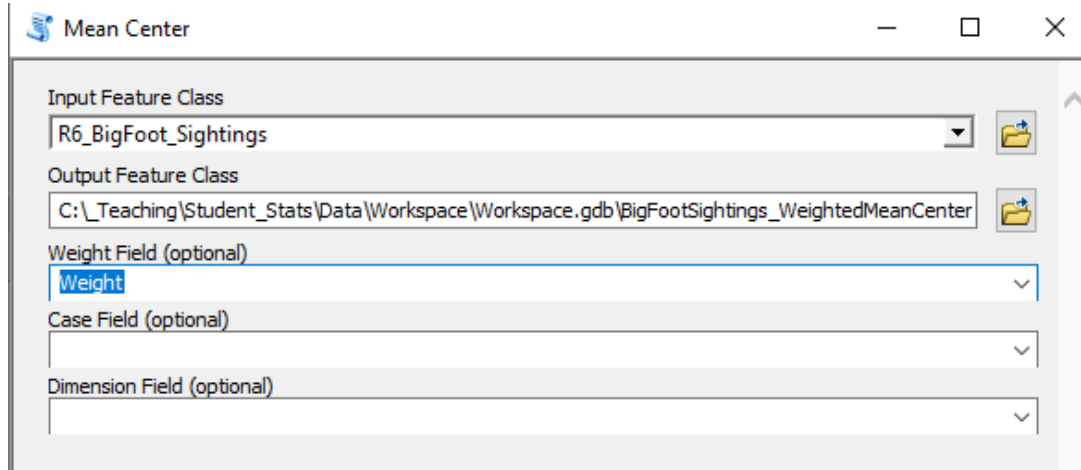
NOTE: You can use the mean center tool to find the center of features based on an attribute value by choosing an attribute to use as a weight field. Let's run the tool again using the *Class* of the sightings as a weight.

Type	Class	Weight
Physical	A	3
Audio	B	2
Footprint	C	1

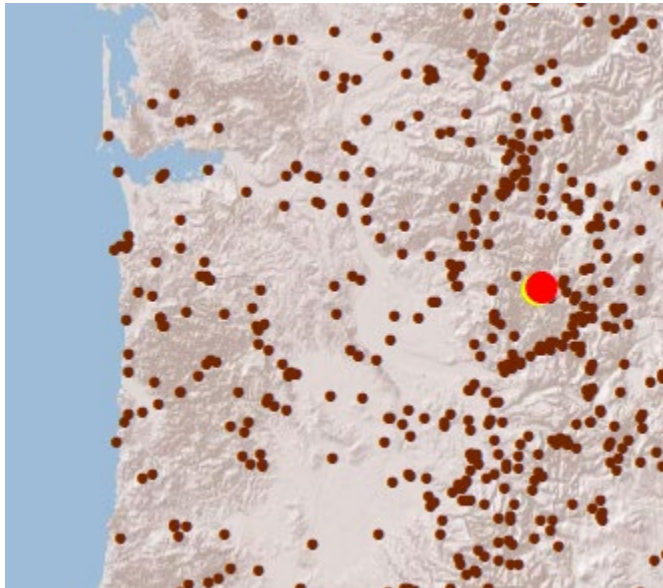
Locate the average location of BigFoot sightings based on the Class of the sightings.

1. From the *Measuring Geographic Distributions toolset*, open the **Mean Center** tool.
2. For *Input Feature Class*: select **R6_BigFoot_Sightings** from the dropdown. For *Output Feature Class*: type **BigFoot_Sightings_WeightedMeanCenter**. For the *optional Weight Field*, choose **Weight**. The Weight field contains values that correspond with the Class of the Sightings.

- Accept the remaining defaults and click **OK** to run the tool.



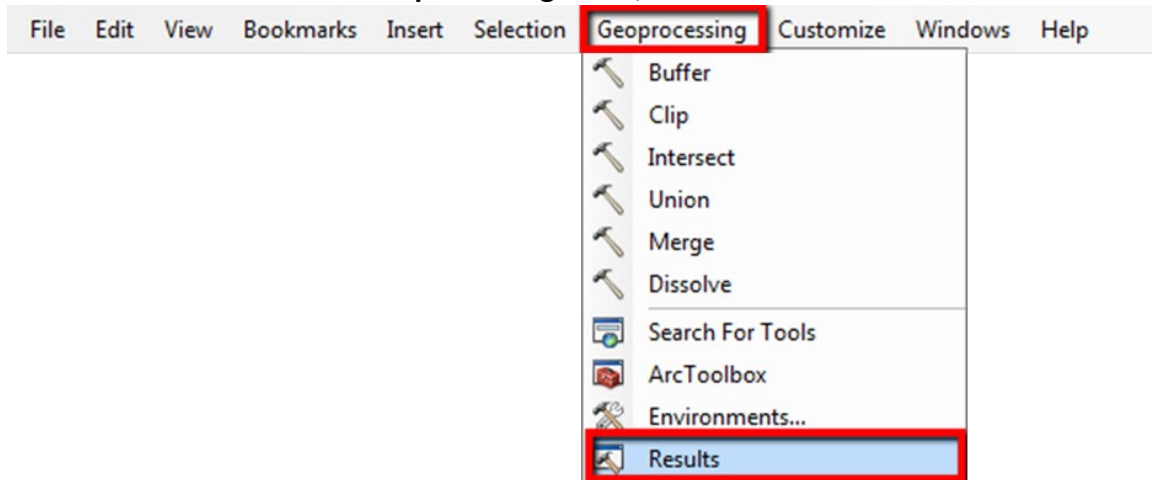
- Change the symbology to a big yellow dot.



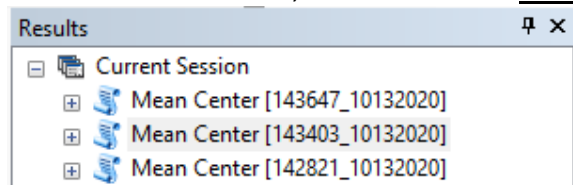
Notice the location of the weighted mean center is very close to the location of the mean center. This tells us that there are no attribute values that vary too much from the average attribute value; there are no significant outliers in this case.

Locate the average location of BigFoot sightings based on the Year of the sightings.

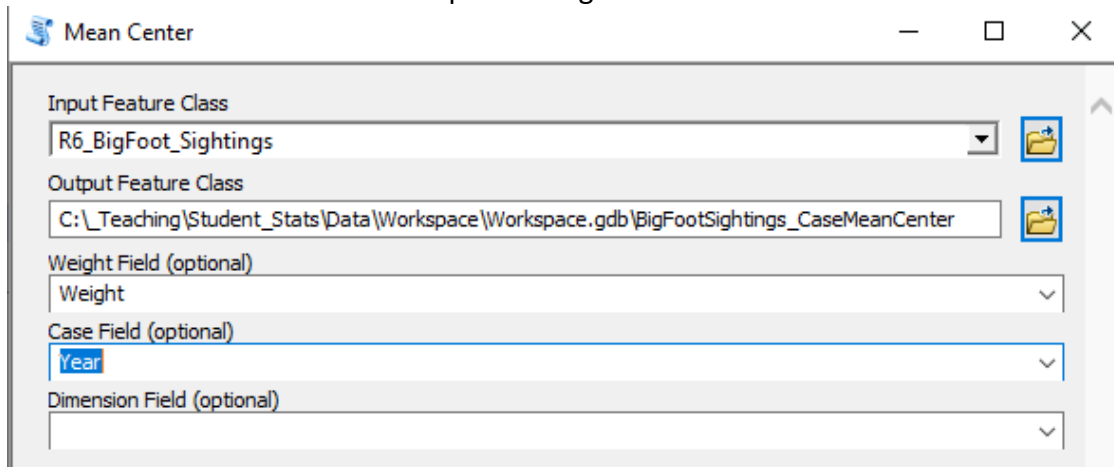
- Now let's run the tool using a class field. You can reopen previously ran tools from the Results window. From the **Geoprocessing** menu, select **Results**.



- In the *Results* window, double click the most recent run of the **Mean Center** tool.

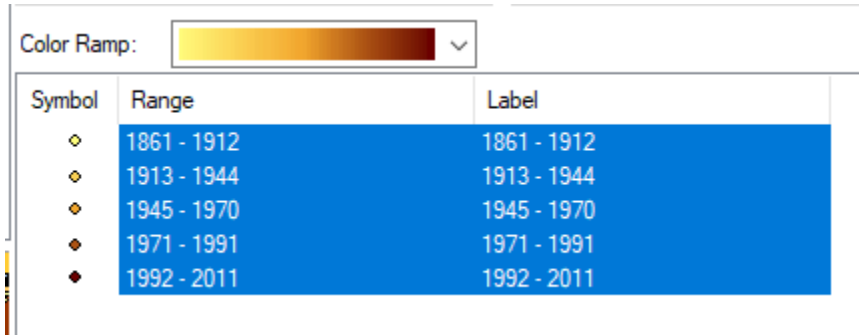


- The tool reopens with the parameters set up exactly as before. We only need to make the following changes: update *Output Feature Class* to: **BigFootSightings_CaseMeanCenter**.
- For *Case Field*: select **Year**. The Input & Weight Fields will remain the same as before.

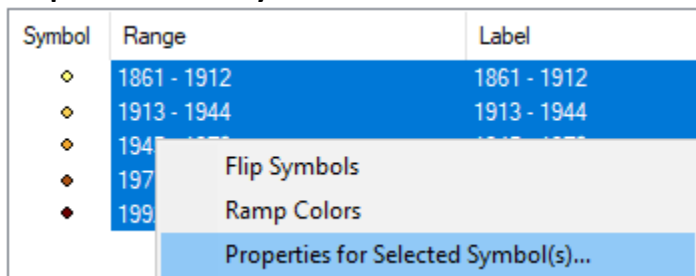


- Click **OK** to run the tool and close the Results window. Your output should have a separate point representing the average location for each year.
- Change the symbology to display each year differently. From the *Table of Contents*, double click **BigFoot_Sightings_CaseMeanCenter** to open the layer's properties.

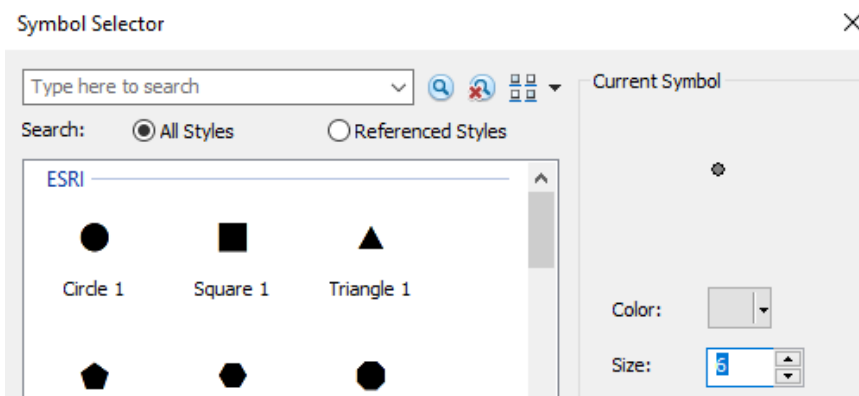
7. From the Layer Properties dialog, click the **Symbology** tab. Under **Show**: select **Quantities | Graduated colors**.
8. Under *Fields*, update the *Value*: dropdown to **Year**.
9. Hold down the Shift key and selecting all Symbols.



10. Increase the size of all points by right-clicking one of the symbols and then selecting **Properties for All Symbols...**



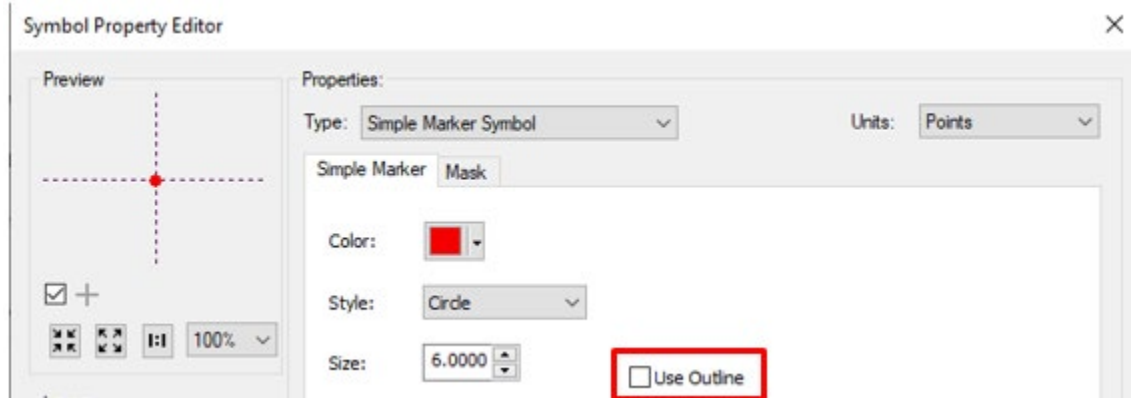
11. Increase the size to 6.



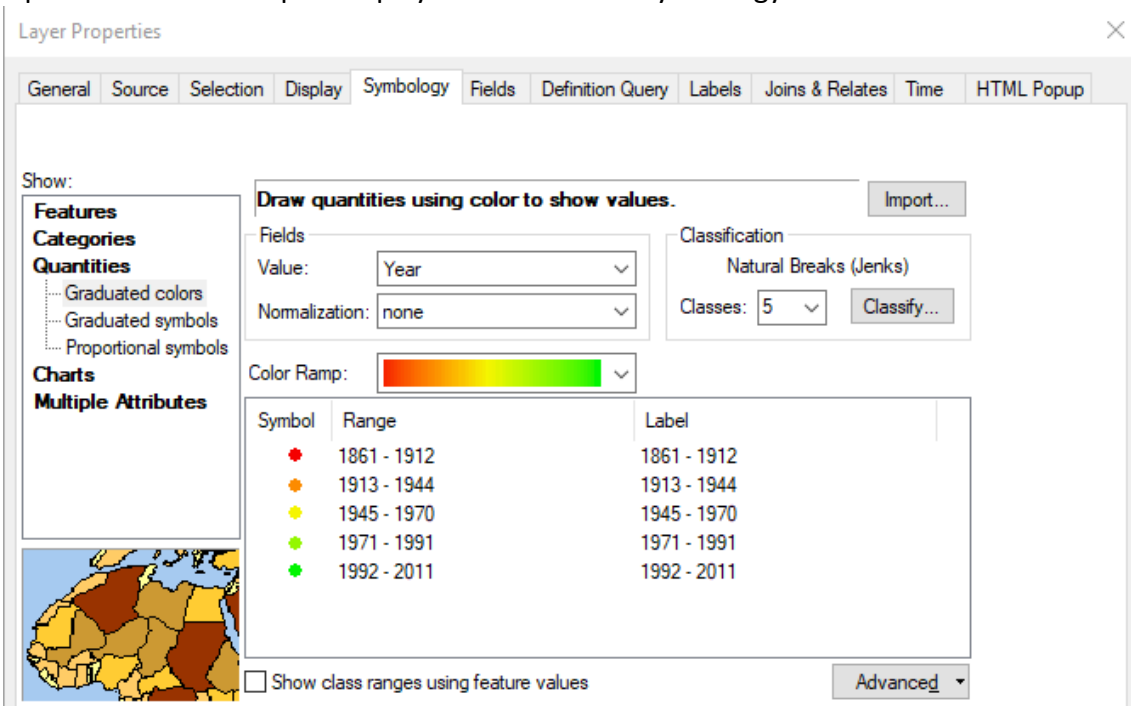
12. Click the Edit Symbol button.



13. Turn off the Use Outline checkmark and click OK.



14. Update the color ramp to display a **Red to Green** symbology.



15. Ensure the parameters you entered match those shown above and click **OK**.

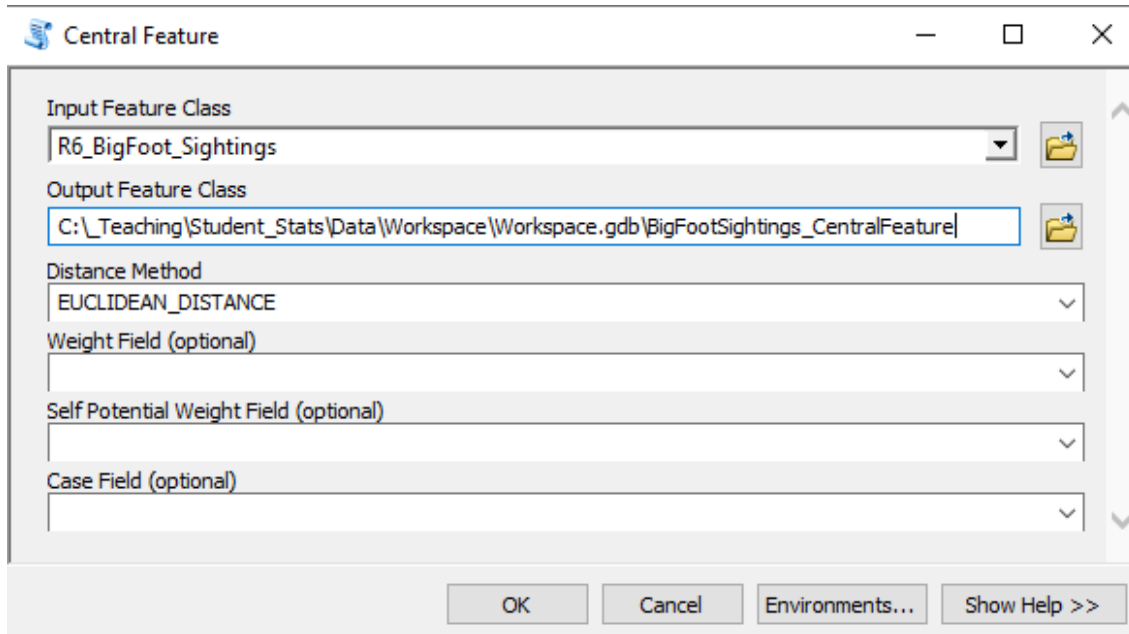
The pattern of our points suggests that over time, the sightings became more concentrated.

NOTE: The central feature tool identifies the feature that has the lowest total distance to all the other features. This tool answers the questions: *What feature is closest to all other features?* *Where are the sightings most prevalent?*

Locate the most centrally located BigFoot sighting.

1. From the Measuring Geographic Distributions toolset, open the **Central Feature** tool.

- In the Central Feature dialog, enter the following parameters: For *Input Feature Class*: select **R6_BigFoot_Sightings** from the dropdown. For *Output Feature Class*: type **BigFootSightings_CentralFeature**.



Central Feature

Input Feature Class
R6_BigFoot_Sightings

Output Feature Class
C:\Teaching\Student_Stats\Data\Workspace\Workspace.gdb\BigFootSightings_CentralFeature

Distance Method
EUCLIDEAN_DISTANCE

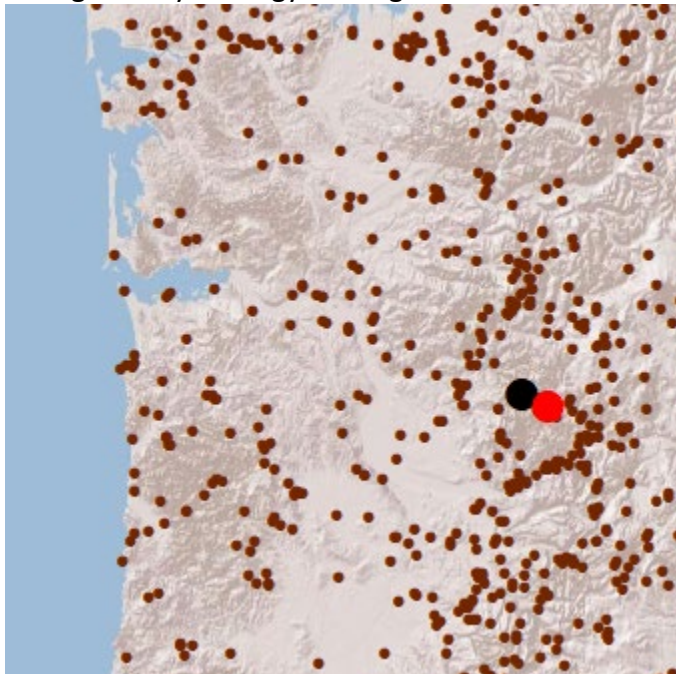
Weight Field (optional)

Self Potential Weight Field (optional)

Case Field (optional)

OK Cancel Environments... Show Help >>

- Accept all other default. Click **OK**.
- Change the symbology to a big black dot.



The location of the Central Feature compared to that of the Mean Center tells us that we do not have any extreme outliers in the dataset.

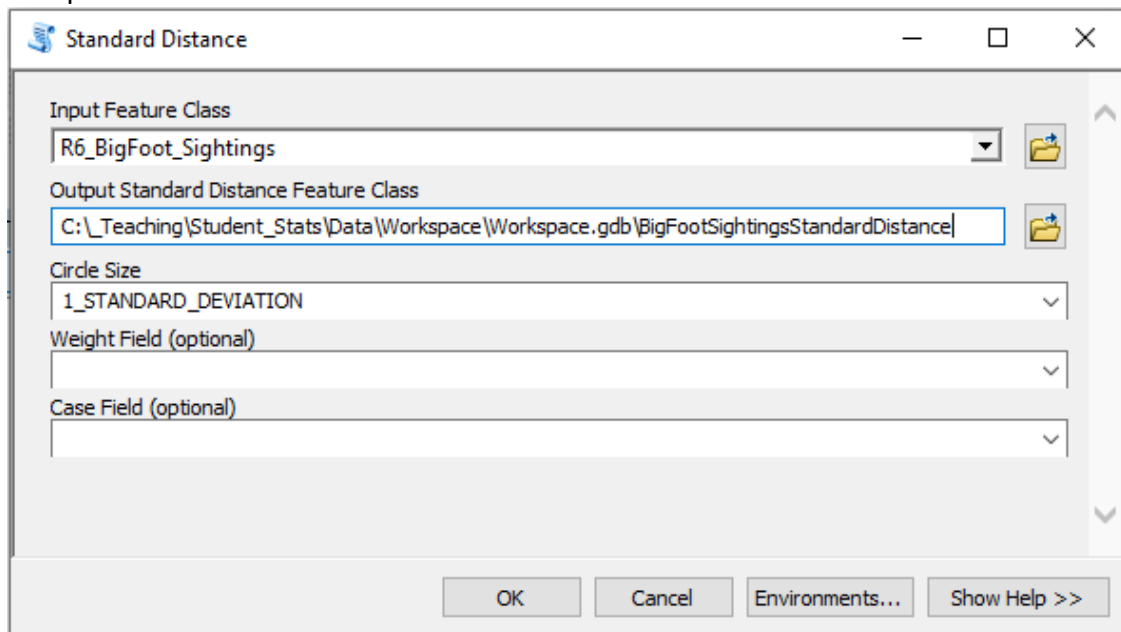
To give you a little better understanding, let's imagine a single point in the BigFoot Sighting dataset has an *inaccurate* XY location somewhere near the north pole. Think about how this would affect the output location of the Mean and Central Feature tools.

While both outputs would understandably be inaccurate, this would skew the output location of the Mean Center to be much farther North than that of the Central feature.

Determine how BigFoot sightings are dispersed around the mean.

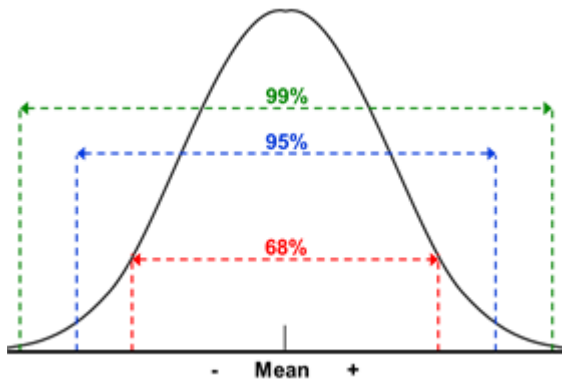
While the Mean Center and Central Feature tools tell us about the center of a distribution of our points, they don't tell us how dispersed the features are around the center. What if we need to know information about the overall distribution of the data and how the data is dispersed around the center? The Standard Distance tool will provide this evidence.

1. From the Measuring Geographic Distributions toolset, open the **Standard Distance** tool.
2. In the Standard Distance enter the following parameters: For *Input Feature Class*: select **R6_BigFoot_Sightings** from the dropdown. **BigFootSightings_StandardDistance** for *Output Feature Class*. Select **1 Standard Deviation** for *Circle Size*.
3. Accept all other defaults.

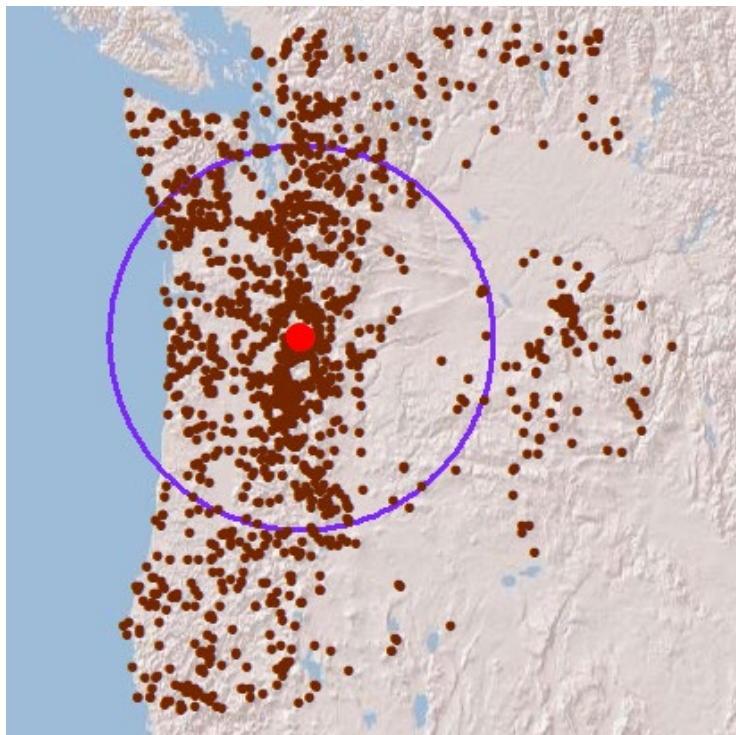


4. Click **OK**.

We chose 1 standard deviation for the sample size, 1 standard deviation includes 68% of the data that is closest to the mean in the analysis. Run the tool again with 2 or 3 standard deviations. The ellipses will include a larger percentage of points.




NOTE: The standard distance ellipse shows that a majority of BigFoot sightings occur within a specific region and indicates possible clustering.



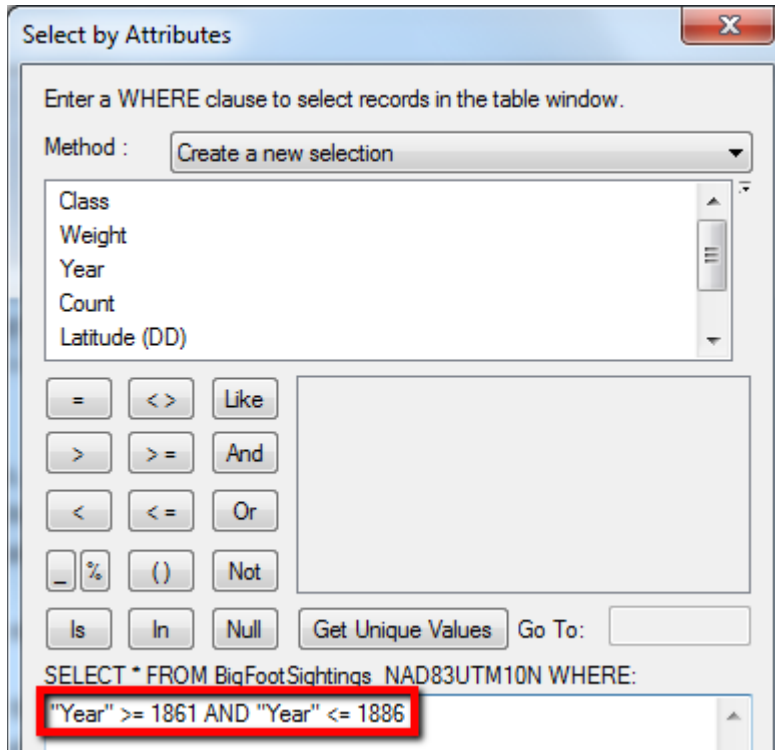
Determine how BigFoot sightings are dispersed around the mean over time.

Let's include time in our analysis. We have 150 years of BigFoot sighting data. By creating a new "Case" field for R6_BigFoot_Sightings that includes 25 year increments, we can monitor the change of sightings over time.

1. Open the attribute table for **R6_BigFoot_Sightings**.
2. From the *Table Options* pull-down, select **Add Field**. 
3. From the *Add Field* dialog, enter **Case** for the name.
4. Leave *Type* as **Short Integer**.
5. Click **OK**. You should see the new field to the far right of the attribute table
6. Now, one at a time, we will select each span of years as outlined in the chart (below) and assign the appropriate Case value. Click the **Select by Attribute** button.

Time	1861—1886	1887—1911	1912—1936	1937—1961	1962—1986	1987—2011
Case	1	2	3	4	5	6

7. In the Select by Attribute dialog, enter the following query in the query window: **"Year" >= 1861 AND "Year" <= 1886**



Select by Attributes

Enter a WHERE clause to select records in the table window.

Method : Create a new selection

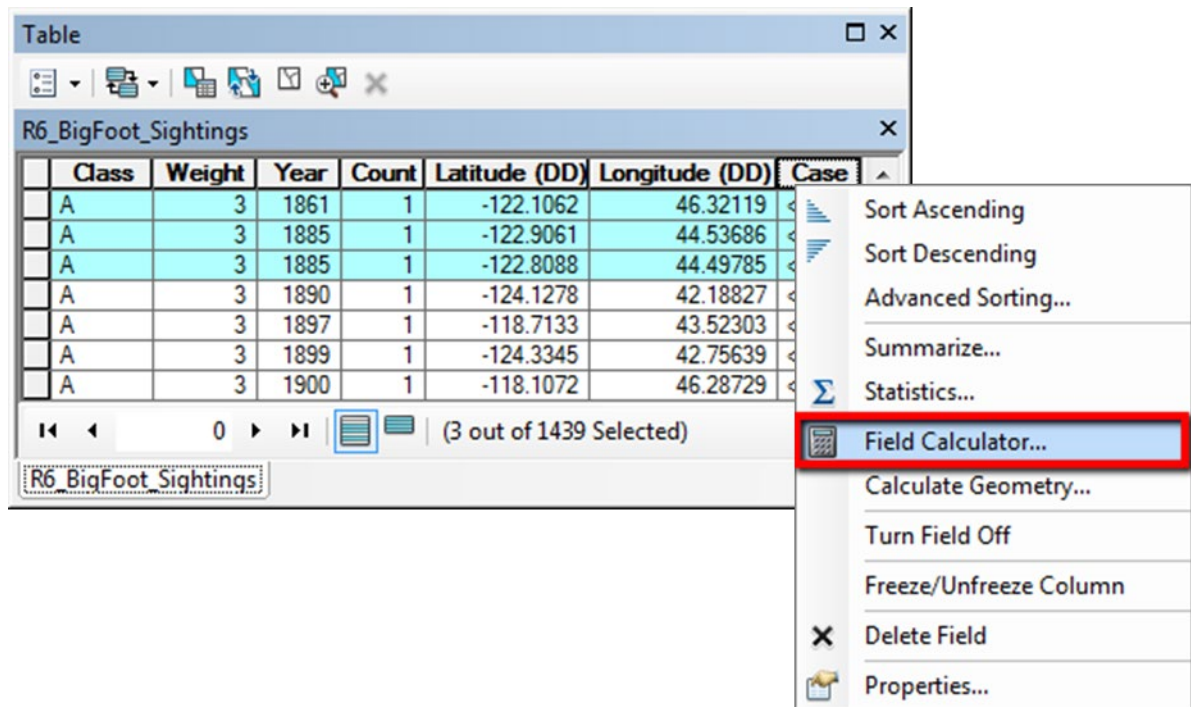
Class
Weight
Year
Count
Latitude (DD)

= < > Like
> > = And
< < = Or
_ % () Not
Is In Null Get Unique Values Go To:

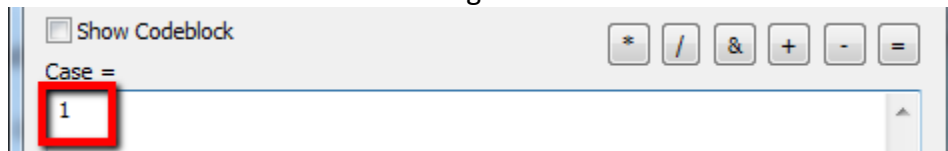
SELECT * FROM BigFootSightings NAD83UTM10N WHERE:
"Year" >= 1861 AND "Year" <= 1886

8. Click **Apply**. There will be 3 features selected.

- We want this selection to have a Case value of 1. *Right click Case*, and open the **Field Calculator**.



- Select **Yes** to consent to the warning. At the bottom of the Field Calculator, enter 1.

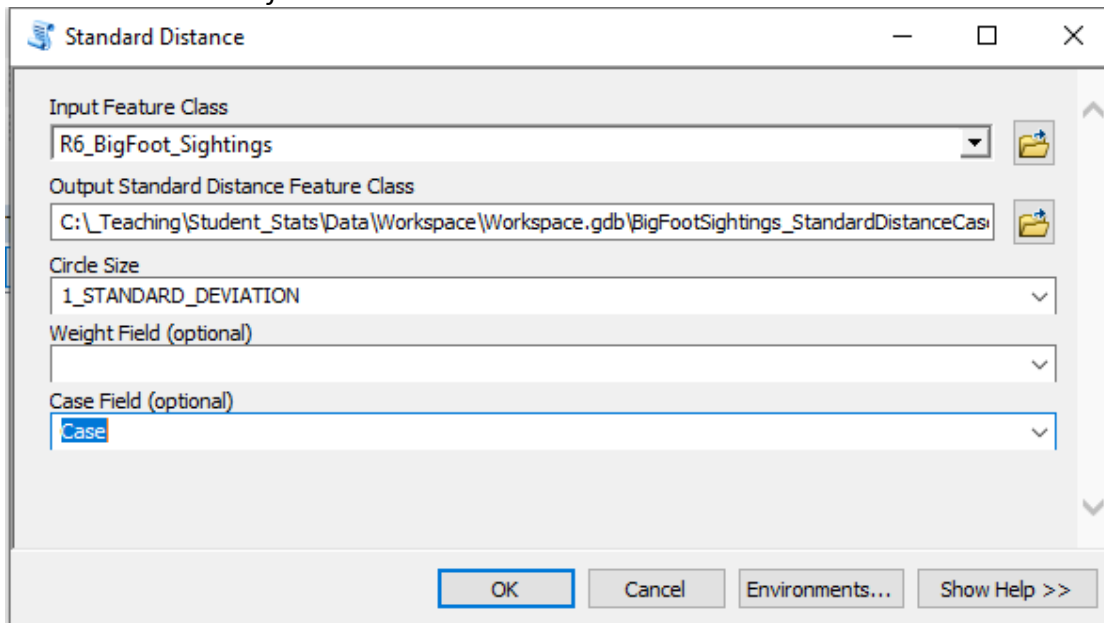


- Click **OK**. The Case field for the selected records is updated with the number 1.
- Using the chart below, repeat those steps for the remaining time periods.

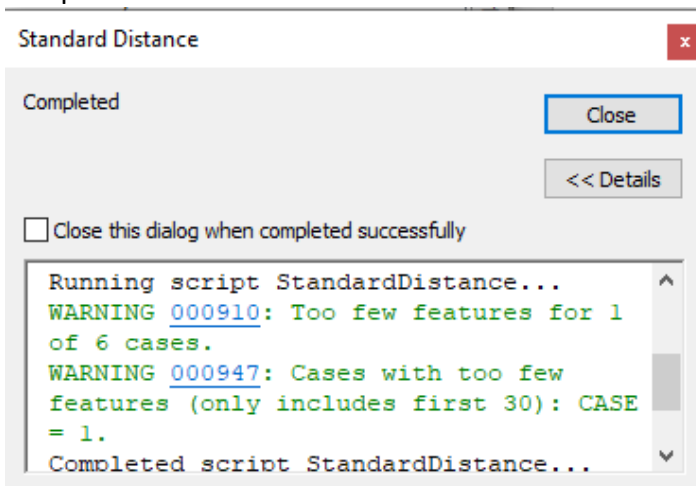
Definition Query	Case
"Year" >= 1861 AND "Year" <= 1886	1
"Year" >= 1887 AND "Year" <= 1911	2
"Year" >= 1912 AND "Year" <= 1936	3
"Year" >= 1937 AND "Year" <= 1961	4
"Year" >= 1962 AND "Year" <= 1986	5
"Year" >= 1987 AND "Year" <= 2011	6

- When finished, *clear* any selected features and *close* the attribute dialog.
- Now that we have a case field, we can create our standard distance ellipses. From the *Measuring Geographic Distributions* toolset, open the **Standard Distance** tool.
- In the *Standard Distance* tool, enter the following parameters: For Input Feature Class: select **R6_BigFoot_Sightings** from the dropdown. *Type*:

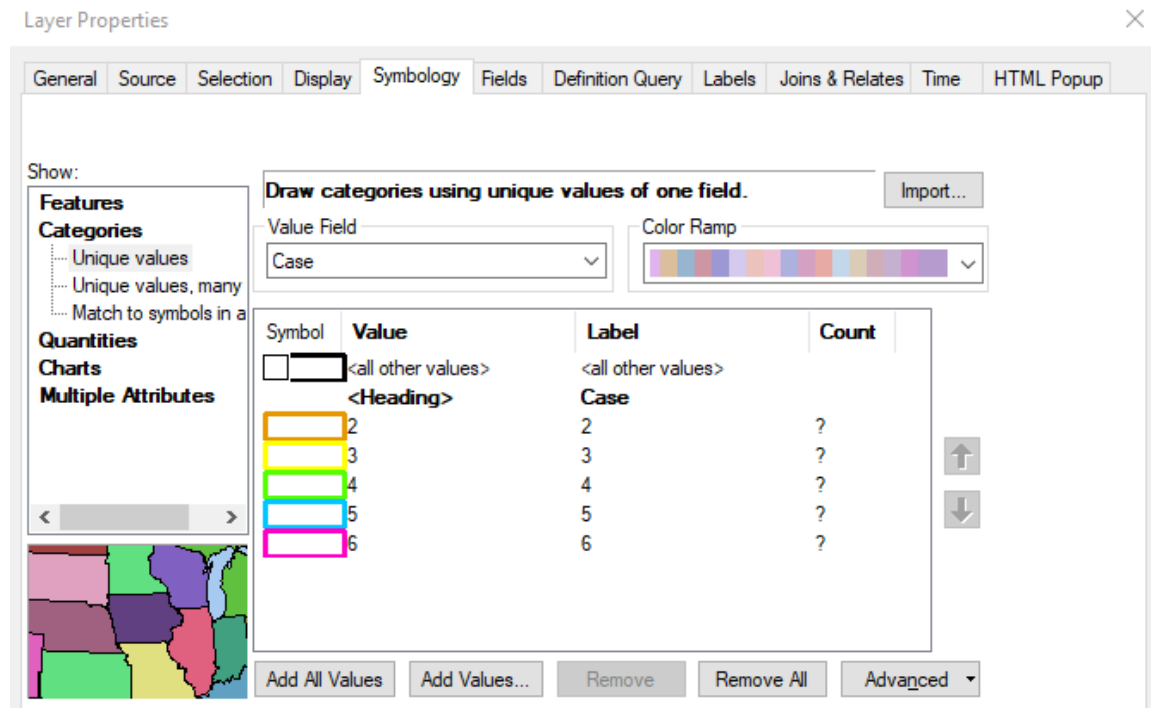
BigFoot_Sightings_StandardDistanceCase as the *Output Feature Class name*. Select **1 Standard Deviation** for *Circle Size* and for *Case Field*: select **Case**.



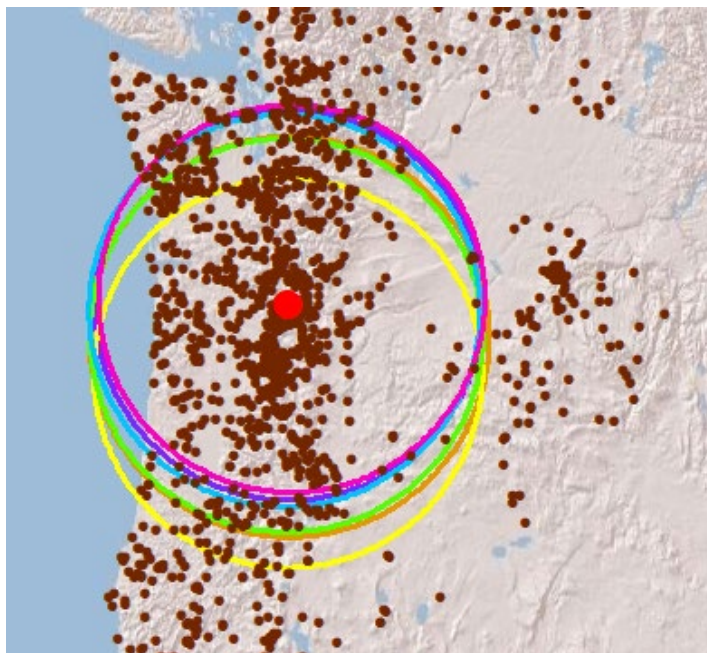
16. Click **OK**. The output will be one standard distance ellipse for each 25 year time period, except for Case = 1 which has too few features.



- Change the symbology of the new layer to display each Case as a separate ellipse and color. Click **Categories | Unique Values** and **Case** for the Value Field.



The ellipses appear to be moving slightly north but for the most part have maintained a relatively consistent location. For future sightings, a similar mean location is likely.

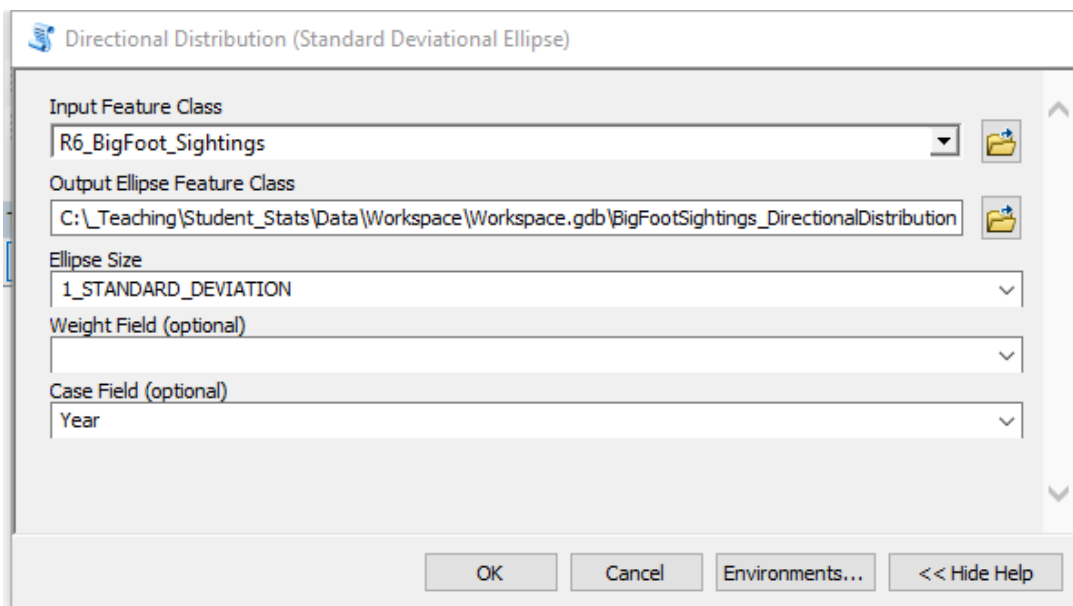


What is the distribution and orientation of recent BigFoot sightings?

1. From the Measuring Geographic Distributions toolset, open the **Directional Distribution (Standard Deviation Ellipse)** tool.

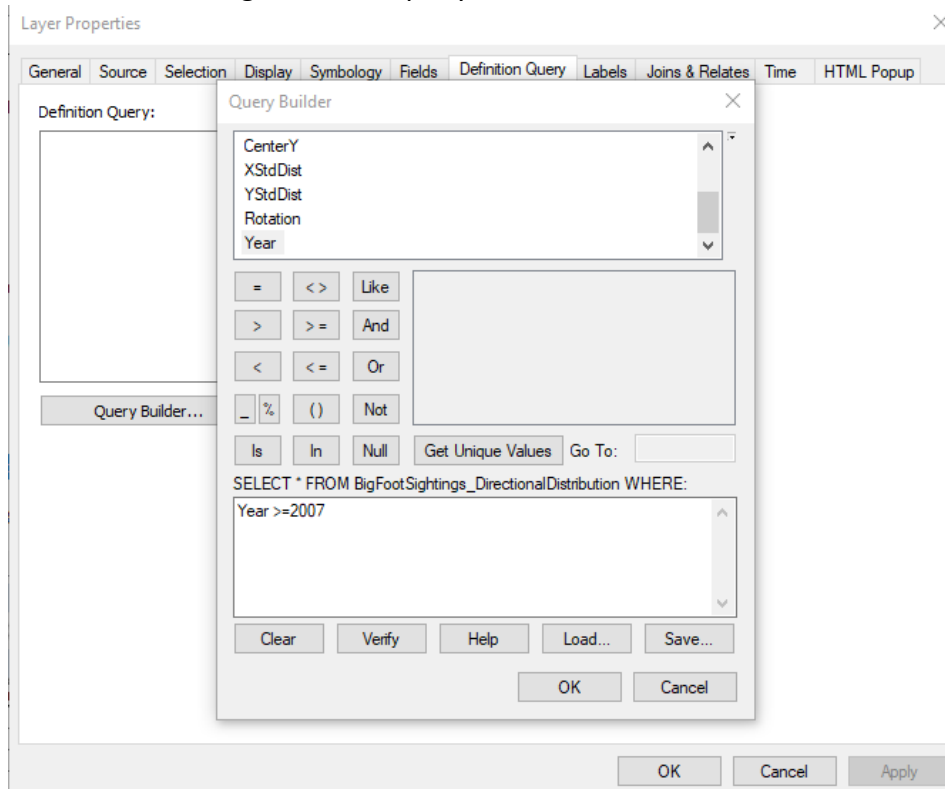
NOTE: The Directional Distribution (Standard Deviation Ellipse) tool will show us the distribution of the data as well as any directional trends or orientations in the distribution of the data. In this step, we will look at the variance in distribution of the sightings over the last 5 years.

2. In the *Directional Distribution (Standard Deviation Ellipse)* window, enter the following parameters For *Input Feature Class*: select **R6_BigFoot_Sightings** from the dropdown. *Type* **BigFoot_Sightings_DirectionalDistribution** as the *Output Feature Class name*. **1 Standard Deviation** for *Circle Size* and for *Case field* enter: **Year**.

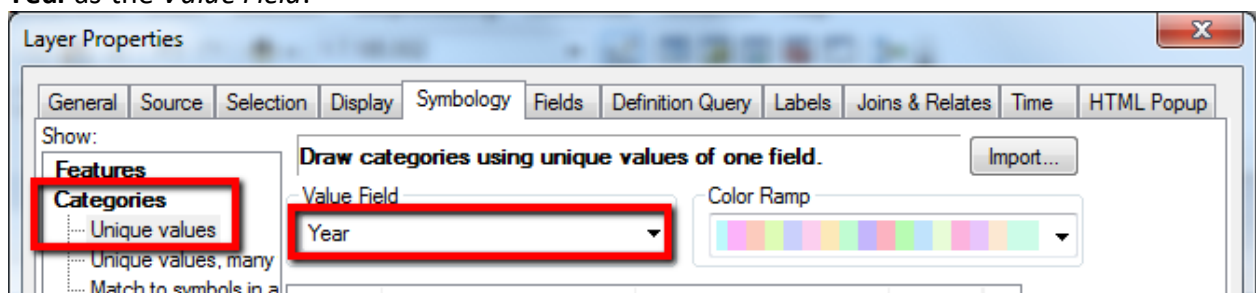


3. Click **OK**.
4. Remember we are only interested in the distribution of sightings for the last 5 years. We can create a definition query to exclude anything occurring before 2007. Open **Layer Properties** for *Big_Foot_Sightings_DirectionalDistribution* and select the **Definition Query** tab.

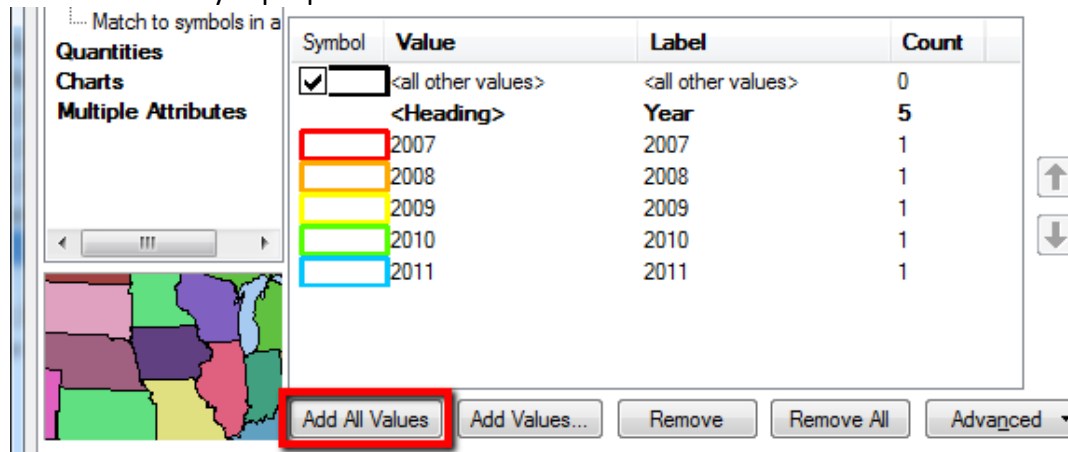
5. Enter the following definition query "**Year**" >= 2007. Click OK.



6. Click **Apply**.
7. From the **Symbology** tab, change the symbology to **Categorized | Unique Value** with **Year** as the *Value Field*.

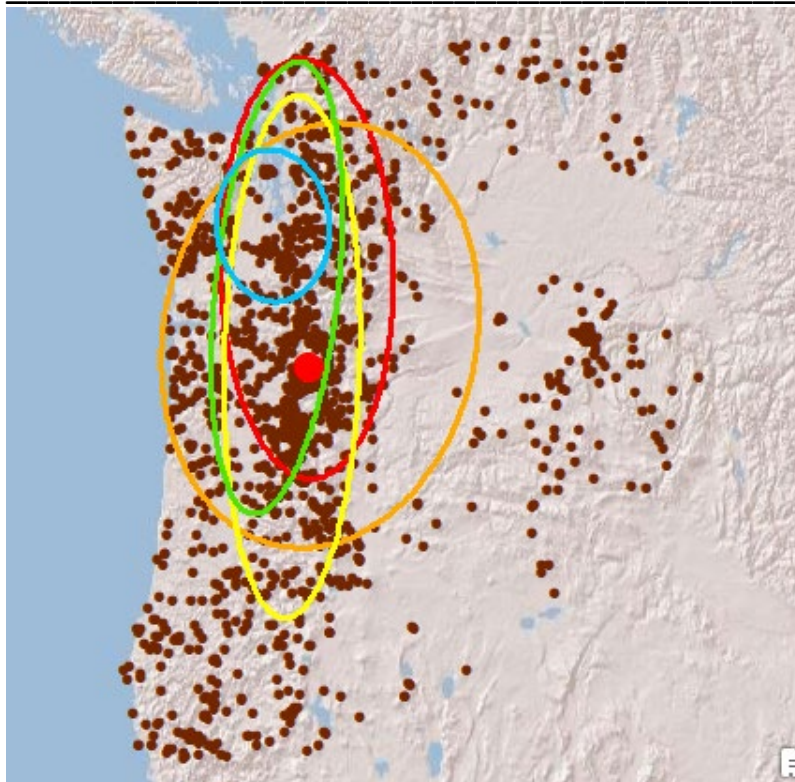


- Click **Add All Values** and set the symbology as shown below. When finished, click **OK** and close the layer properties window.



QUESTION – Are there any trends in the data?


QUESTION – What is significant about the location of sightings that occur in 2011?

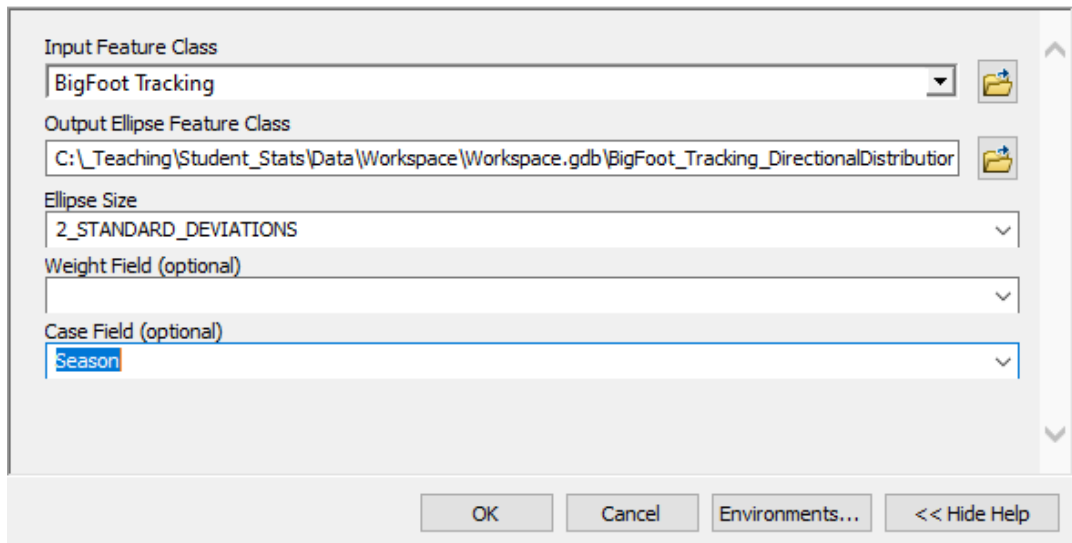


Monitor the seasonal movement of a radio collared BigFoot.

GOOD NEWS! We were able to capture and radio collar a BigFoot near the Olympic Peninsula. The collar will capture a GPS point every 24 hours. With this data, we hope to gain a better understanding of the species with respect to their seasonal movement in order to help maintain their basic needs of food, water, and security. Our goal is to measure and document seasonal movement patterns.

1. From the *Table of Contents*, turn on the **BigFoot Tracking** layer. And zoom to the layers extent. (*Hint, right-click **BigFoot Tracking | Zoom to Layer**).
2. Open the layer's attribute table. Right-click **BigFoot Tracking** and select **Open Attribute Table**. *The attributes for BigFoot Tracking include a date, the location and the season. We will use the Standard Deviation Ellipse tool to analyze the BigFoot's movement during different seasons.*
3. From the Measuring Geographic Distributions toolset, open the **Directional Distribution (Standard Deviation Ellipse)** tool.
4. In the *Directional Distribution (Standard Deviation Ellipse)* window, enter the following parameters: *Input: BigFoot Tracking; Output Feature Class name: BigFootTracking_DirectionalDistribution; Select 2 Standard Deviations for Circle Size and for Case Field: enter Season.*
5. Because we are focused on a more localized area, we also want to update our processing extent; from the bottom of the Directional Distribution window, click the **Environments...** button.
6. In the *Environment Settings* window, expand **Processing Extent**, in the dropdown under Extent; select **Same as layer BigFoot Tracking**.
7. Click **OK** to close the Environment Settings dialog.

 Directional Distribution (Standard Deviation Ellipse)



Input Feature Class
BigFoot Tracking

Output Ellipse Feature Class
C:_Teaching\Student_Stats\Data\Workspace\Workspace.gdb\BigFoot_Tracking_DirectionalDistribution

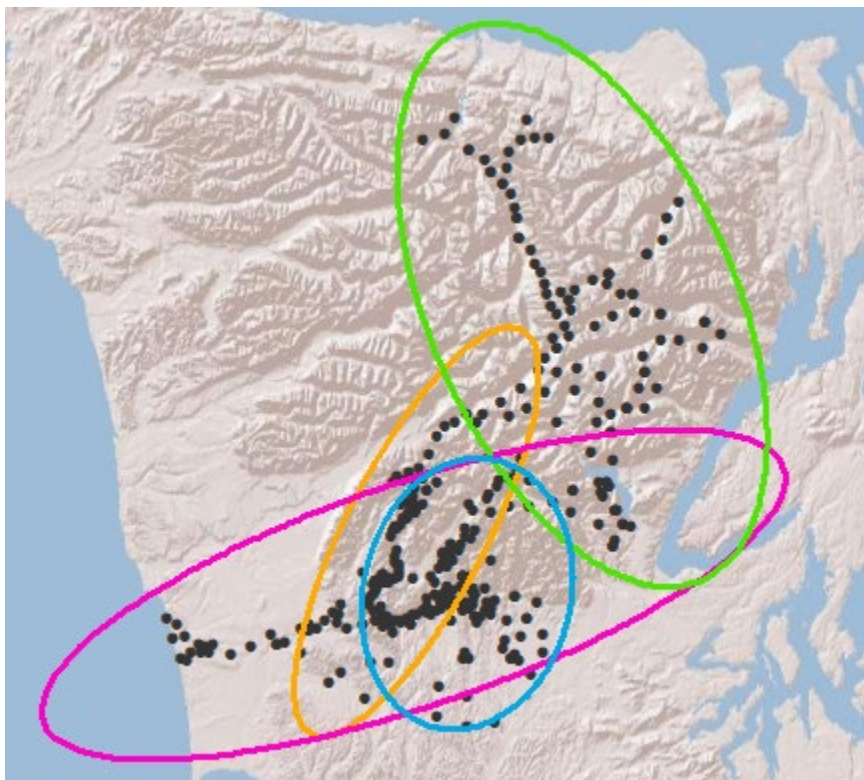
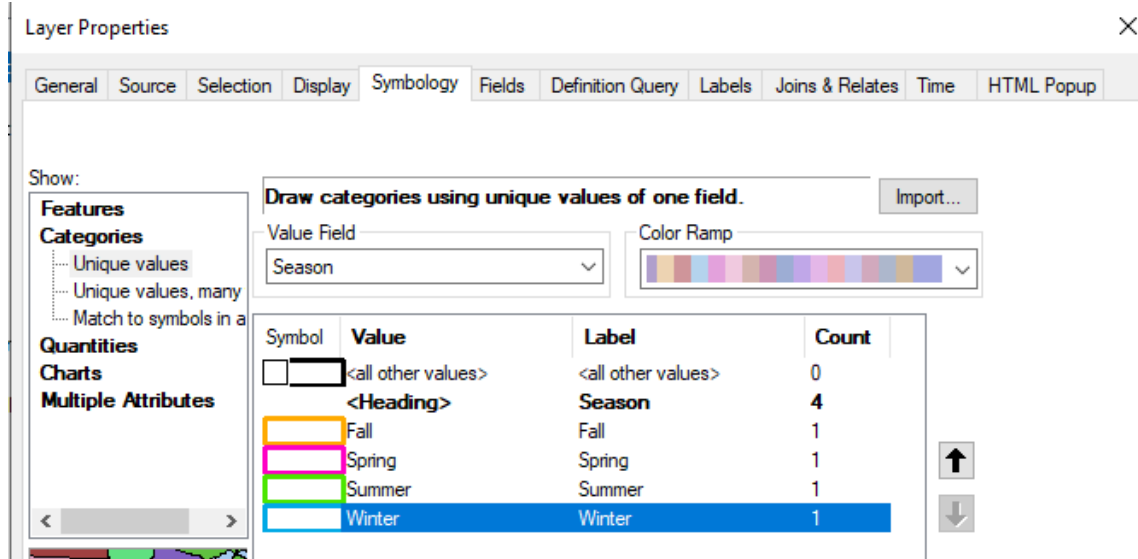
Ellipse Size
2_STANDARD_DEVIATIONS

Weight Field (optional)

Case Field (optional)
Season

OK Cancel Environments... << Hide Help

8. Click **OK** again to run the Directional Distribution tool.
9. Change the symbology of the new output layer to **Categories**, based on **Season**.



NOTE: The ellipse allows us to see if the distribution of features is elongated and consequently has a particular orientation. In the example below, we see several ellipses with different orientations. Fall + NE/SW, Spring = E/W, Summer = NW/SE, Winter-Clustered



So... what have we learned? The standard deviational ellipses tell us there is very little movement during the winter; the fall and spring show movement in a southwest/northeast direction but remain reasonably close to that same area. The summer months allow movement into higher elevations and further away from the average distribution and display movement in a northwest/southeast direction.

You have completed Exercise 1

