Lab Exercise

Wildlife Habitat and Home Range Analysis

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Background and Discussion

These exercises will demonstrate methods to identify animal habitat at two different scales. First we will take a landscape-level approach to identify the general habitat used by an entire population of animals. Next we will look at two finer-scale methods to estimate home range areas for individual animals. In many cases a wildlife biologist will use more sophisticated methods than illustrated in this lab (or at least take additional steps beyond what we will do), but these methods are at the root of many habitat and home range analysis techniques and definitely worth your while to learn.

We will use the Mexican spotted owl for these exercises. This spotted owl subspecies lives throughout the forests and canyons of Arizona, New Mexico, Southern Utah and Mexico, and parts of Colorado and Texas. They were declared a Threatened Species by the U.S. Fish and Wildlife Service in 1993 and have ever since been used as a banner and rallying cry for almost any group who stumbles into the forest. Love them or hate them, they have been a major component of southwestern National Forest planning for the past four decades.

Landscape-Level General Habitat Analysis

There are many methods and approaches to identify the general habitat and range that a species will inhabit. As with most things that attempt to explain the natural environment, wildlife habitat analysis can quickly become very complex and no method can perfectly describe and predict the requirements or behavior of a species. You can never capture all the factors that influence a species because everything is connected, and there will always be individual animals that behave unpredictably.

Of course, that won't stop us from trying. And there are a few simple ways to make a decent first guess. The first lab exercise will demonstrate one of the most basic and intuitive methods, sometimes called the *Environmental Envelope*. There are many variations on this method but basically the goal is to identify all areas on the landscape that fall within some range of values along one or more variables. Most variations on this method are conceptually similar to this basic approach, except that they use more complex statistical descriptors of the data than simply the range of observed values. We will try the simplest method here.

Just to illustrate the concept, let's look at a less controversial species than the spotted owl.

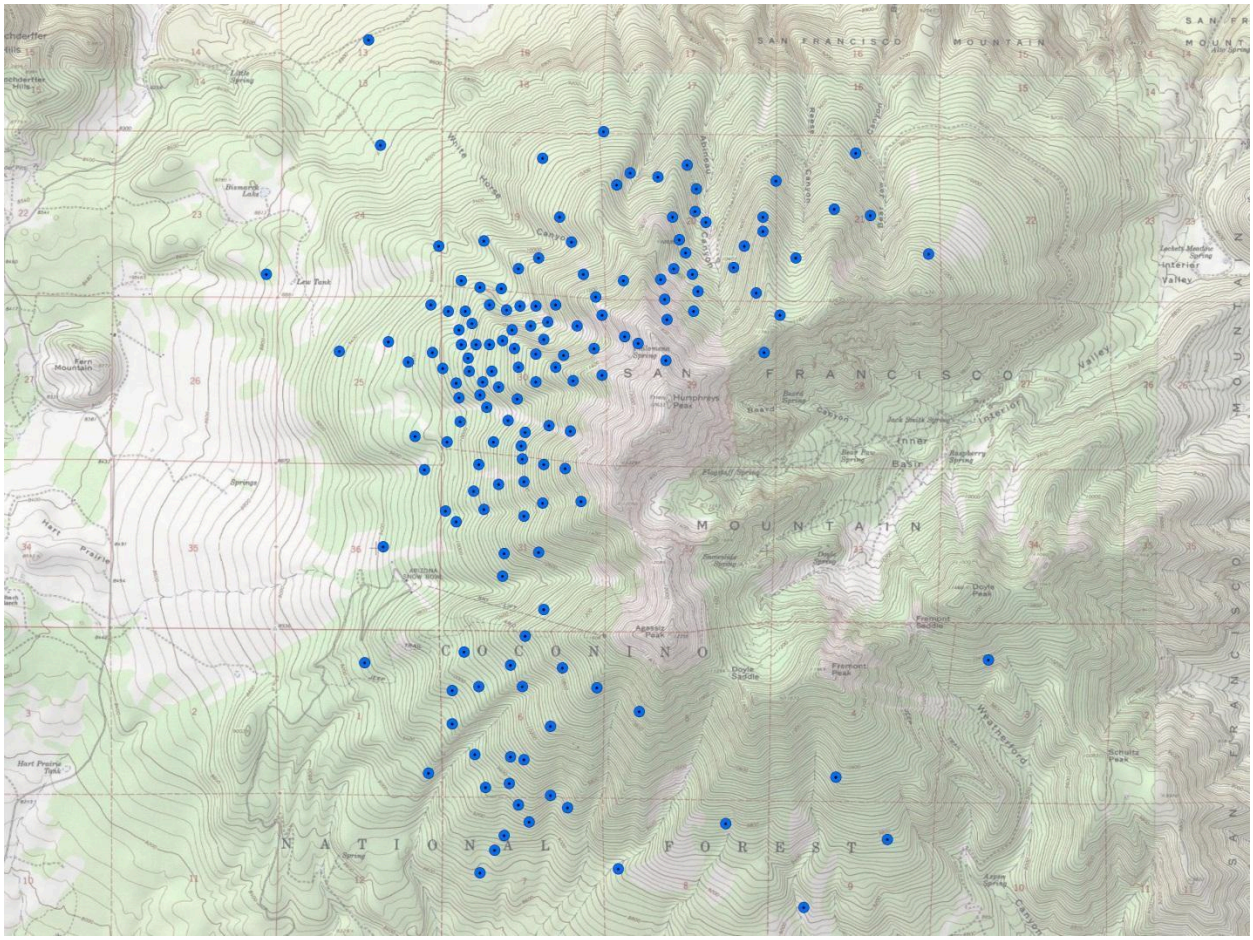
The Star-Belly Sneetch

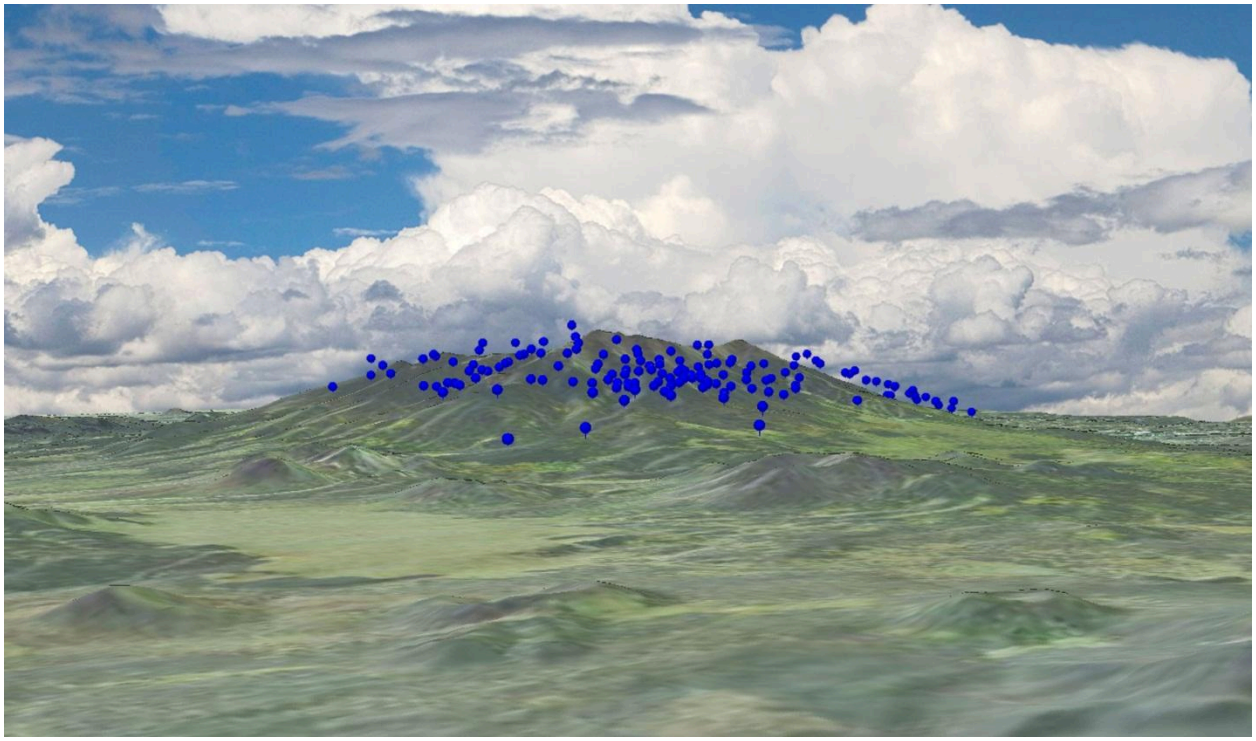
Now, the Star-Belly Sneetches had bellies with stars.
The Plain-Belly Sneetches had none upon thars.
Those stars weren't so big. They were really so small
You might think such a thing wouldn't matter at all.
But, because they had stars, all the Star-Belly Sneetches
Would brag, "We're the best kind of Sneetch on the beaches."
Geisel 1961

Suppose we get a report of a population of Star-Belly Sneetches living on the San Francisco Peaks, and we want to learn more about them. We conduct a thorough survey of the area during Sneetch breeding season (on or about February 14), and we locate a large number of individuals.

We want to understand Sneetch habitat requirements so we measure habitat components everywhere we find one. To make this example simple, suppose we only measure slope and elevation at every point.

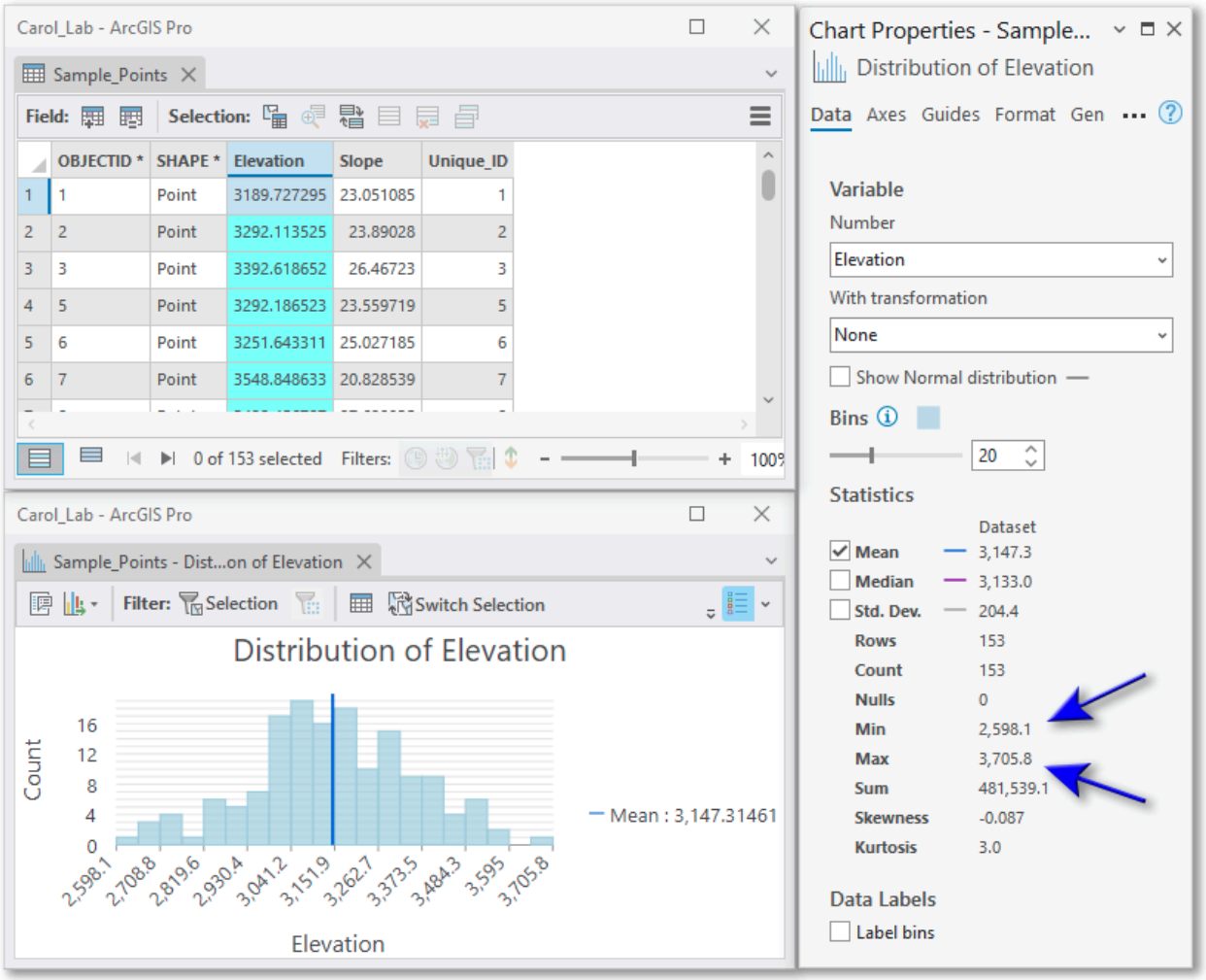
As suspected, we find that Star-Belly Sneetches appear to stay on the San Francisco peaks:


SAN FRANCISCO MOUNTAIN
SAN FRANCISCO
MOUNTAIN
COCONINO
NATIONAL FOREST
Inner Basin
Humphreys Peak
Doyle Peak
Fremont Peak
Agassiz Peak
Kern Mountain
Hart Prairie
Schultz Peak

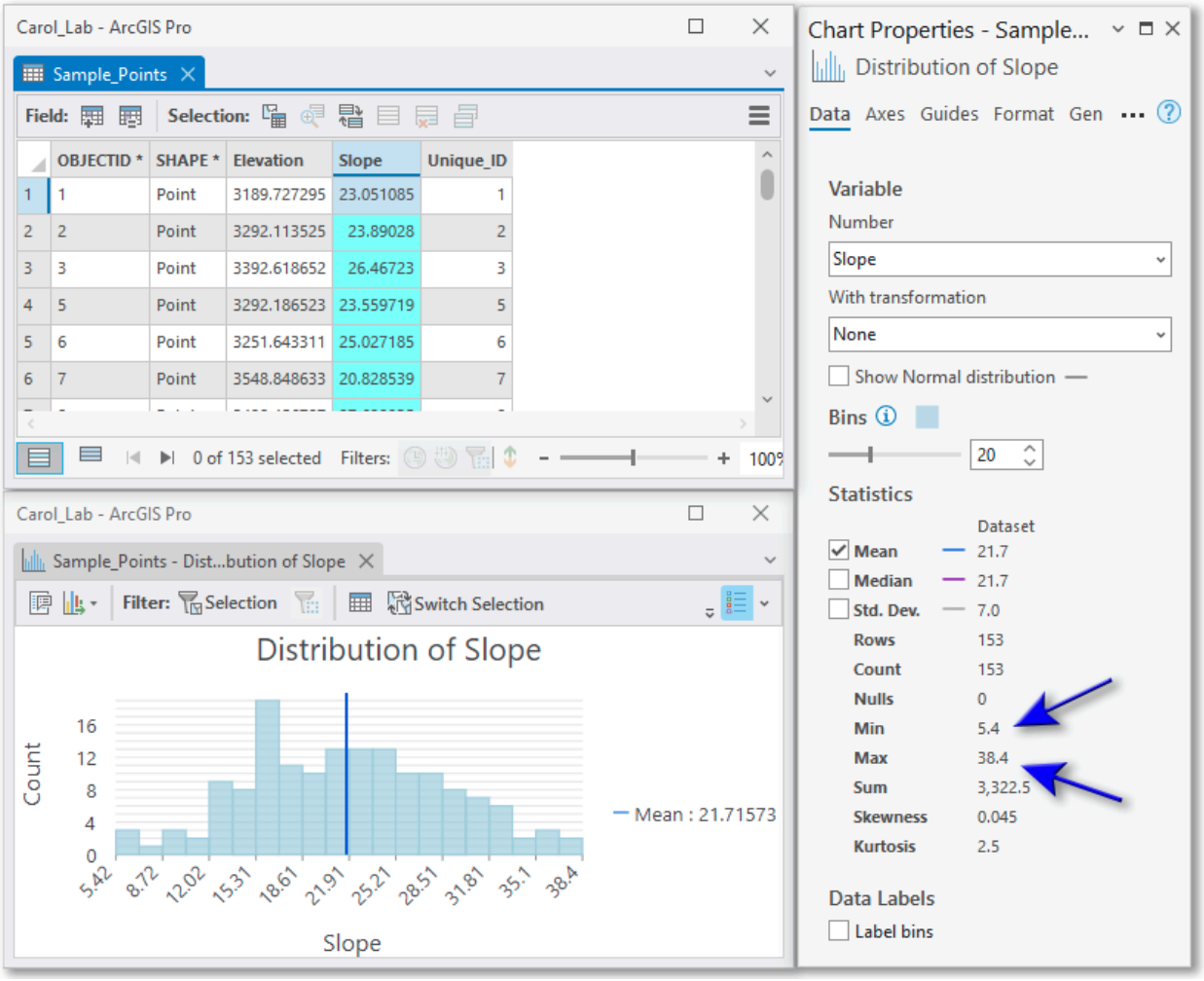


We find 153 Sneetches, and therefore we have 153 elevation and slope values for this animal.

Using the ArcGIS **Visualize Statistics** tool, we can easily see the minimum and maximum observed elevations (in meters) where we found Sneetches:

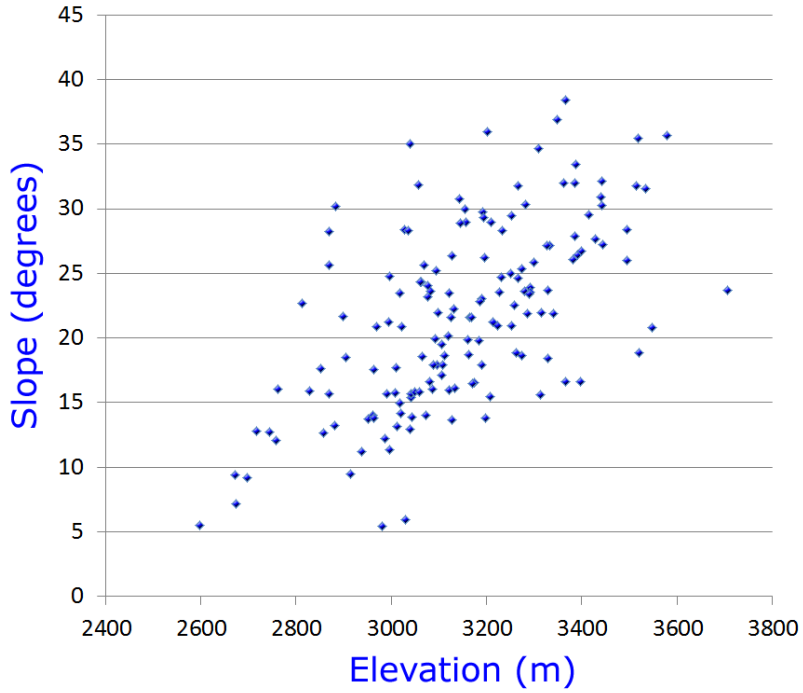


In a similar manner, we can see the minimum and maximum slope:

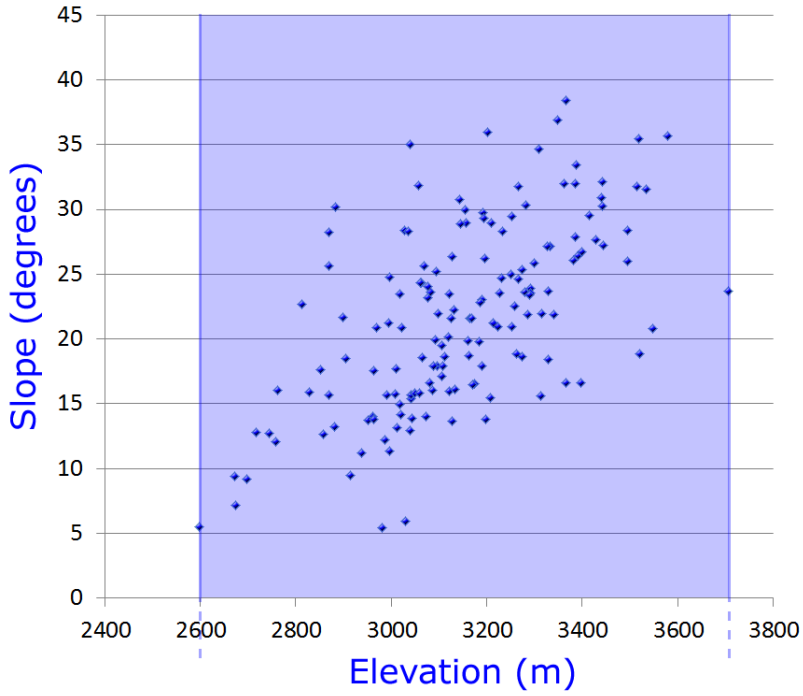


Based on these simple statistics, we can see that we've never found a Sneetch below 2,598m or above 3,706m. We have also never found it on a slope shallower than 5° or steeper than 38°.

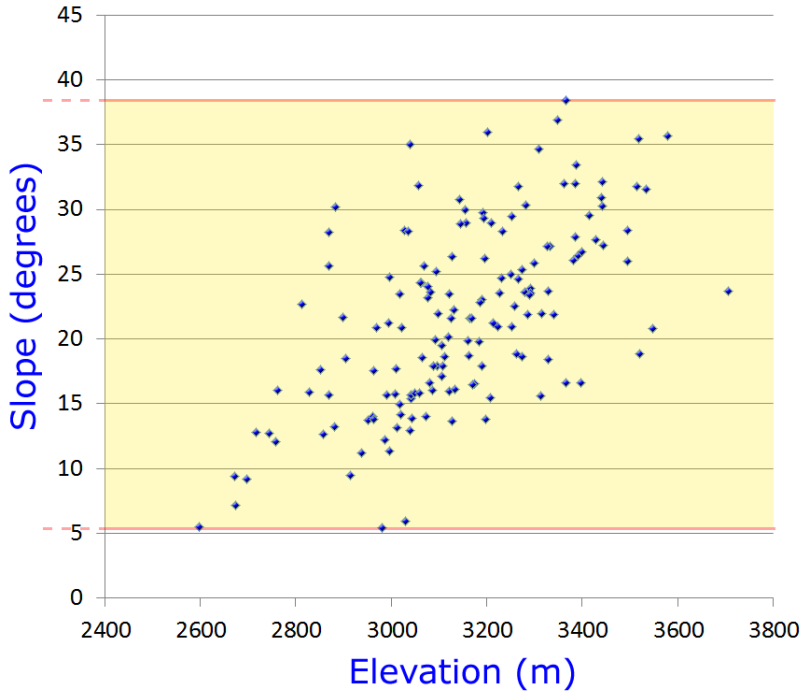
We can generate a scatterplot of our observed slope and elevation values to see a little bit more about the data.



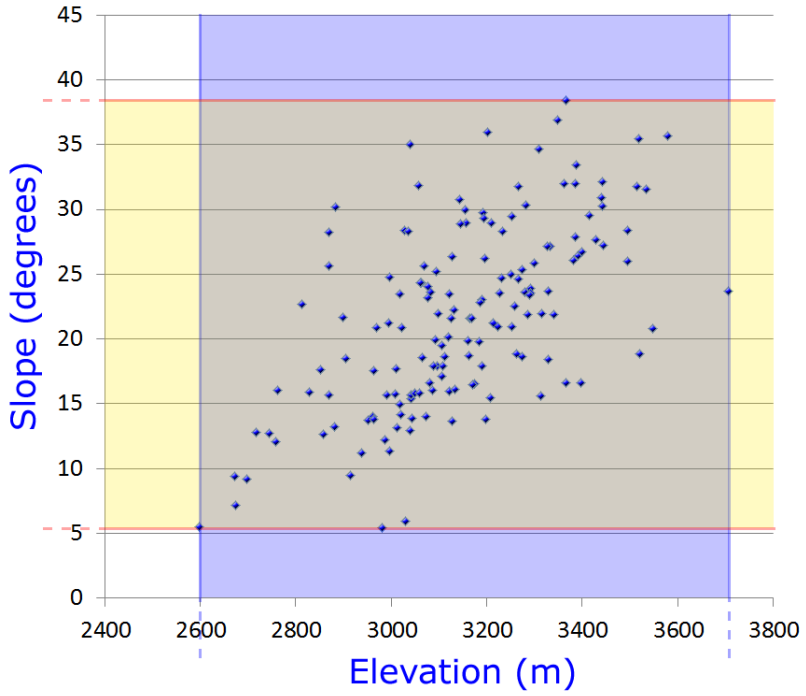
Our elevation range is between 2,598m and 3,706m:

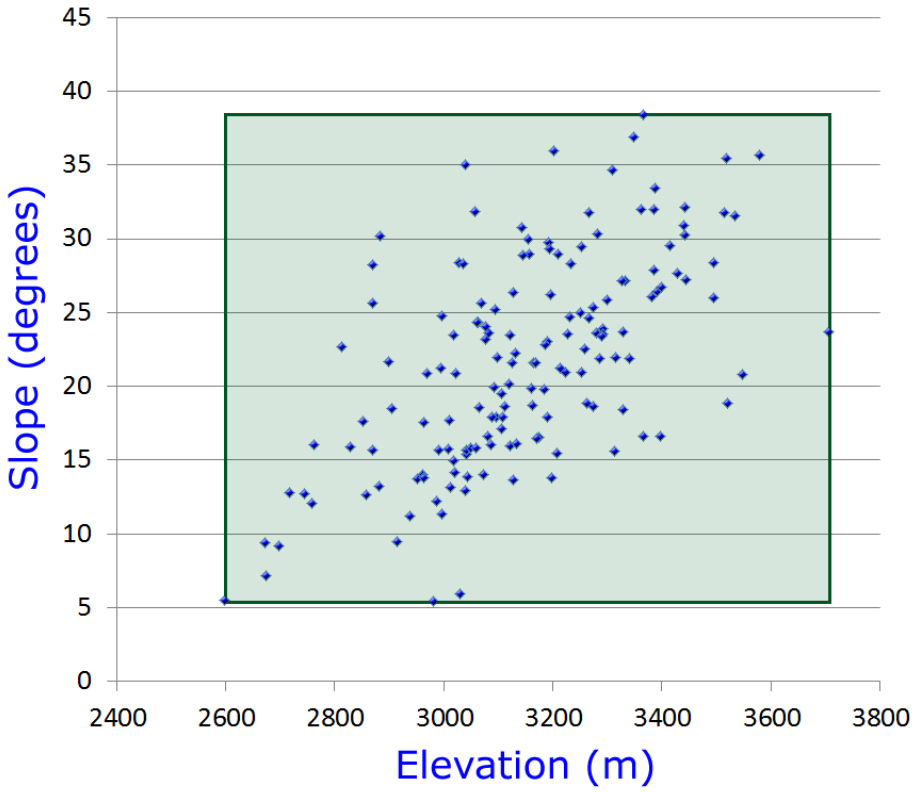


Our Slope range is between 5° and 38°.



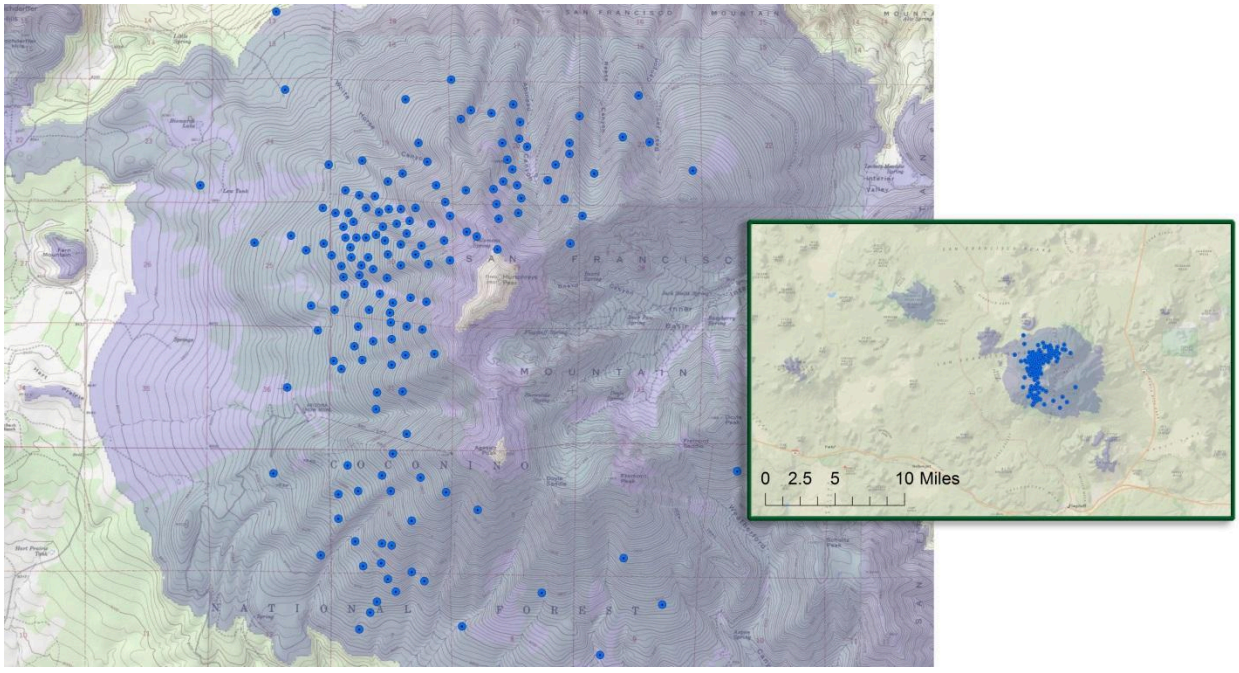
Based on these two ranges of values, we now arrive at our **environmental envelope**. This is simply the intersection of these two ranges on the graph.



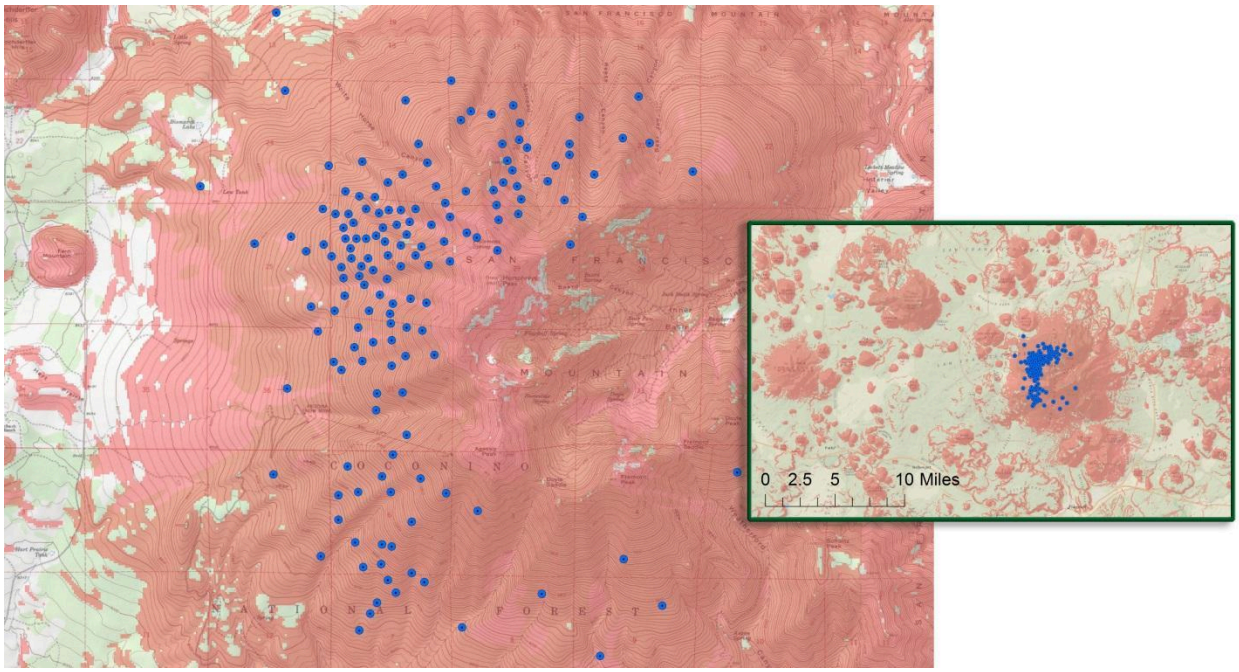


And that is all there is to it. Any point on the landscape that has a combination of elevation and slope that lies in the green rectangle would be considered potential habitat.

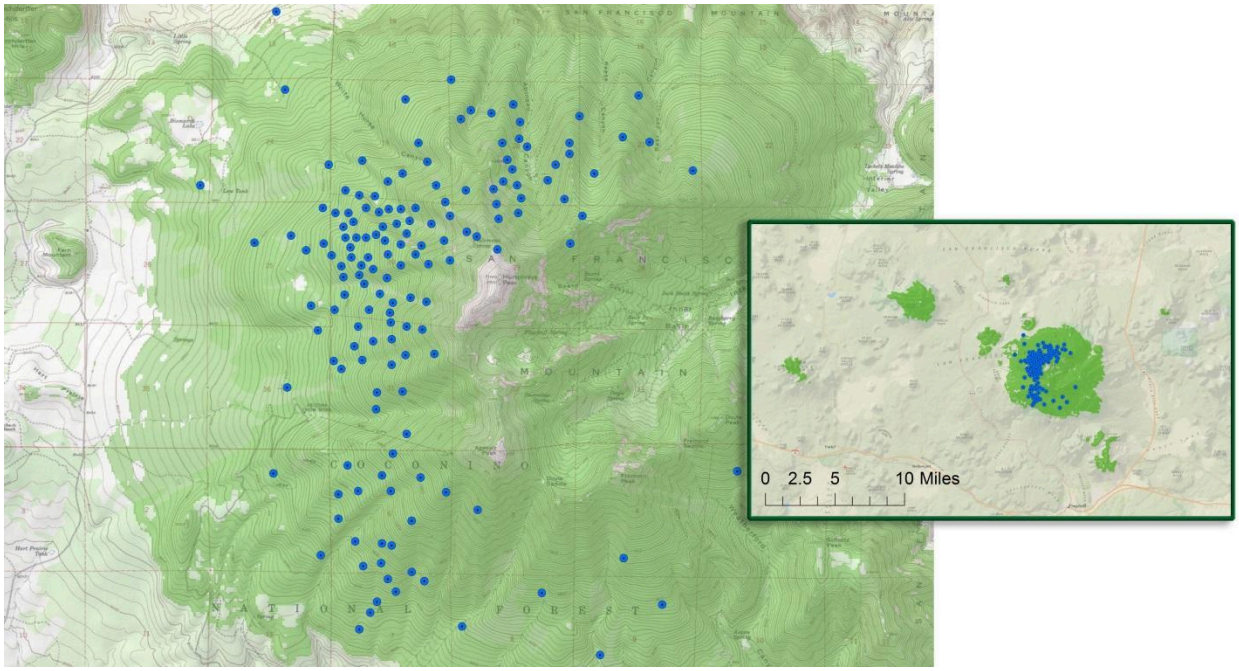
For example, let's look at the portions of the landscape that meet the various criteria. The map below shows the regions around the peaks that lie within the **elevation** range (between 2,598m and 3,706m):



Here are the regions that lie within the **slope** range (between 5° and 38°):



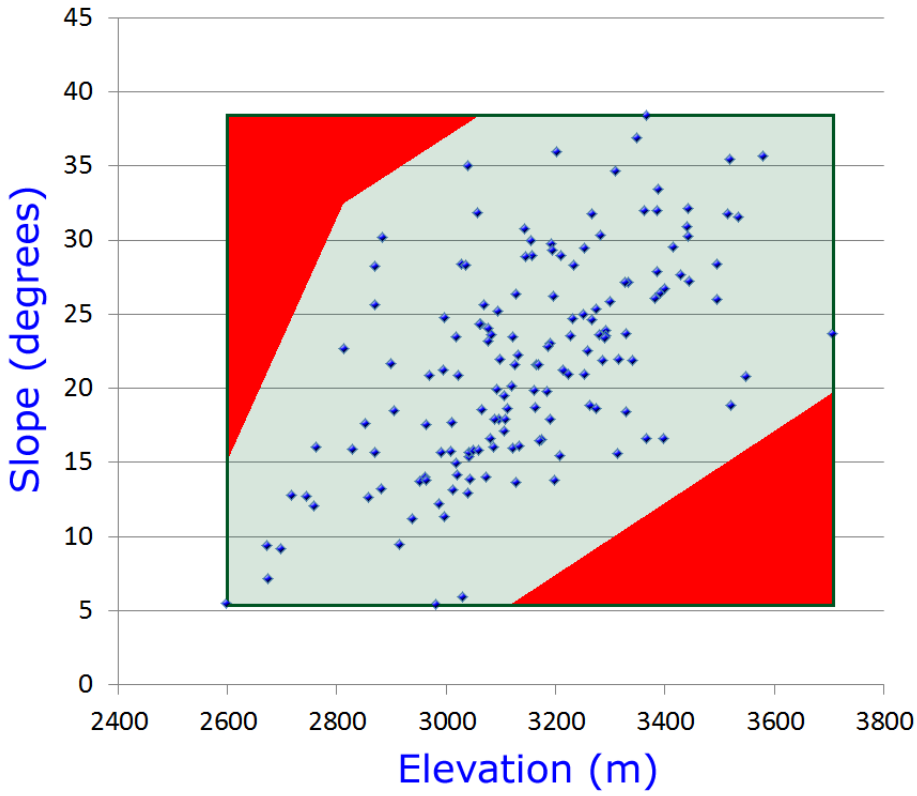
Finally, here are the areas that meet both criteria at the same time (i.e. the **environmental envelope**). Based on only elevation and slope, this is the habitat we would predict for Sneetches.



How could we improve this? Looking at the map, it seems clear that the great majority of observations occurred at higher elevations. There are very few locations near the base of the peaks, and therefore only a few low-elevation locations cause us to designate a large amount of low-elevation area as Sneetch habitat. It **might** be more reasonable to consider these rare low-elevation locations as outliers that do not truly represent Sneetch habitat (maybe they were lost, or we misidentified a few Plain-Belly

Sneetches), and therefore we might consider excluding them from the analysis. In fact, one common variation on this environmental envelope method is to use the middle 90% or 95% of observations rather than all observations.

A drawback to the method: Referring back to the scatterplot, notice that the data are not evenly distributed through the rectangle. They seem to follow a linear pattern, going from the bottom left corner up to the top right. We never see points that have high slopes and low elevations, nor points with low slopes and high elevations, yet we still classify those combinations as potential habitat. Do we really have good reason to believe that the red portions of the graph below represent good Sneetch habitat?



A factor to consider: We only surveyed for Sneetches during Sneetch breeding season. This probably means that we can only be confident that we have found Sneetch breeding habitat. What about Sneetch foraging, roosting, juvenile dispersal, or non-breeding season habitat?

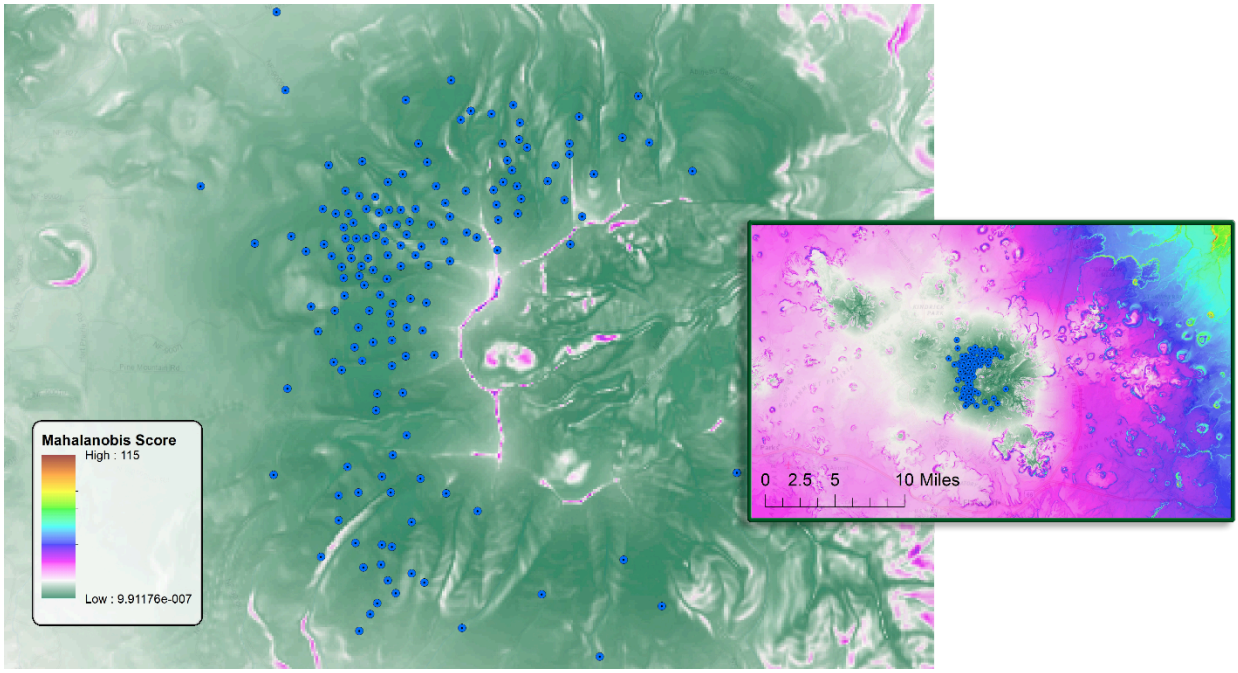
Another factor to consider: Most of these locations appear on the northern and western slopes, and a few on the southern slopes. None are on the eastern slopes. Maybe Sneetches love sunsets but tend to sleep late and dislike sunrise. Based on this, we might consider aspect to be important to this animal, and apply an additional constraint to remove all east-facing slopes.

And another factor: We did not include any vegetation variables in the analysis, and we know that most animal species prefer particular vegetation species or vegetative structural components. Very few species exist equally well in all vegetation types. Therefore, if we can find the vegetation data, we could further restrict this range based on vegetative community, canopy cover, tree height, tree density, successional stage, etc. We can put as many variables as we want into an environmental envelope.

Environmental Envelopes: A Step Farther

Note: We will not do this in class! One possible drawback to environmental envelopes is that they produce a binary response. Either a location **is** or **is not** potential habitat. This is good information as far as it goes, and sometimes that's all we really need to know, but often we would like to actually estimate the relative quality of all points on the landscape.

There are a variety of statistical ways to do this, and one fairly simple one is the **Mahalanobis Distance** (Farber and Kadmon 2003). This generates a raster surface where every raster cell value describes how similar that cell is to some theoretical ideal combination of the input variables. In this simple example, where we just looked at slope and elevation, we would consider the ideal combination of slope and elevation to be the mean value of each variable (i.e. Mean Elevation = 3,147 meters, and Mean Slope = 21.7°).



The Mahalanobis distance values also depend on the covariance between the input variables. Covariance describes how much one variable changes in a predictable way if the other variable changes. For example, in the scatterplot above, there appeared to be a diagonal cluster in the data spreading up and to the right. This means that as the elevation of each Sneetch location increased, slope also tended to increase. Since slope appears to change in a predicatable way when elevation changes, this means there is covariance between these two variables.

Using this covariance value, the Mahalanobis analysis produces values that are essentially multivariate standard deviations from the mean. If a value is one standard deviation from the mean, then it is not that much different than the ideal habitat. If it is > 3 standard deviations from the mean, then it is very **dissimilar** to the ideal habitat, and would probably be very poor landscape to preserve.

Unfortunately there are no standard tools in ArcGIS Pro to calculate Mahalanobis Distances, so if you want to try this then you'll need to take up coding.

Home Range Analysis:

Until now we have been discussing a landscape-scale approach to identify habitat that would support a population of animals. Now we will turn to a finer scale analysis that identifies the specific area used by an individual animal.

Defining a home range means to delineate the area that an individual animal (or mated pair) typically uses, sometimes defending it from other members of its species ("conspecifics") or at least alerting others when they encroach. Naturally not all wildlife species stick to well-defined home ranges, but many do and we often want to know where those places are. Knowing the exact location of home ranges is especially important in the case of threatened or endangered species so we don't put the whole species at risk with a timber sale, golf course, strip mine or some other landscape-altering project.

Home range? Territory? Activity Center?

There are lots of ways to define the area used by an animal. We will not spend much time exploring the differences in these definitions in this lab, but for those who are interested the "Home Range" usually refers to all the area ***used*** by an animal while the "Territory" often refers to the area ***defended*** by an animal. These areas may change seasonally or over the course of an animal's life, or sometimes after the death of one member of a mated pair.

There are other ways to define owl use areas. The Recovery Plan for the Mexican spotted owl uses a special delineation called a "PAC" (Protected Activity Center), defined as at least 600ac of the best habitat surrounding known nest and roost sites for an individual or mated pair. This is the area within the larger home range that is used the most by the owl. PACs often have smaller "core areas" inside them that contain known roosts, nest sites or groves used to rear young. Alternatively, some researchers have used "CACs ("Circular Activity Centers") delineating simple circles around known locations.

This exercise will focus on defining the general home range and core area of two individual spotted owls, using a set of owl locations collected by radio telemetry between 1992 and 1994. Because of the threatened status of the owl, and also because the Forest Service prohibits us from disclosing exact owl locations, we have shifted the owl points and background data far from their actual location and removed all location names from the topo maps. This means that if you load an online basemap into your map while looking at this data, you will only see the Amazon forest in the background. So far as we know, there are no Mexican spotted owls down in the Amazon (although, if anyone's funding exotic but pointless field trips, give me a call!)

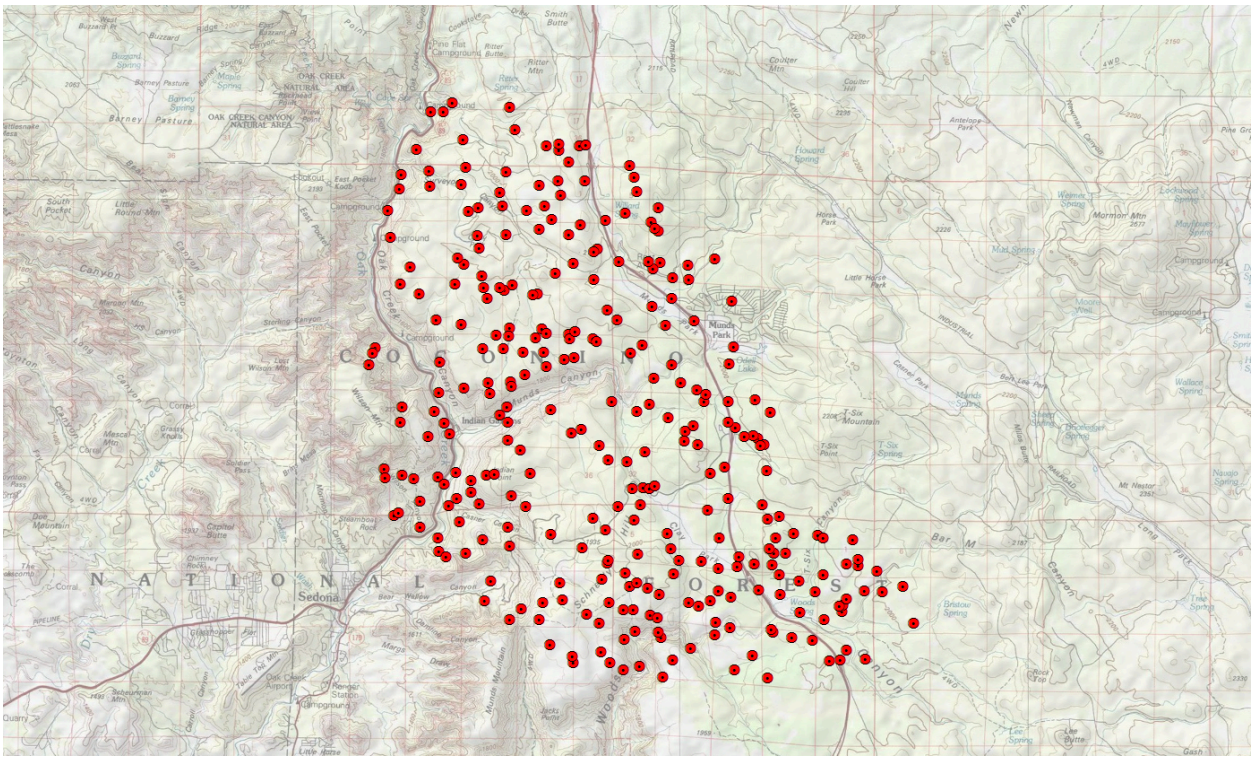
Two Methods for Estimating Home Ranges:

Minimum Convex Polygons

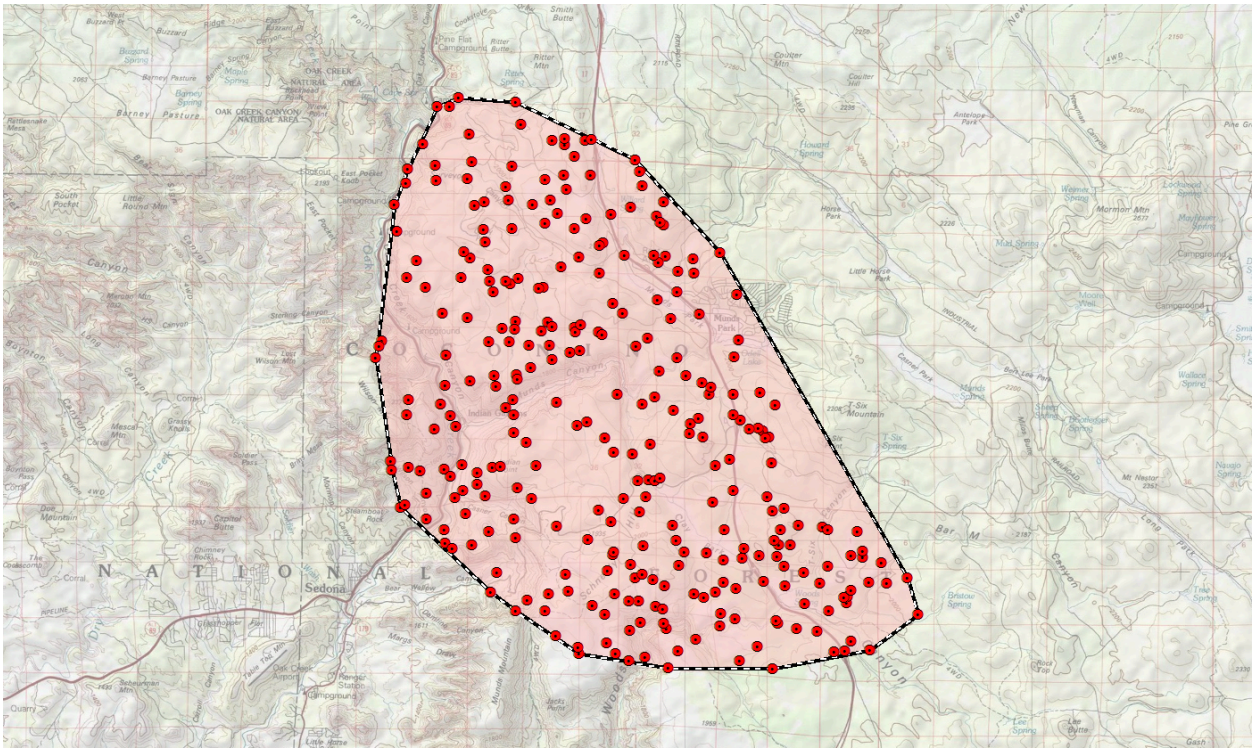
The **Minimum Convex Polygon**, also referred to as the **MCP** or the **Convex Hull**, is a very common method to define home ranges. There are a lot of rather esoteric and abstract mathematical definitions of the MCP, but this concept is actually simple, intuitive and easy to understand, and is one of the simplest and most conservative ways to estimate home range. "Conservative" in this sense means that it usually delineates **more** area than the animal actually uses. Given any set of animal locations, it will **never** delineate **less** than the total area used by the animal (unless the set of animal locations is deficient; you can never get around the problem of bad data).

If you remember back to the difference between **vector** and **raster** spatial data, then MCP analysis uses **vector** input data (usually points, but you can also generate convex hulls around polylines or polygons), performs a **vector** analysis and produces a **polygon vector** output.

The easiest way to think of an MCP is to imagine stretching a rubber band around all the points in your sample. The shape of the rubber band represents the convex hull. For example, suppose we wanted to generate an MCP for the points below:

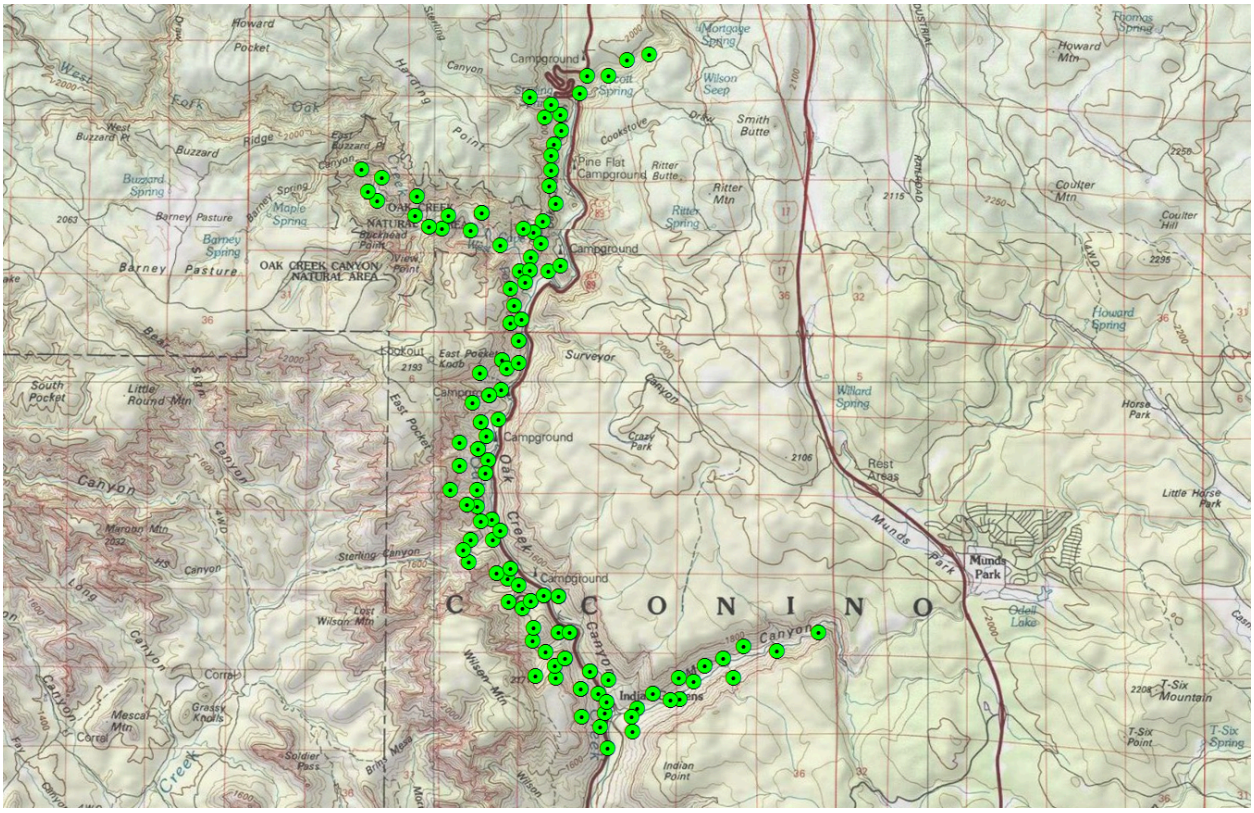


If we pictured all the points as pins in the map, and stretched a rubber band around them, the resulting convex hull would look like this:

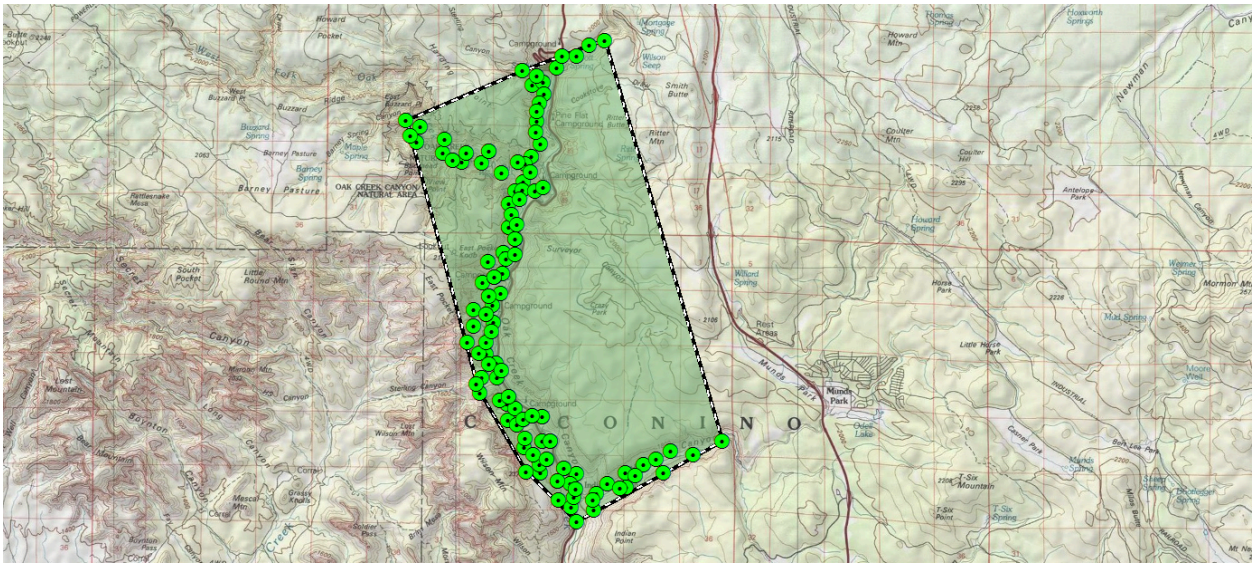


Notice that there is no place on the polygon boundary where the edge bends inward. If you follow the boundary clockwise, then you will turn right at every vertex. **At no point** will you bend in toward the inside of the polygon, and later bend out again. Every bend on the boundary is **convex** with respect to the inside of the polygon, hence the name **convex polygon**. The term **minimum** convex polygon simply means this is the smallest possible convex polygon that contains all the points.

Convex polygons are conservative estimates because they enclose every possible straight-line route an animal could follow from one point to another, regardless of whether an animal would actually traverse that area in real life. This looks like a reasonable approach in the illustration above because the points are well-distributed throughout the polygon. However, there are times where an MCP will include areas we strongly suspect the animal does not use. For example, consider an animal that strongly prefers to stay in canyons. Suppose all known locations for this animal put it inside Oak Creek Canyon or one of its tributaries:



In this case, an MCP will include lots of area outside the canyon where we have never observed the animal.



In this scenario, it would be difficult to argue that the MCP represents the true home range of the animal. If this were an endangered species and your goal was to protect its home range, and you submitted this polygon as the area you want to preserve, then you would meet a lot of resistance (for good reason) from anyone who wanted to do a management activity above the canyon rim.

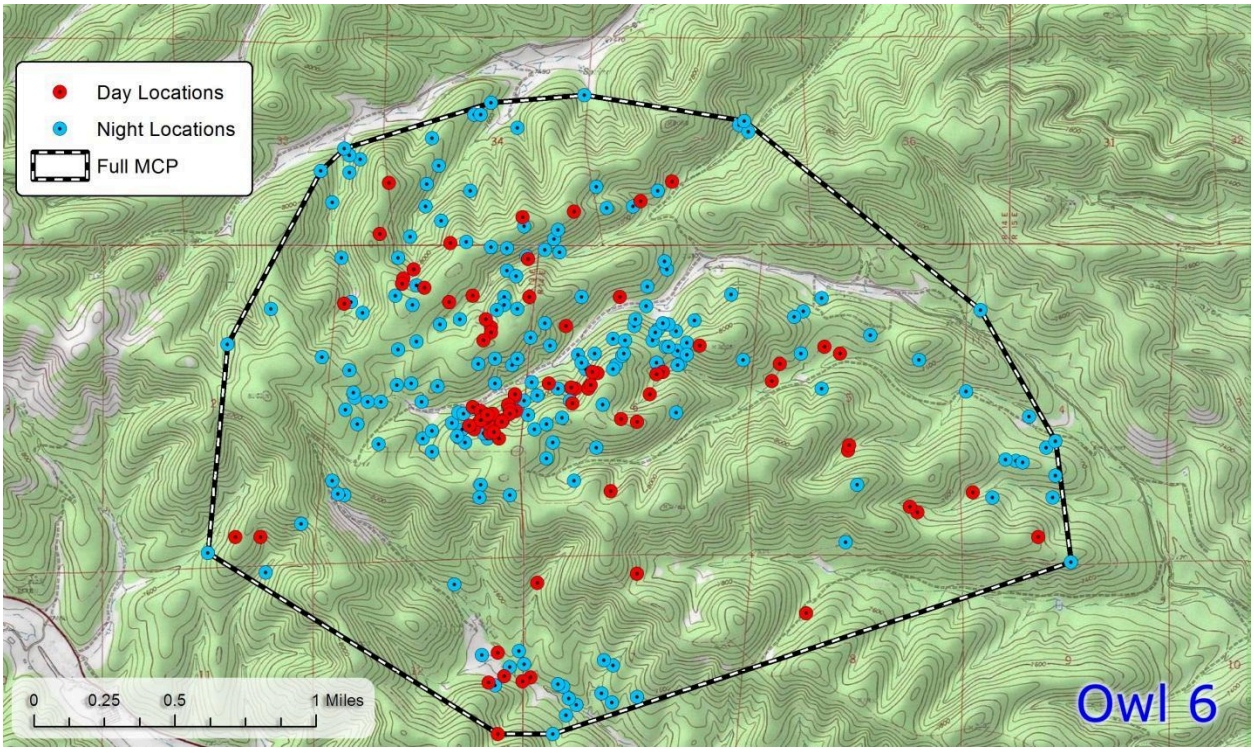
This type of situation calls for a different method. The **Kernel Density** method is a little more complicated, but often a good alternative, and we will examine that shortly.

Local Convex Polygons (aka Local Convex Hulls)

There is an interesting variation on the standard MCP approach that does reasonably well at excluding areas the animal does not use, and even distinguishes between areas with different levels of use. This method, called "LoCoH" for "Local Convex Hulls" (Getz and Wilmers 2004, Getz et al. 2007) generates a series of convex hulls around subsets of locations, then progressively combines them into larger polygons. This method allows you to classify regions according to how many of the points are captured, and does well at finding areas with high and low use. It also does well at capturing natural boundaries and obstacles that may exist on the landscape.

Unfortunately this method is not one of the standard tools, but the methods are pretty straightforward if you are up to writing code to do it. We won't try Local Convex Hulls in this class, but I want you to know what they are and I've got the original papers by Getz et al. for you to download if you are interested (https://drive.google.com/file/d/1dbRP-OH-gXpY3ihDnHLC0FoRWWFlLwTa/view?usp=sharing).

Let's start by looking at the standard MCP around all locations for Mexican spotted own #6 (whom you will get to know in the lab exercises). The full convex hull looks like this:



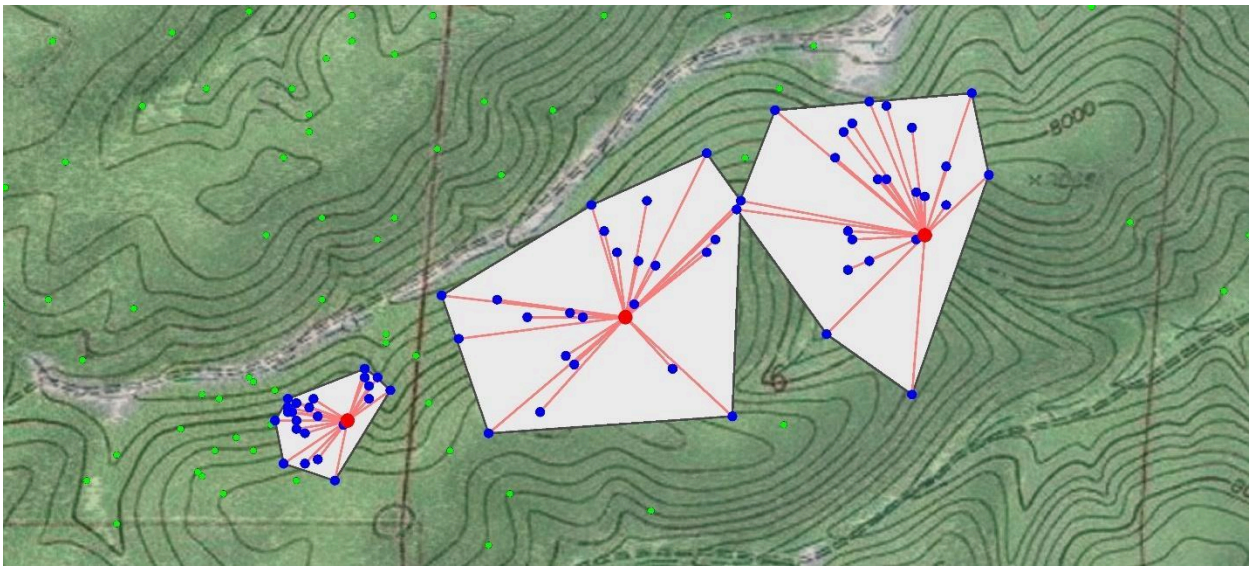
Visually we can see that some parts of this hull are used more than others, so the simple MCP is missing some important information about where the owl **prefers** to be. We could turn to Kernel Densities (see below) if we wanted to look for where this owl concentrates its activity, but Local Convex Hulls might be another method worth trying.

The method starts with finding the *k* nearest neighbors to every point. You specify the value for *k*, and larger numbers produce output that comes closer to the original full MCP. If your value of *k*

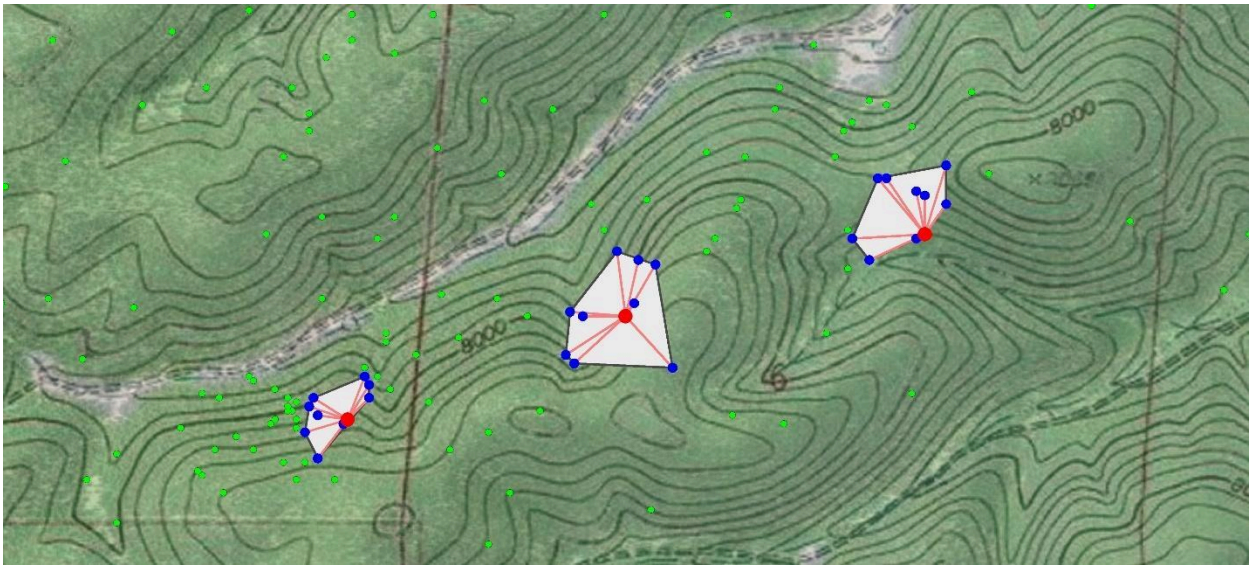
is equal to the total number of points in your dataset, then you end up with the full MCP above. Lower values of *k* classify the landscape in a much tighter range around the clusters of points.

We generate a convex hull around the group of *k* nearest neighbors to the first point in the dataset, then repeat the process for the next point, then again for all points. At the end of the process we have as many small convex hulls as we have points.

For example, if we chose *k* = 25, we would generate convex hulls containing the nearest 25 locations for every location in the dataset:



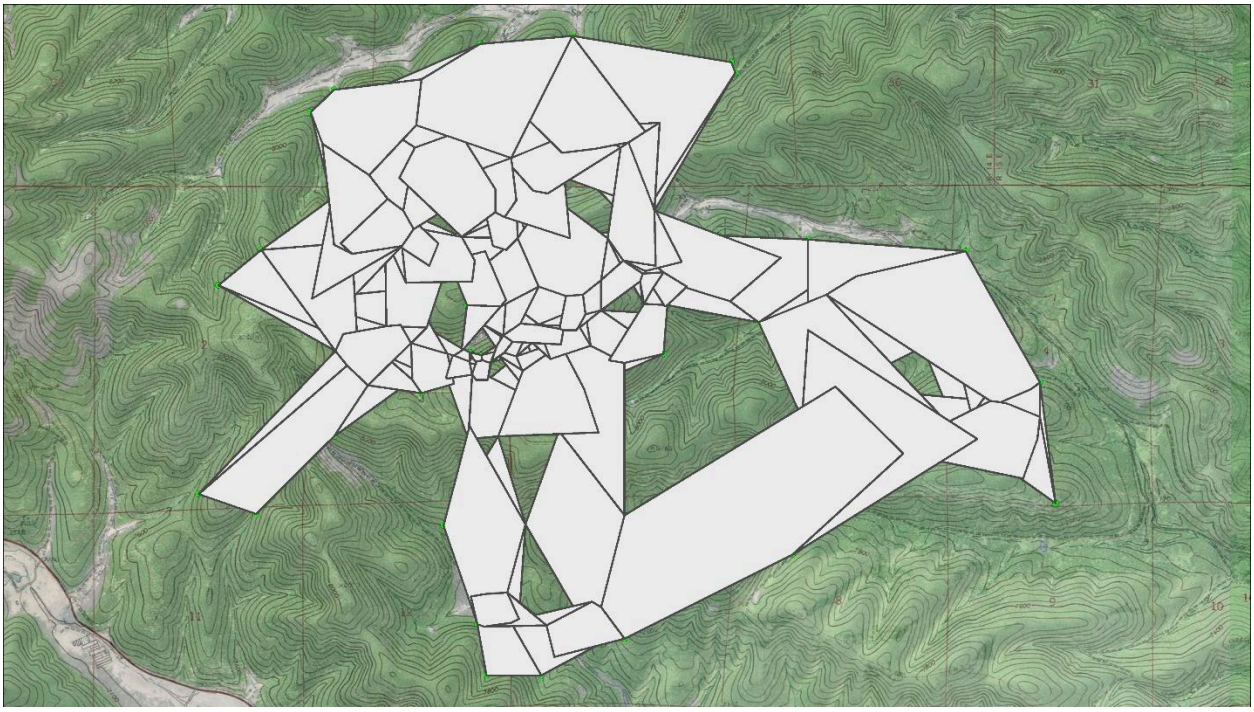
If we chose *k* = 10, we would generate just as many convex hulls, but they would all be a little smaller because they only enclose the 10 nearest points to every location in the dataset:



At the end of this step, we have as many convex hulls as we do points. At *k* = 25, the final set of MCPs looks like this:



At *k* = 10, the MCPs look like this:



Then we sort the convex hull polygons by size, from smallest to largest.

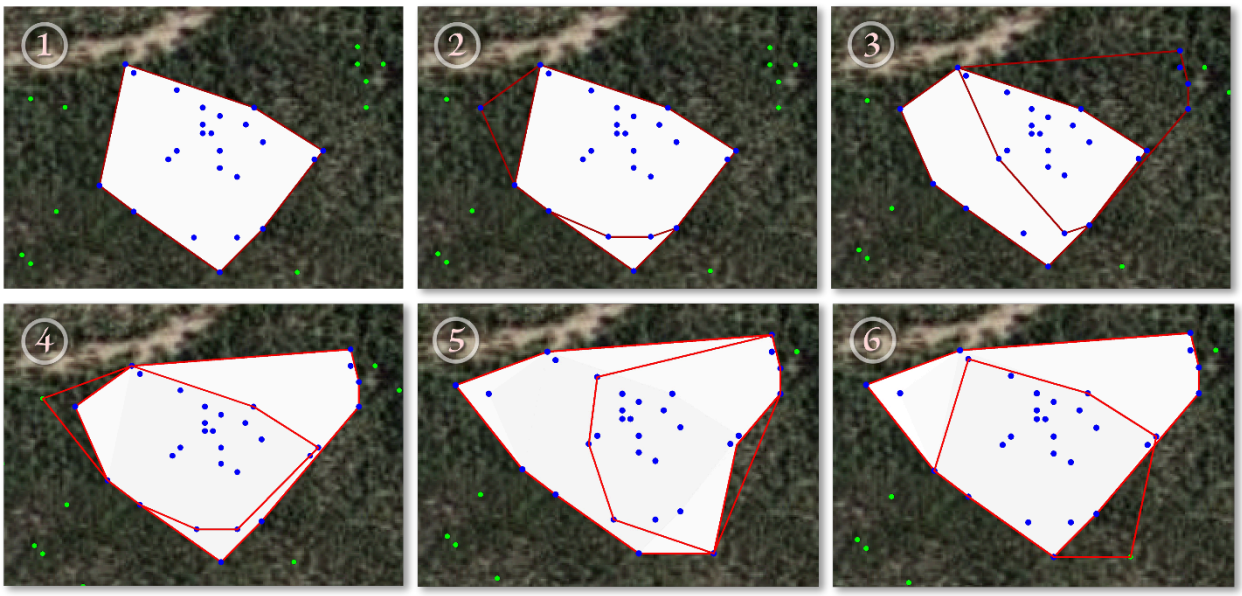
Once sorted, we create a new empty feature class and start adding polygons to it. We start with the smallest polygon and add it to our new feature class. We then **Dissolve** or **Union** the smallest polygon with the next smallest polygon and add that to the feature class. This second combined

polygon now covers all the regions covered by the first two polygons (i.e. the two smallest convex hulls).

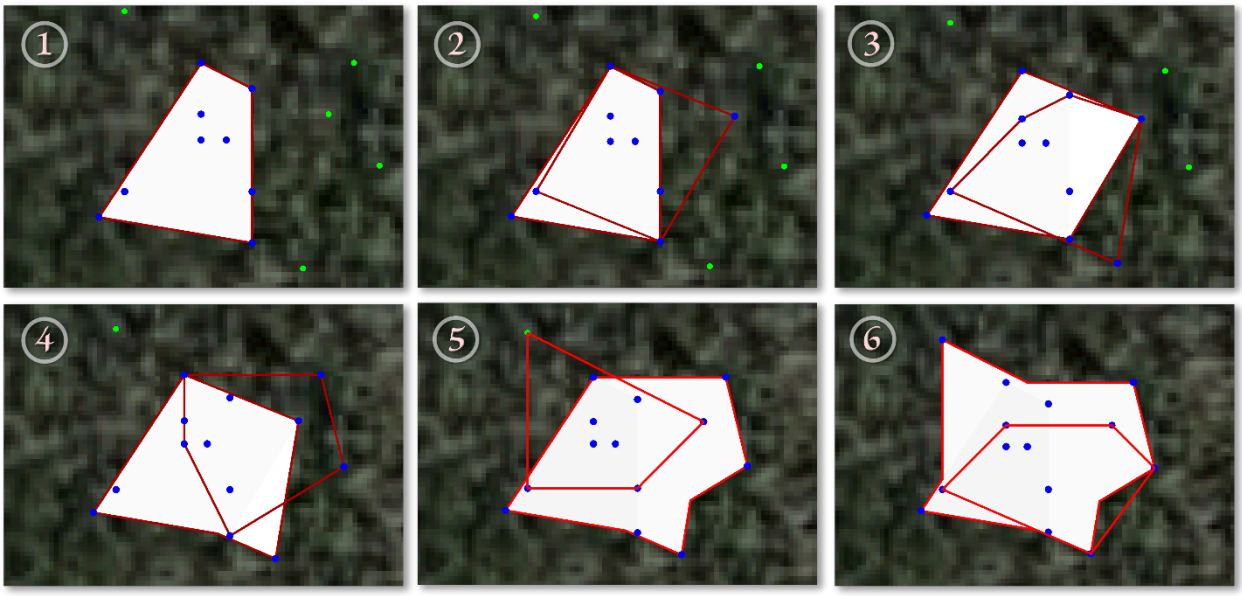
Then we take that combined polygon and dissolve it with the 3rd-smallest polygon, and add that to our new feature class. This third combined polygon now covers all the regions covered by the first three polygons (i.e. the three smallest convex hulls).

We repeat the process for all polygons, until by the last polygon we have a single dissolved polygon that covers the entire region covered by all the convex hulls.

In our *k* = 25 example, the first six iterations of this process looks like this:



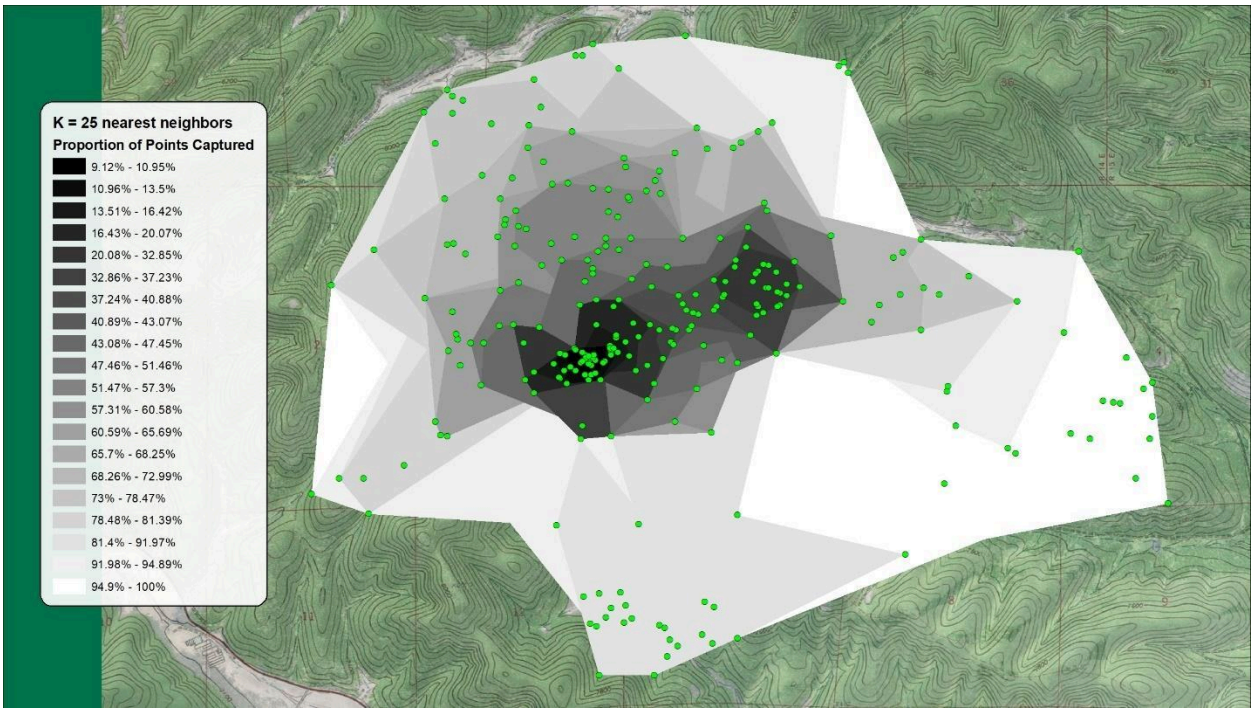
In our *k* = 10 example, the first six iterations of this process looks like this:



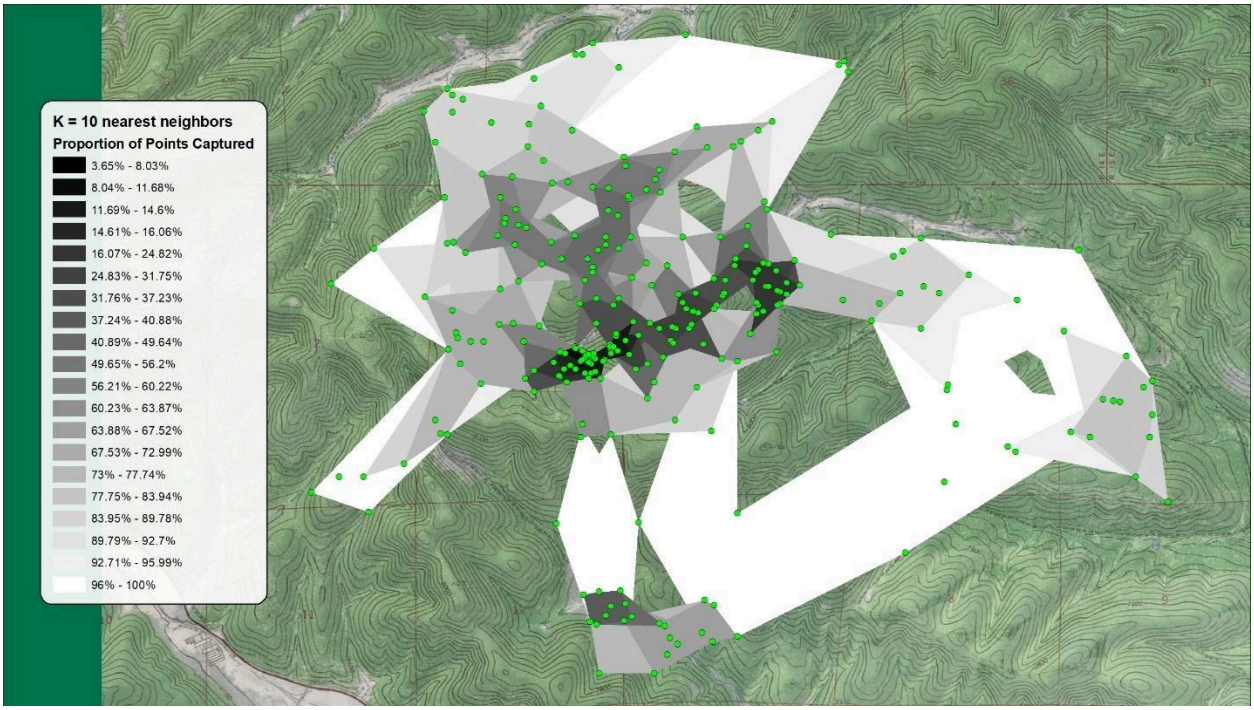
We then go through all our dissolved polygons and count how many points each of them intersects. The first (smallest) one will only have *k* points, and the last (largest) one is guaranteed to contain

all the points. And once we have the point count covered by each polygon, we can then easily calculate the proportion of points covered by each polygon. This last step allows us to identify the regions that contain some proportion of points that we care about, such as the region that contains 90% of all activity, or the more important areas that contain the innermost 10% of all activity.

The final result for our *k* = 25 analysis, shaded according to the proportion of points captured by the polygon, looks like this:

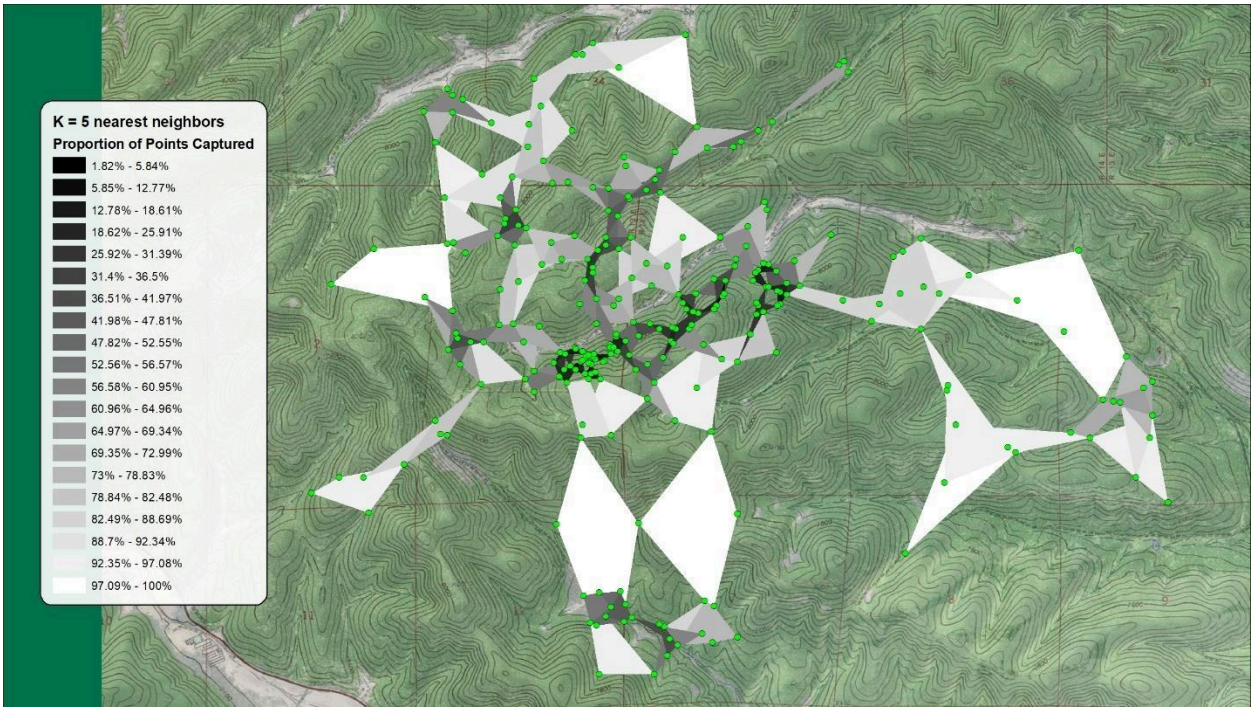


The final result for our *k* = 10 analysis, shaded according to the proportion of points captured by the polygon, looks like this:

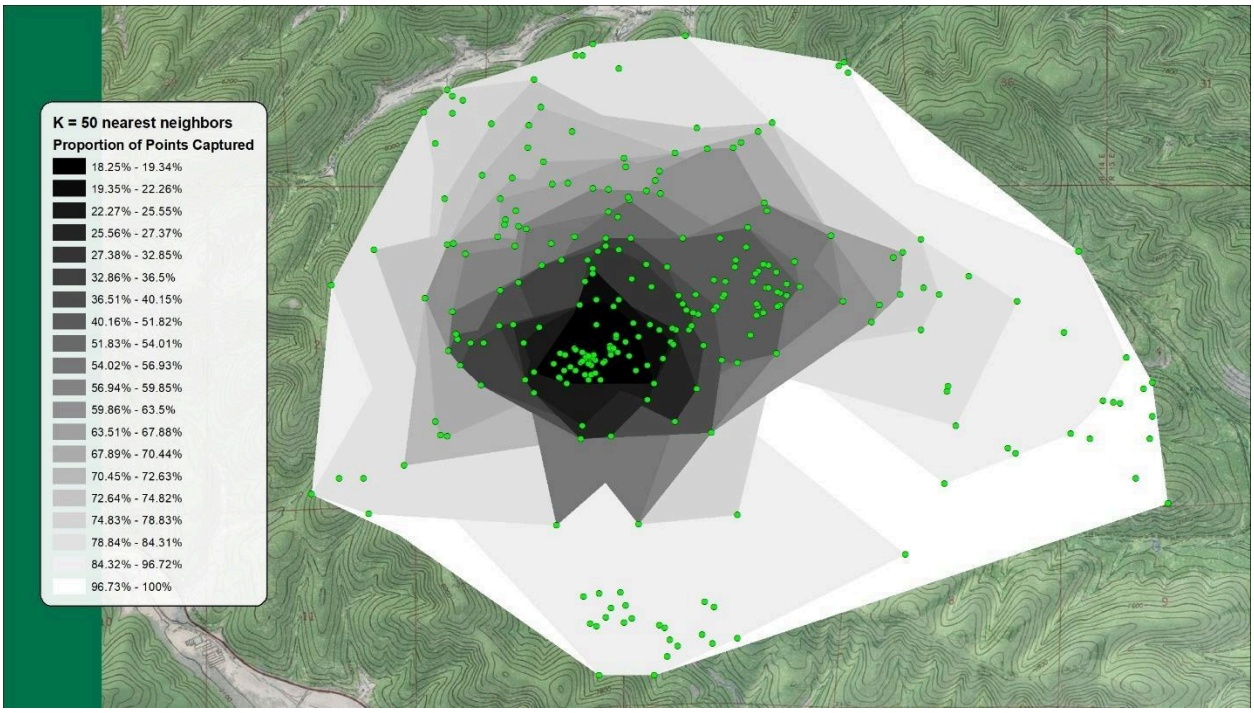


Notice how these final datasets allow for sharp boundaries at the edge of the cloud of all locations, yet they allow for indents in the edge, and holes inside the general range where the animal appears to avoid. And you can control the size of these gaps and indentations by using different values of *k*.

For example, if we tried *k* = 5, we would get a much tighter fit around the local clusters of points:



If we tried *k* = 50, the overall extent is much closer to the original MCP, but we still have the advantage of identifying the regions where activity is highest.



Kernel Density

Kernel Density surfaces are definitely more abstract than MCPs, but they are also fairly intuitive once you understand them. In truth, one of the most confusing things about the entire concept is the name. In this case, the word "kernel" actually refers to a mathematical equation which defines a 3-dimensional bell-shaped curve. Like many things in GIS, this concept could probably have been given a more intuitive name.

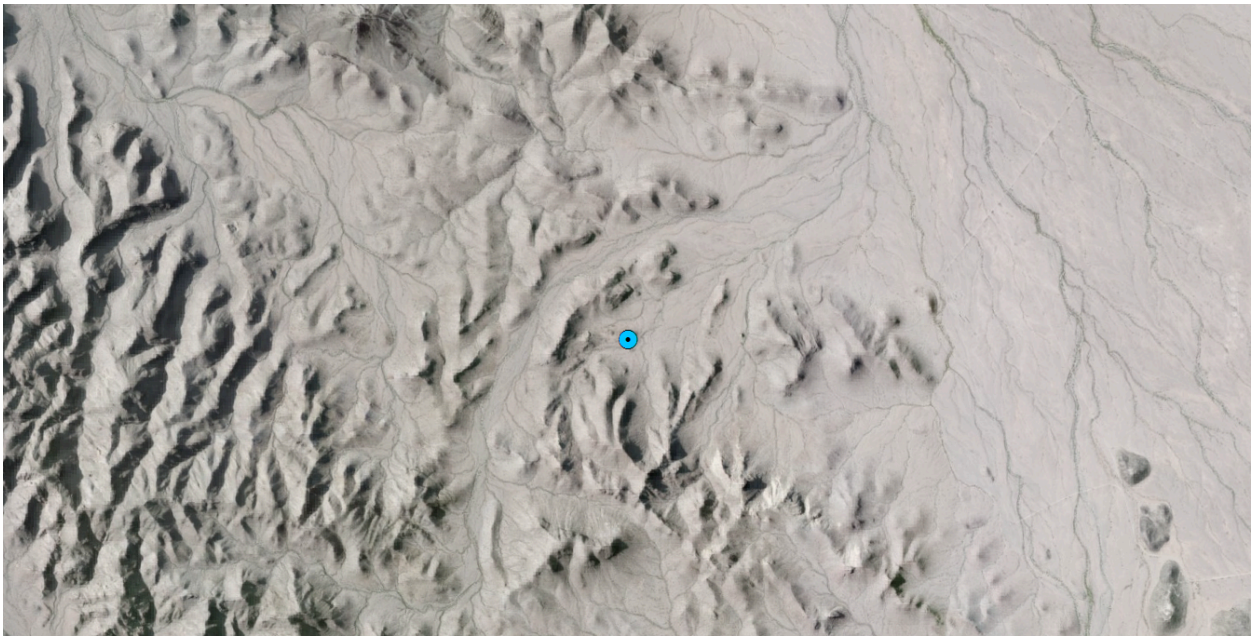
Again recalling the difference between **vector** and **raster** spatial data, **Kernel Density** analysis uses **vector** input data (either points or polylines), performs a **raster** analysis and produces a **raster** output dataset representing the density surface.

A proper understanding of Kernel Density analysis should start with a discussion a simpler type of analysis called a **Point Density** analysis. We will briefly cover this concept before moving on to describe kernel density.

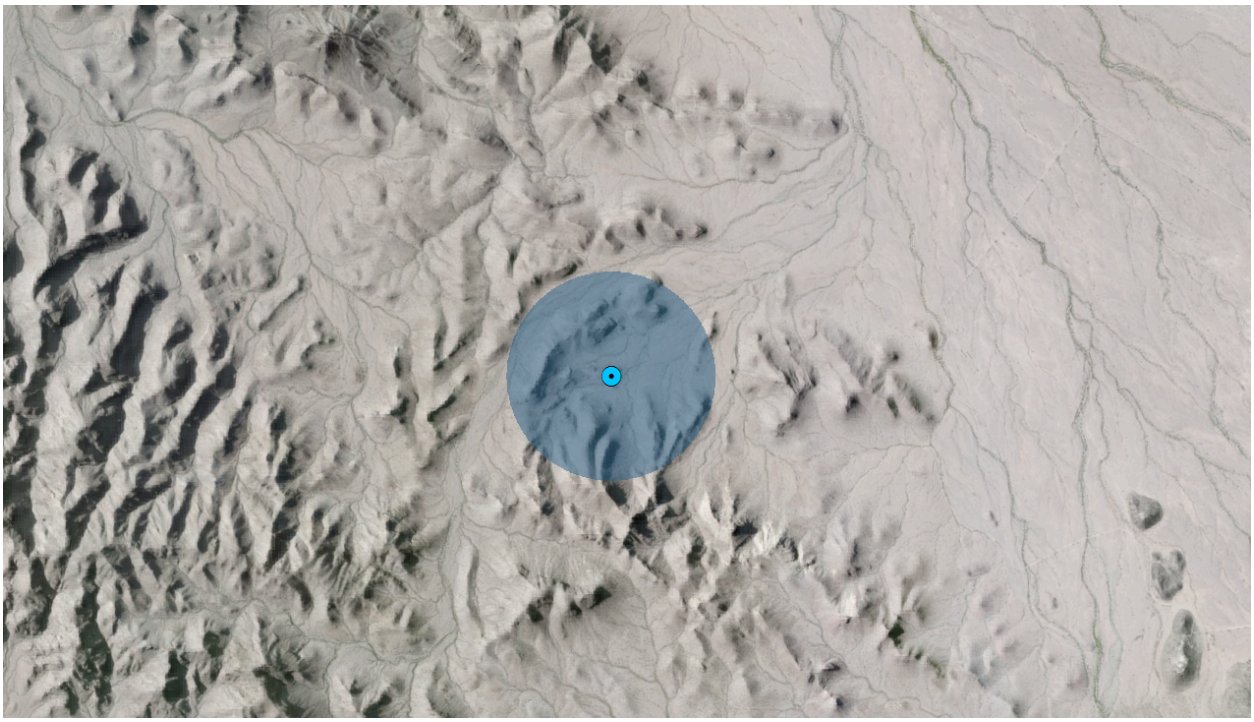
Point Density: Similar to Kernel Density but Simpler

The goal of any point density analysis (including kernel density) is to describe the landscape in terms of how densely points are distributed in that area. For example, we may be interested in how many water sources there are, per square mile, in the desert in southwestern Arizona. Places with a high density of water sources (i.e. many water sources per square mile) might be more likely to support various vertebrate and invertebrate populations than places with low water source density.

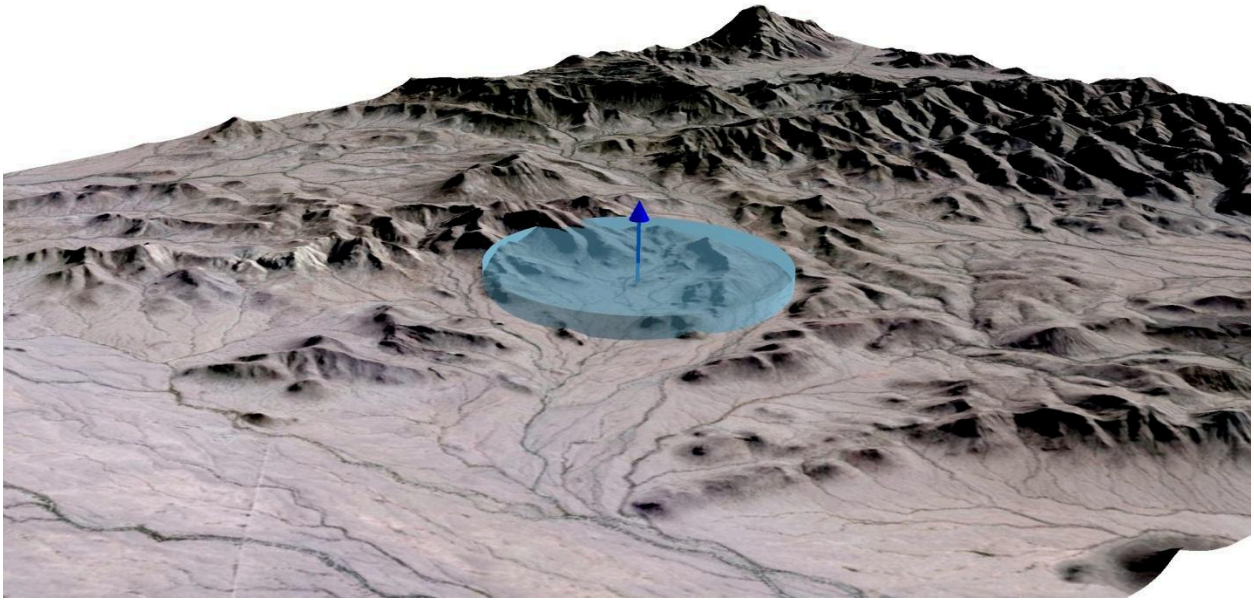
Suppose we know of one spring on the landscape and we generate a point density surface around it. The original water source is at the blue dot below:



The simple point density surface would look like the illustration below. The larger blue circle happens to have an area of exactly 1 square mile. In this case, any place inside that blue circle has a density value of 1 water source per square mile, while any point outside the circle has a density of 0 water sources per square mile.

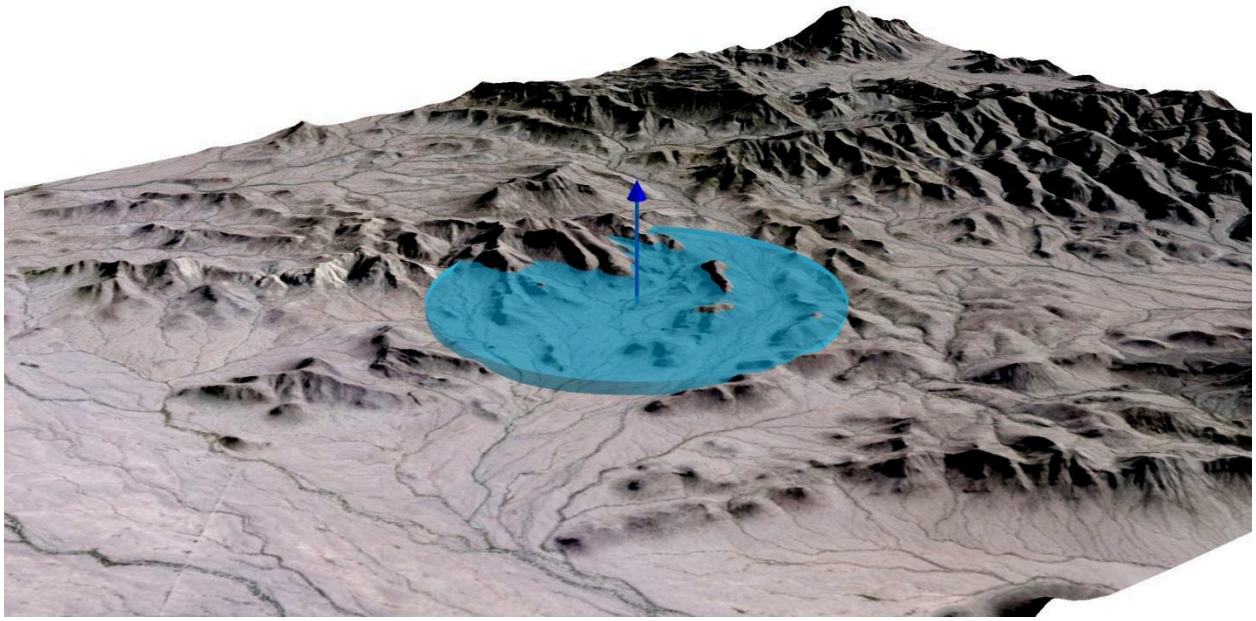


It can help to visualize this in a 3D perspective, where the density region rises like a disk laying on the landscape. This 3D perspective will be especially useful when viewing overlapping point density circles, and even more so when comparing simple point density to kernel point density.

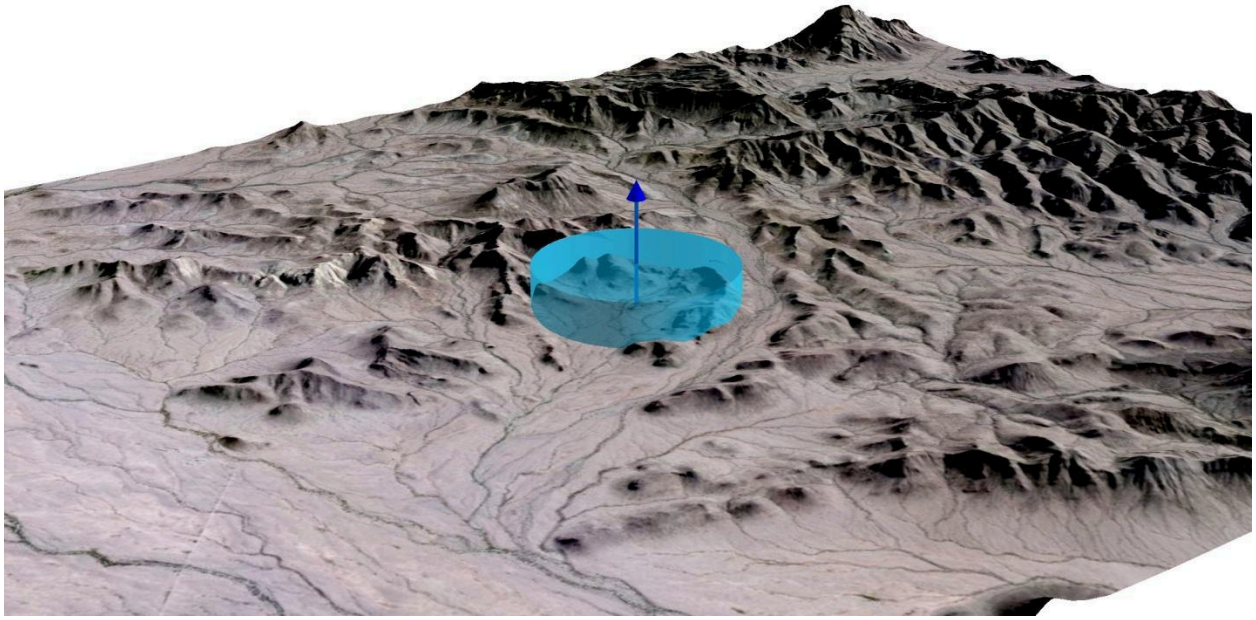


An important point to understand is that the density value inside the disk is based on the size of the disk! The size of the disk (more specifically, the "radius of the circular neighborhood" or the "search radius") is one of the parameters of the tool. You have to specify the circle size when you run the tool. In this example, we generated a disk that was exactly 1 square mile in size. There is exactly one point inside that disk, and therefore the density everywhere inside the disk is 1 point per square mile. What would happen if we used a different search radius?

- If we had used a larger neighborhood radius (say to produce a circular neighborhood 2 square miles in size), then the density values inside the disk would be 1 point per 2 square miles, or **0.5 points per square mile**. The disk is twice as large and the density inside the disk is half as high.



- If we had used a smaller neighborhood (say to produce a circle ½-square mile in size), then the density values inside the disk would be 1 point per ½-square mile, or **2 points per square mile**. The disk is half as large and the density inside the circle is twice as high.

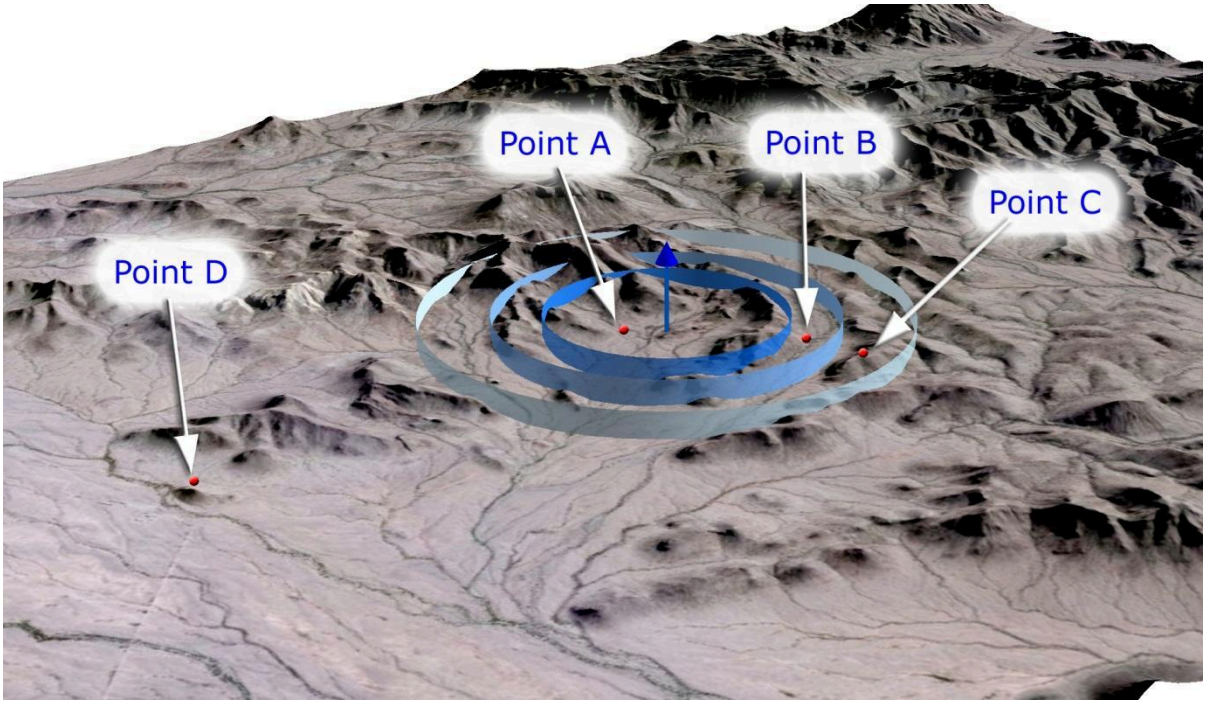


- **Note:** A value of 2 water sources per square mile may seem odd given that there is only one water source on the landscape, but that is the nature of density analysis. Density analysis does **not** tell you how many points there are, but rather the ratio of points per area. If you want to know the density in terms of points per square mile (or per square kilometer, acre, hectare, etc.), and you specify a circle size that is different than your area unit (such as ½ square mile instead of 1 square mile), then your density value will be scaled to fit your area unit.

So what is the water source density at some random point on the landscape? It depends on 2 factors:

1. The number of water sources nearby (i.e. how many are within your search radius distance), **and**
2. The search radius distance you used when you generated the point density surface.

Let's look at some examples. In the illustration below we have 4 points on the landscape to test. Point A is inside the density disks using all three neighborhood sizes we've tested so far. Point B is outside the ½-square mile disk, but inside the 1- and 2-square mile disks. Point C is outside the 1 square mile disk but inside the 2 square mile disk. Point D is outside all three disks.



Since point density at any random point on the landscape depends on **both** the proximity to points **and** the neighborhood size used to generate the density surface, we will get a different density value for each point depending on which density surface we test with.

Density (Water Points per Square Mile) at 4 Sample Locations on the Landscape			
Test Location	**Circle Size Used to Generate Density Surface**		
	½ square mile	**1 square mile**	**2 square miles**
Point A	2	1	0.5
Point B	0	1	0.5
Point C	0	0	0.5
Point D	0	0	0

Please make sure you understand the numbers in this table and how the density value for any point on the landscape will change if you use a different neighborhood size to generate the point density surface.

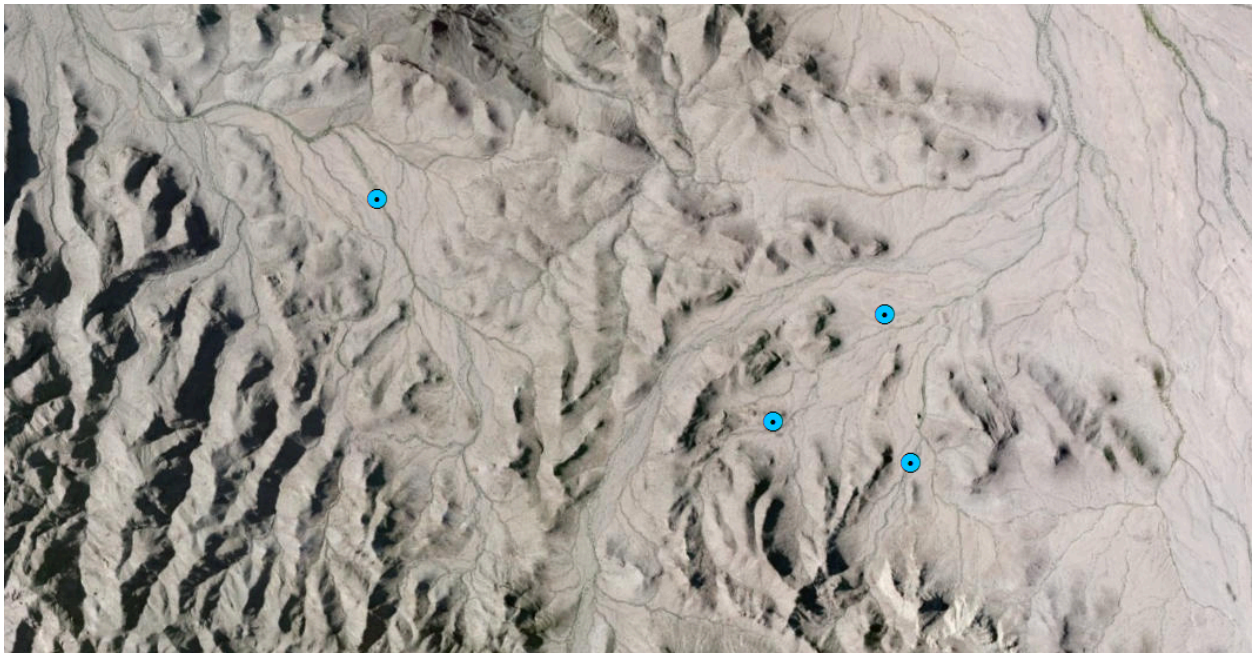
A Clarification of the Point Density Method:

At this point you may be thinking that point density is calculated by drawing circles around the water locations. The output certainly looks like that. This is **not** how point density is actually calculated, though.

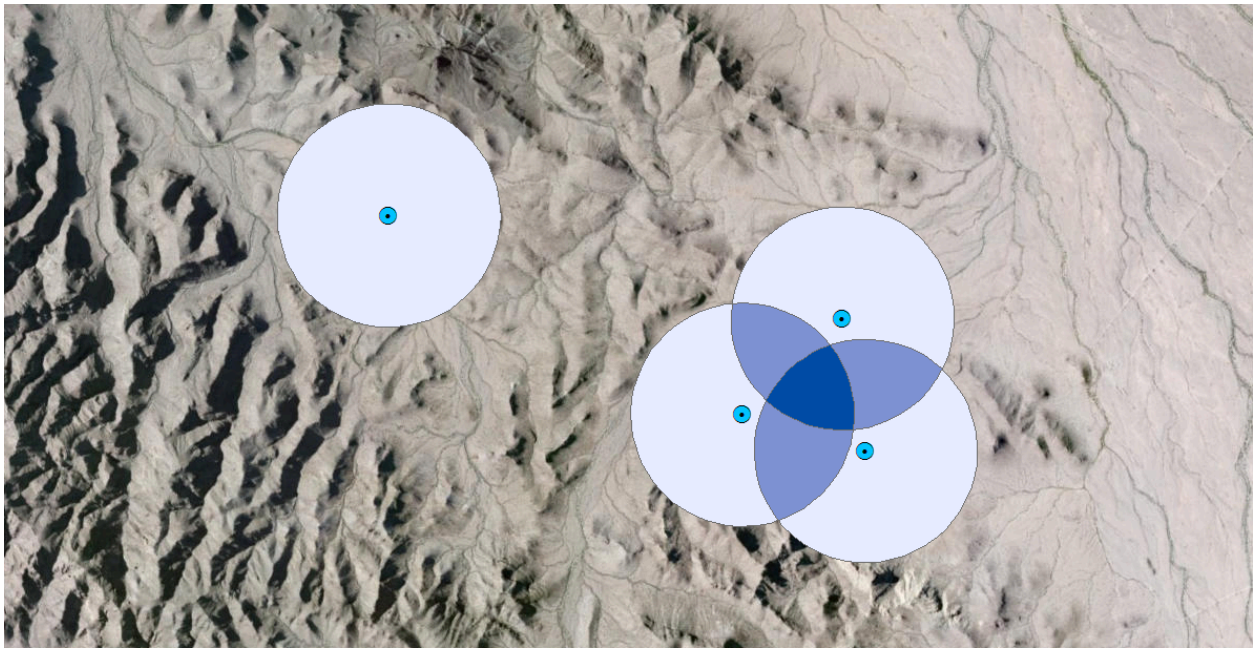
Remember that this is a raster-based operation. Like most raster analytical functions, the output is calculated cell-by-cell on the raster. This means that ArcGIS initially creates a blank raster for the output. It then steps through every cell in the new raster and looks to see how many water sources are within your search distance from that cell. This means that the search radius you specify is applied to every cell in the new raster, not to the water source locations! If ArcGIS finds one water source within the search

radius of a raster cell, then that cell gets a value of “1” (scaled to fit your area unit if necessary; if we use a circle that is 2 square miles, and our area unit is 1 square mile, then “1” will be scaled to “0.5”). If ArcGIS finds 2 points within your search distance, then that cell will get a value of “2”.

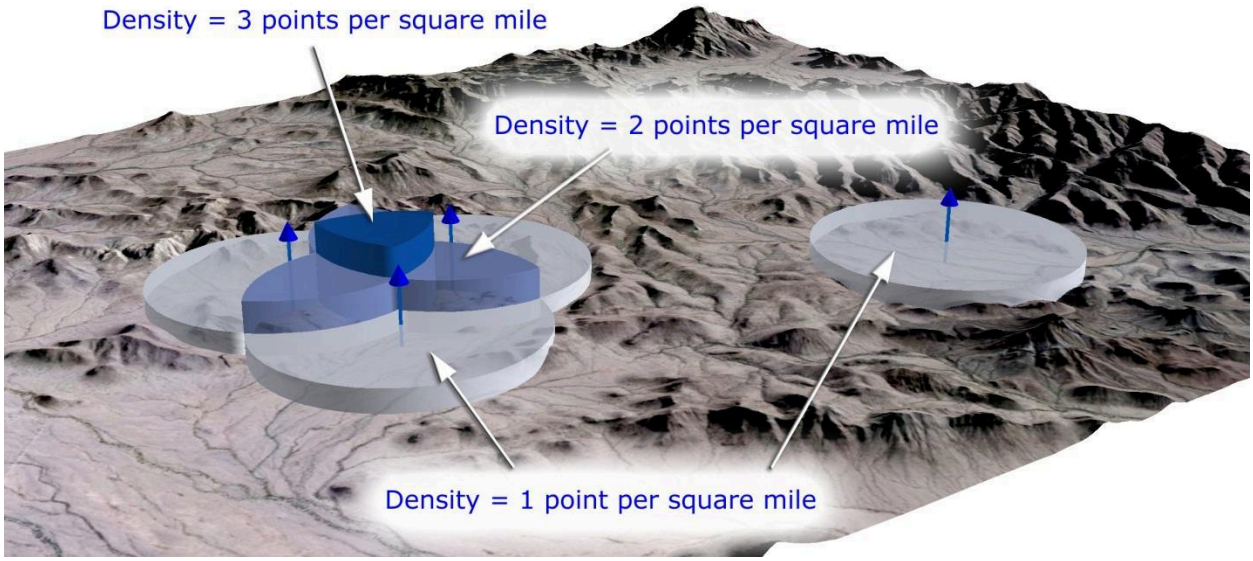
This causes an interesting thing to happen when you have points close enough to produce overlapping disks. Suppose we had 4 water source points in our dataset:



If we use a circle size of 1 square mile, then 3 of these points are close enough to each other to produce overlapping disks and our point density disks would look like the illustration below. Notice the overlaps from the three points on the right. Much like a Venn diagram, some parts of the landscape are overlapped by only 1 disk, some are overlapped by 2 disks and the dark blue region in the middle is overlapped by 3 disks. The point density at any point on the landscape is equal to the number of disks that intercept it multiplied by the density value within a disk.



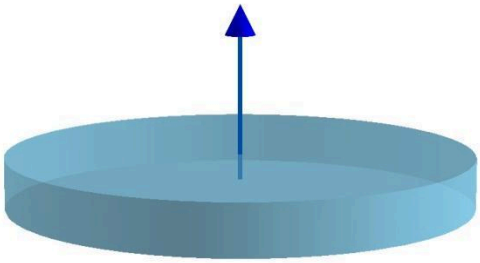
Viewed at an angle, we can see better how the disks stack up.



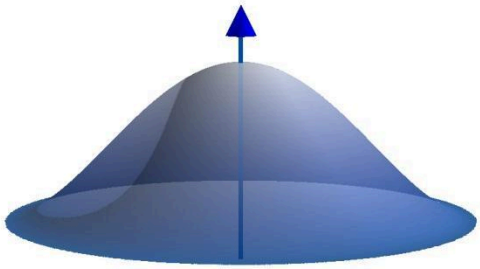
An important point: Because of these stacked disks, notice that point density values tend to be constant over large areas and then change abruptly at sharp edges. You are either inside the radius distance from a point or you are not. There is no adjustment in density for areas based on the distance from a point.

Kernel Density

Kernel density is very similar to simple point density. The difference is in the shape of the density region around each point. As shown above, simple point density produces a disk shape where the entire region inside the neighborhood circle has the same density value:



Kernel density, on the other hand produces a bell-shaped curve around each point:



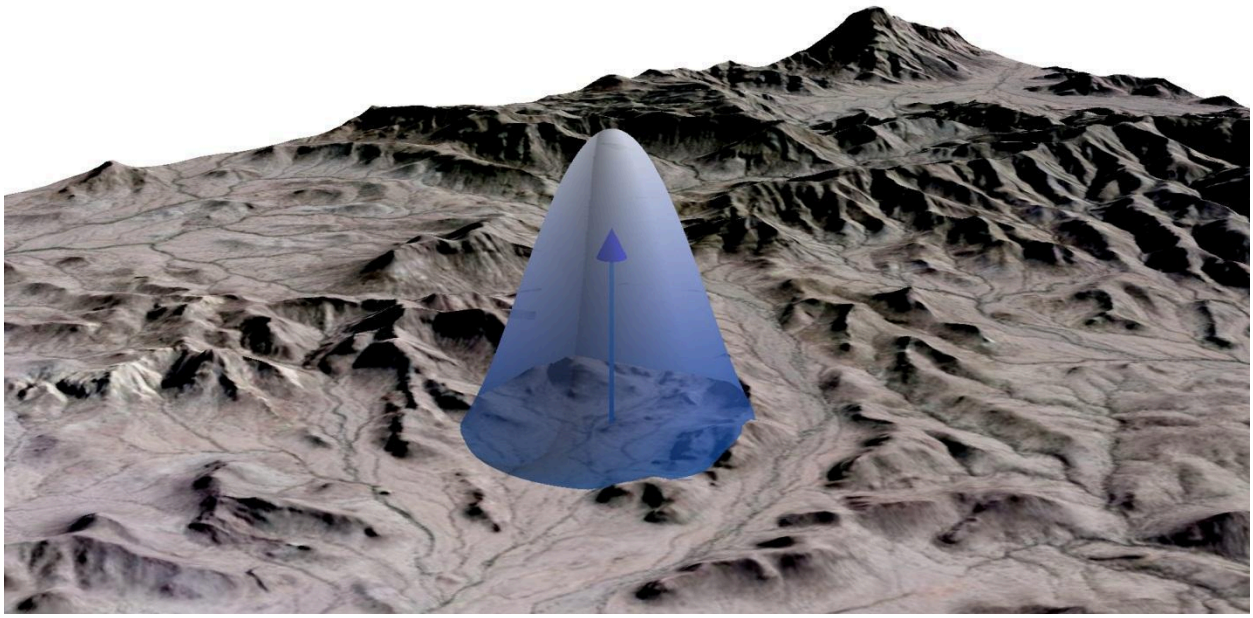
The word “Kernel” is the name given to the mathematical function that produces this bell-shaped curve. The effect it has is to weight the density value at any location according to how close that location is to an actual point. The closer you are to a water source, the higher the density value will be.

As with basic point density, you must specify a circle size for the search area and you define the circle size by specifying a search radius. In kernel density, that search radius is the distance at which the curved bell shape drops to zero. The size of this circle is referred to by various names. You will often see it called the **Search Radius**, **Kernel Size** or **Bandwidth**.

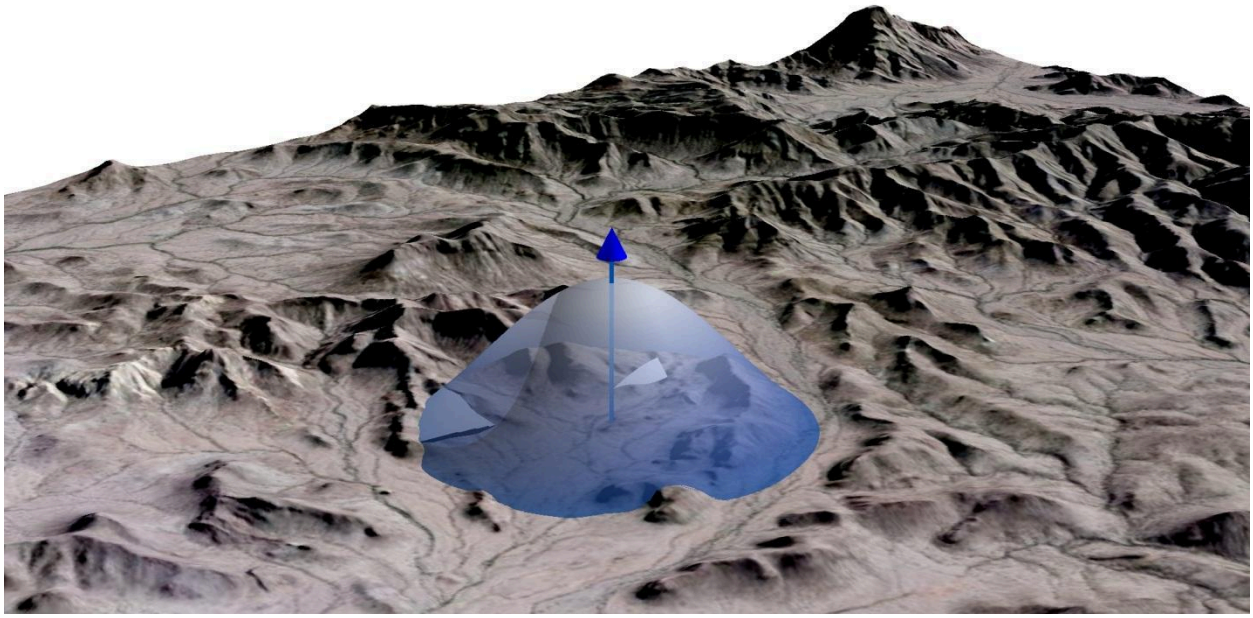
Important Point: The actual density value at any location is interpreted the same way as simple point density. If you specify your area unit as a square mile, then the density is interpreted as points per square mile. Remember, as with simple point density, this value does **not** tell you how many water sources there actually are nearby. It is a ratio of points per area, and therefore you may easily have a higher “points per square mile” than there actually are water sources nearby.

Another Important Point: The **volume** under the curve stays the same regardless of the search radius you set. This means that using a larger search radius (i.e. a larger circle) produces a flatter overall curve. This is similar conceptually to the simple point density results. Setting a larger search radius produced a larger disk with lower density values.

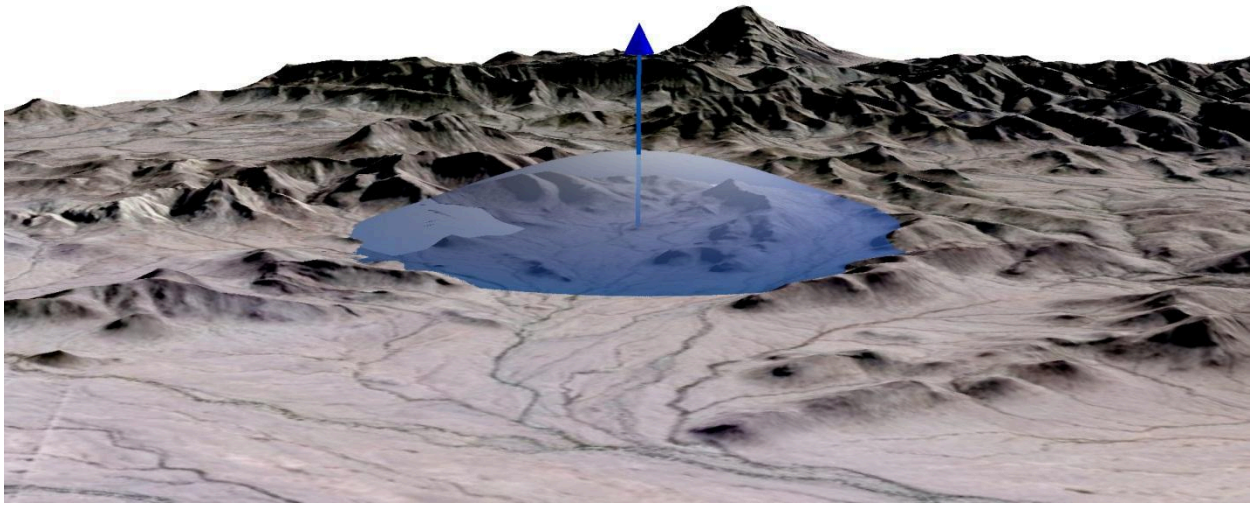
For example, using a search radius equivalent to a ½ square mile circle produces a kernel density surface like this:



A search radius equivalent to a 1 square mile circle produces a broader, flatter density surface:

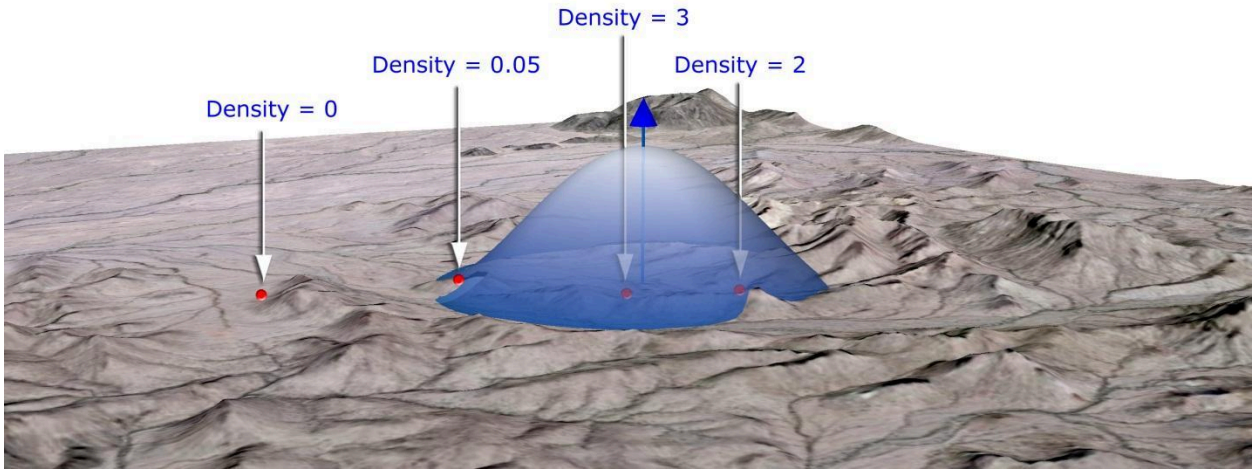


A search radius equivalent to a 2 square mile circle produces this.



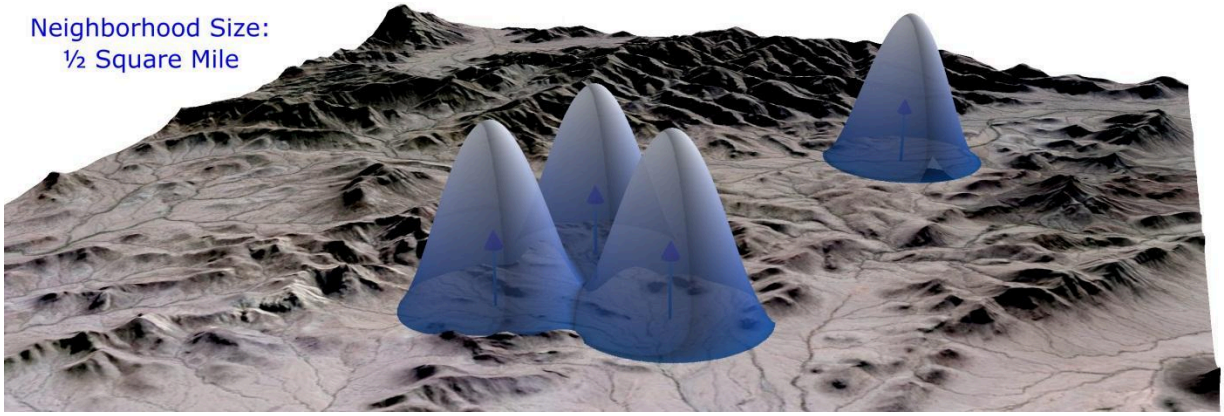
All three density surfaces illustrated above contain the same volume under the curve.

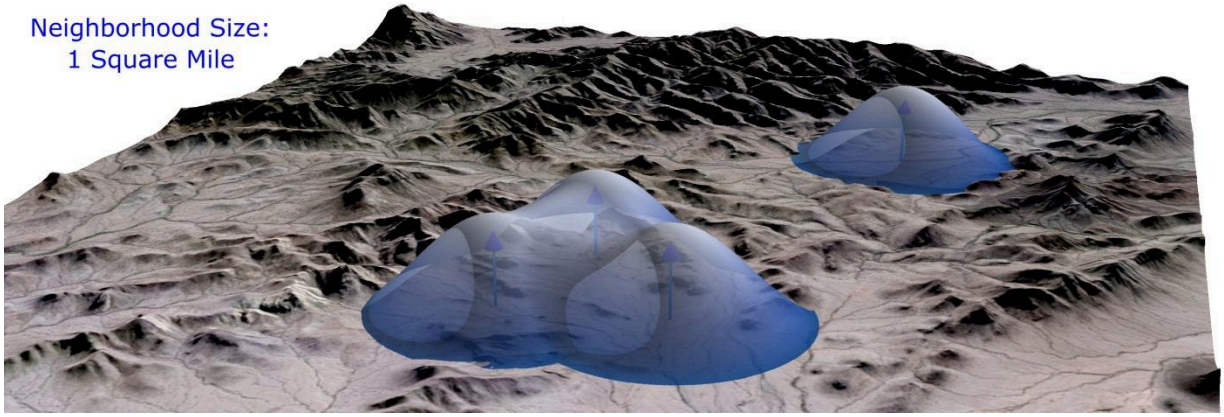
A nice feature about kernel density surfaces is that the density value changes depending on proximity to a water source. Areas closer to a water source, for example, are weighted higher than areas farther away. This is more reasonable for most environmental phenomena. Animals (like people) usually care more about things when they are closer.

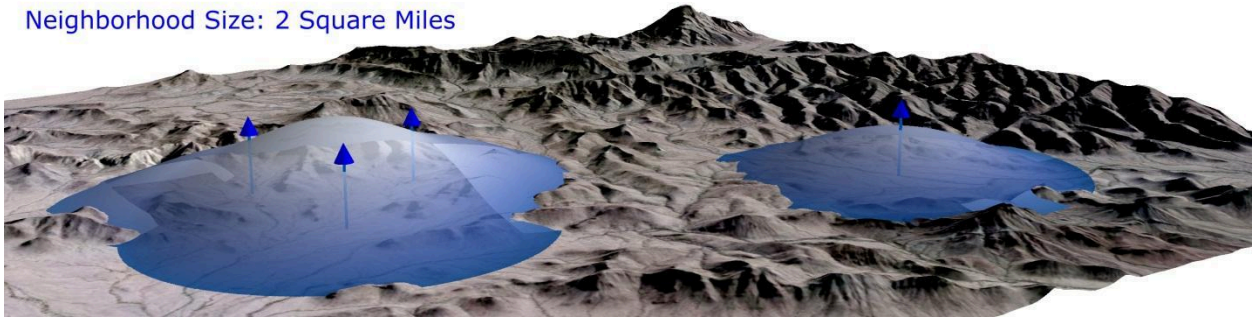


Kernel Density with Multiple Points:

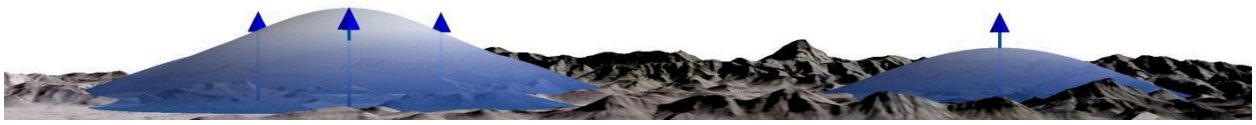
As with the simple point density, a kernel point density analysis conducted with multiple points produces a density surface with higher values when multiple points are nearby. Visually it looks like bell curves stacked on top of each other. Using the same 4 points from our earlier example, we see the following density surfaces using neighborhood circle sizes of 0.5, 1 and 2 square miles.







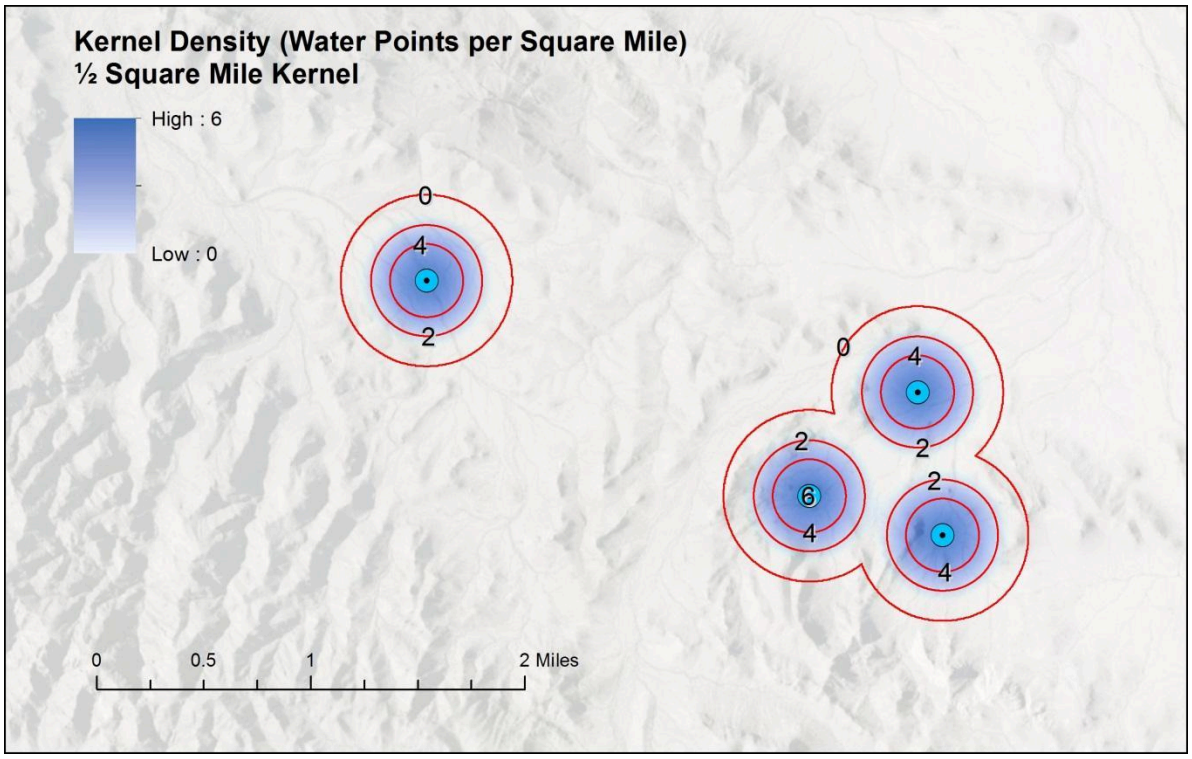
Notice that, with a 2 square mile circle, the density close to the cluster of three points is higher than is possible for the single point on the right.

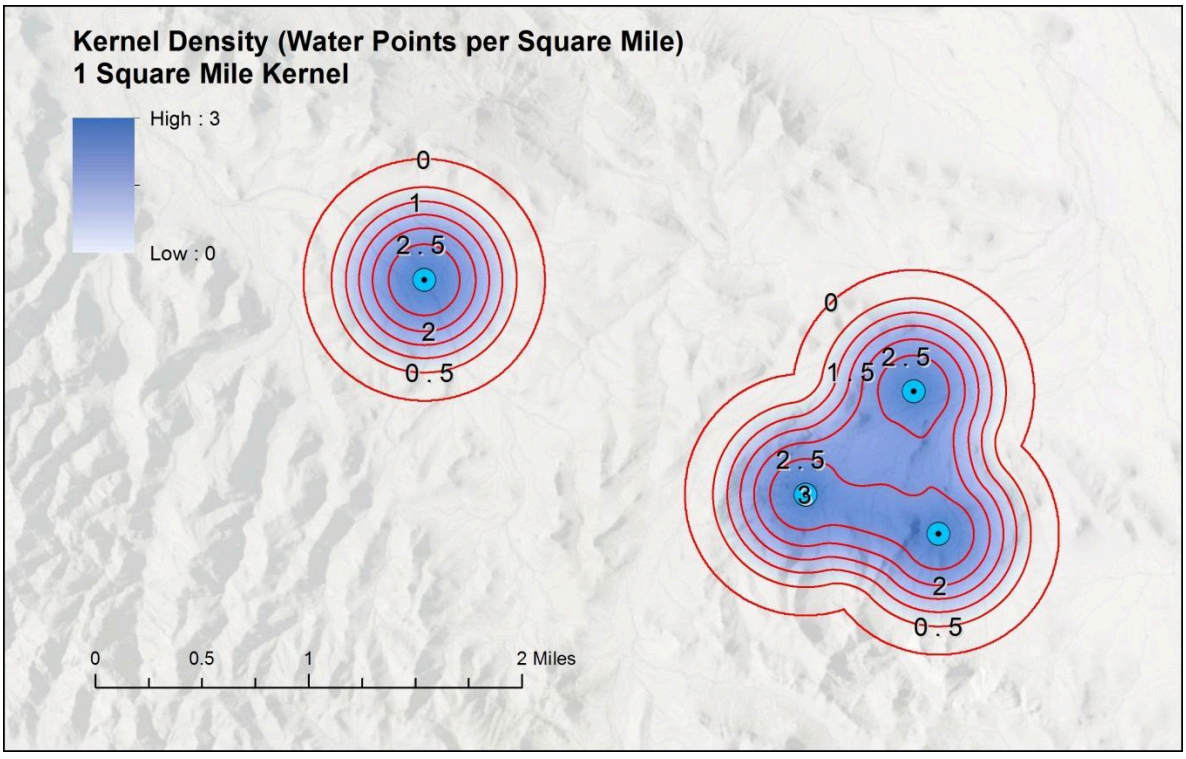


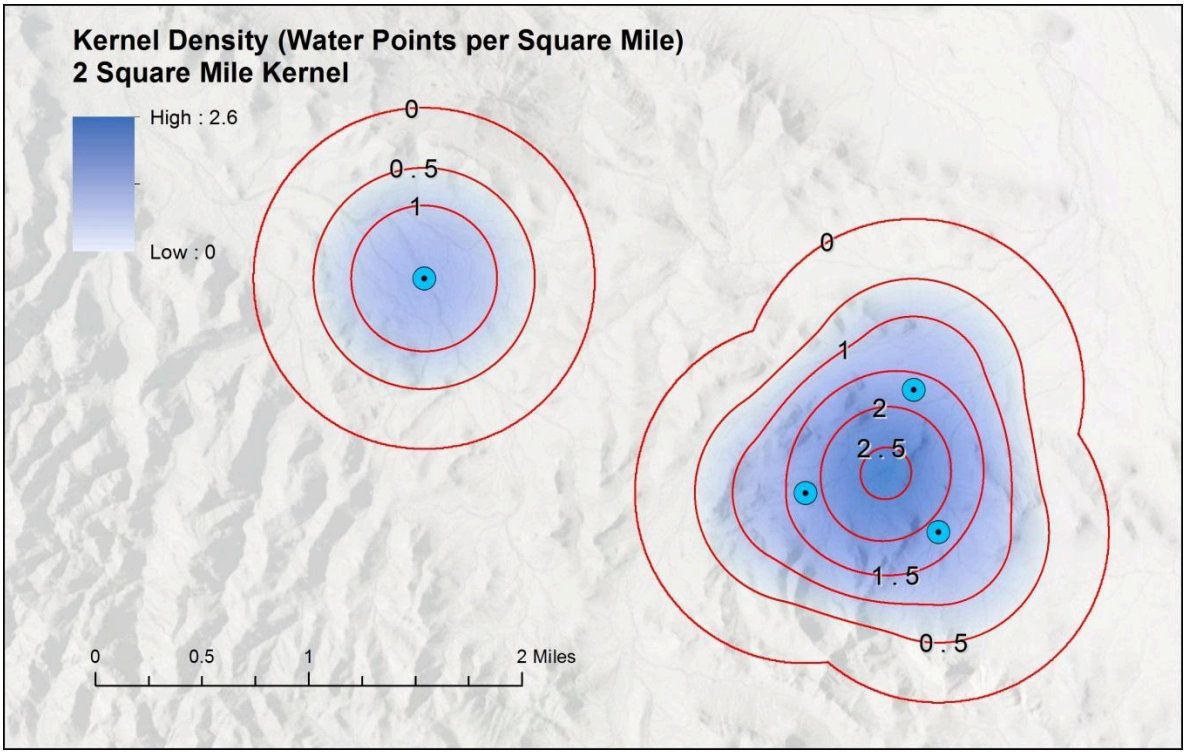
Notice also how the density values generated by the kernel density analysis gradually change over the landscape, rather than having sharp breaks like we saw in the simple point density analysis.

Observe the overall density patterns formed over the landscape. Your neighborhood circle size (aka kernel size, bandwidth) again plays a critical role in the distribution of density values over the landscape.

Larger circles smooth out the data and produce more generalized density regions, while smaller circle sizes show you more detail of density changes over shorter distances.







How do you know what kernel size to use?

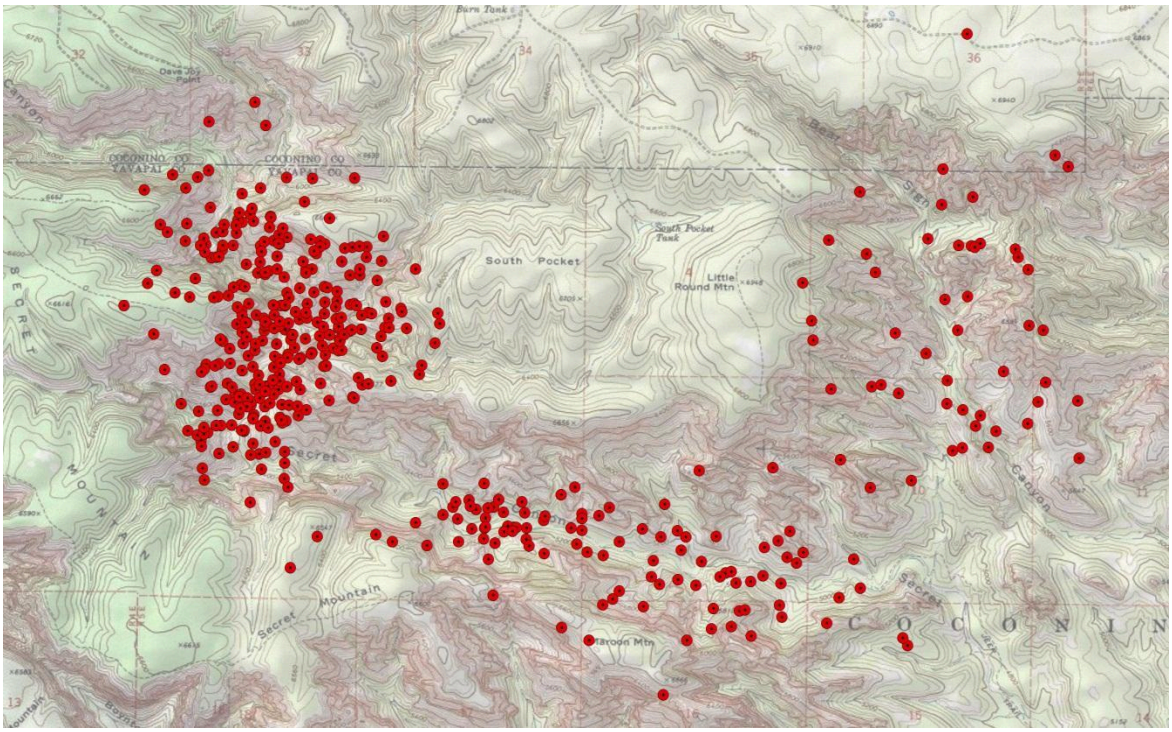
This, unfortunately, can be a very difficult question to answer, and can lead to some fairly sophisticated statistical analysis. I can refer anyone who is interested to books and journal articles on this subject but we will not go into it in this lab. Some people follow a rough rule of thumb based on contour lines such as those illustrated above. They will try progressively larger kernel sizes until the outermost contour lines meet up, so as to create a single polygon that contains all the locations. This method may not be appropriate for your particular project, though.

ArcGIS will set a default kernel size if you do not specify one. If you are curious about how ArcGIS calculates this value, please refer to the Sidebar on p. . In this lab, you will always set your own kernel size value.

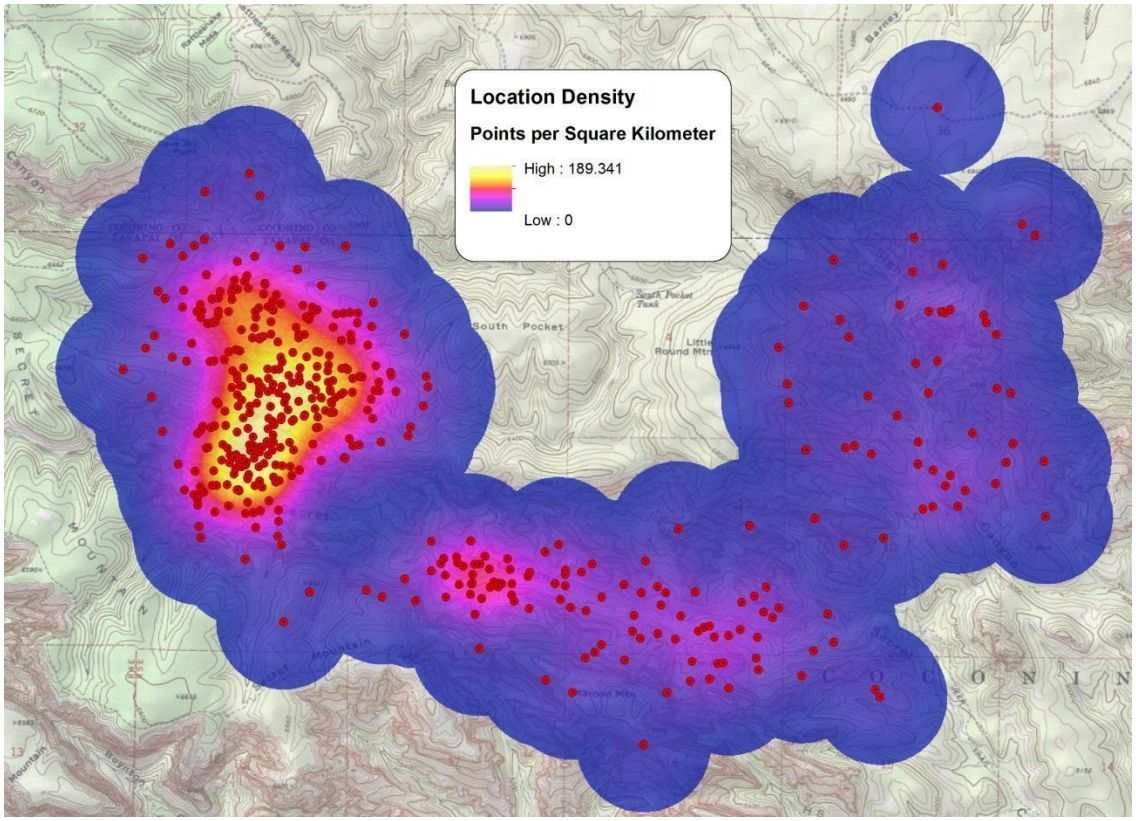
Converting a Kernel Density Surface to a Home Range Polygon

Once you have generated your density surface, the next step is to decide which part of that density surface represents the home range of your animal. The guiding assumption here is that areas with higher location densities are more important to the animal, on the logic that the animal would probably choose to spend the most time in areas that are most important to it.

Suppose we have some animal with a GPS collar down in the Secret Canyon area north of Sedona, and we have recorded a number of GPS locations on this animal:

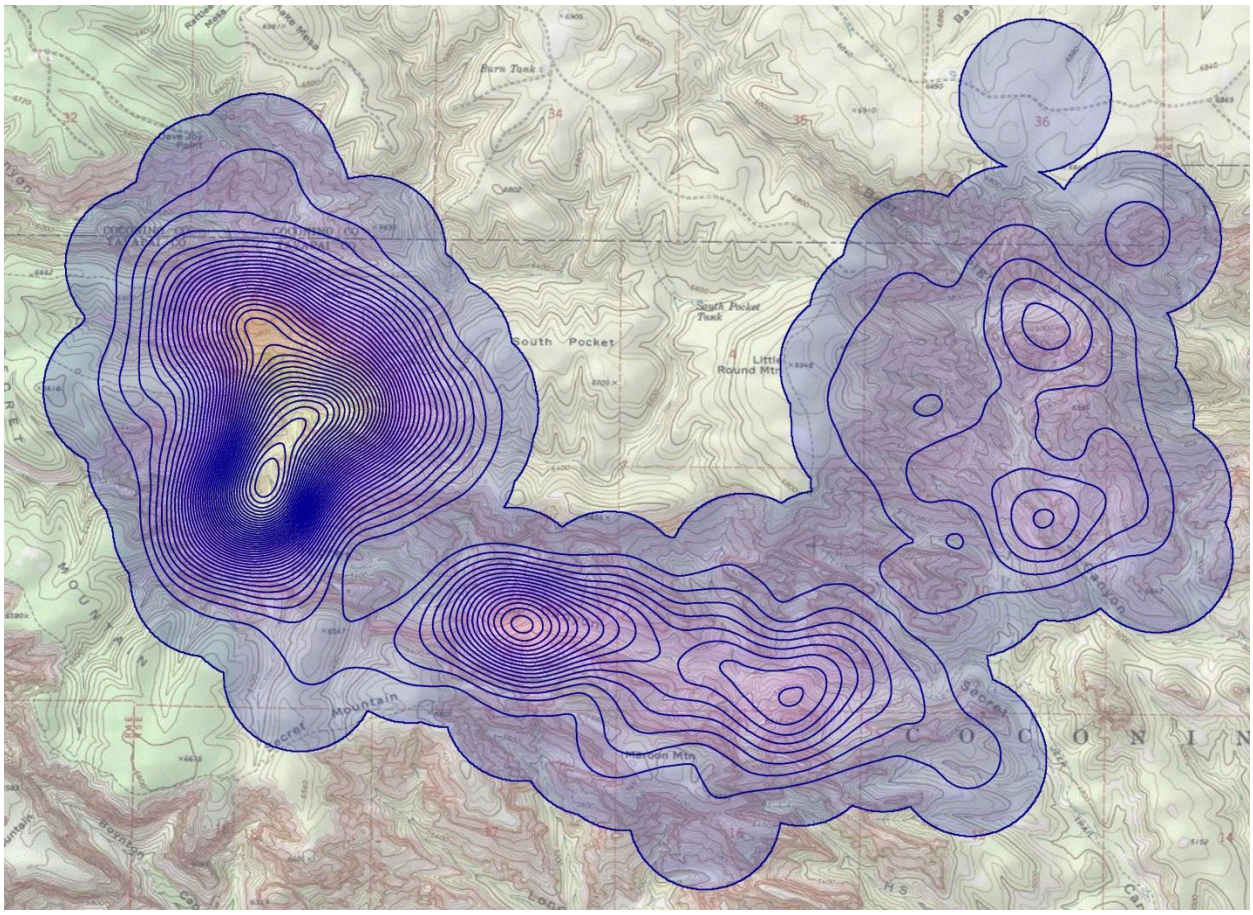


From these points, we generate a kernel density surface (see map below). For this example, we are using a 500m-radius kernel, and density values are in points per square kilometer. Density values range from 0 to 189 observations per square kilometer.

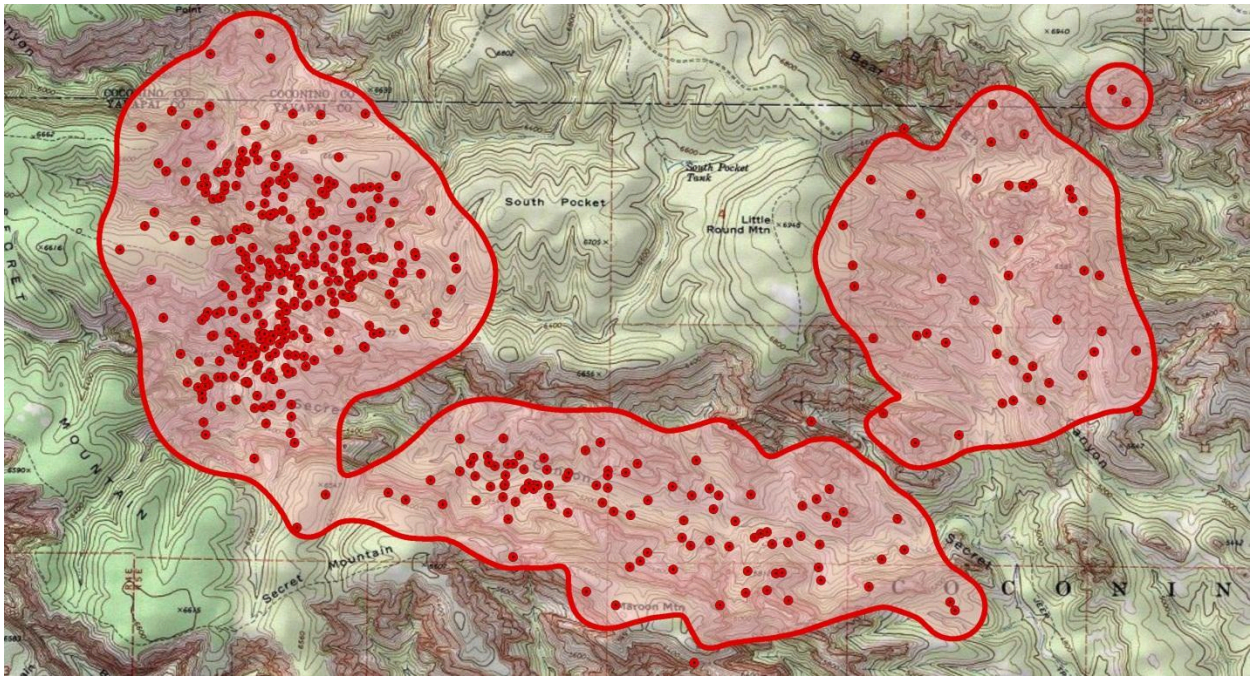


Next we need to decide what part of this density map represents the home range of the animal. We could use all areas where density > 0, which may be reasonable in some situations. That would be a conservative approach that would guarantee we captured the true home range of the animal. However, it runs the risk of delineating more area than is necessary. If you are writing a land management plan, and if you define a home range that is larger than the animal needs or uses, then you may block management actions around the edges of the home range unnecessarily. If you define a home range that is too small, then the animal itself may be threatened. Alternatively, if you are just studying the animal, then setting the density threshold wrong will cause you to include or exclude land erroneously, and therefore not learn the true habitat components used by the animal. This type of problem, trying to figure out the true areas used by an animal based on insufficient data, is common in wildlife analysis.

In this example, we will use some threshold > 0. To help us decide on a good threshold, we generate contour lines to better show where different levels of density lie. The map below shows contour lines at every 5-points-per-km^2 increment. The outermost line is where density drops to 0 points per km^2, and the next line in shows where density = 5 pts per km^2. The second line in is 10 pts per km^2, etc.



Based on visual examination of these contours, we may decide that everything greater than or equal to 5 pts per km^2 should represent the home range polygon of this animal. With a few extra steps in ArcGIS, we can isolate this polygon.

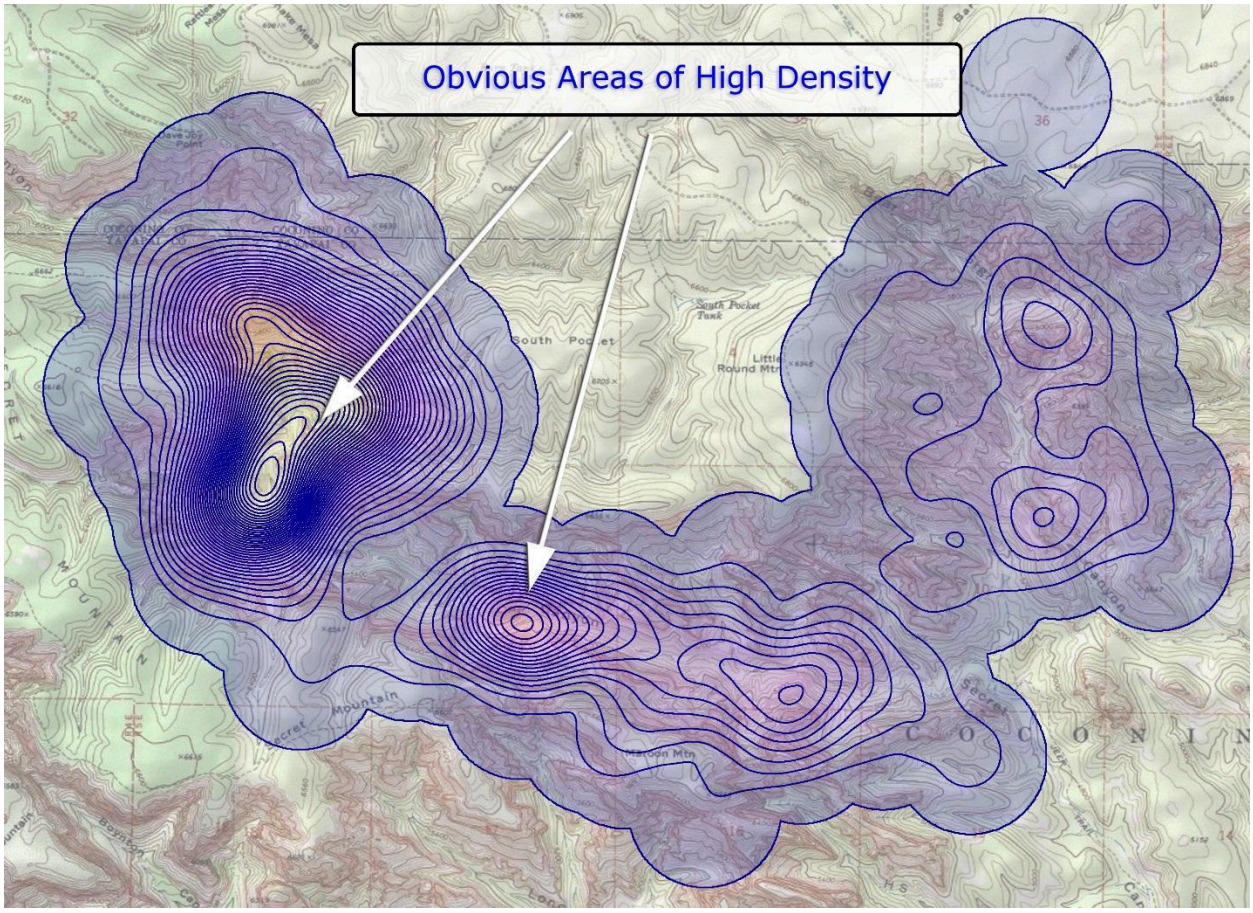


And now we have our estimated home range polygon. We won't do it in this lab, but in actual practice we might want to manually modify this polygon if we see any problems. For example, we might edit it to connect the three islands into a single polygon, or possible delete the small northeastern island entirely.

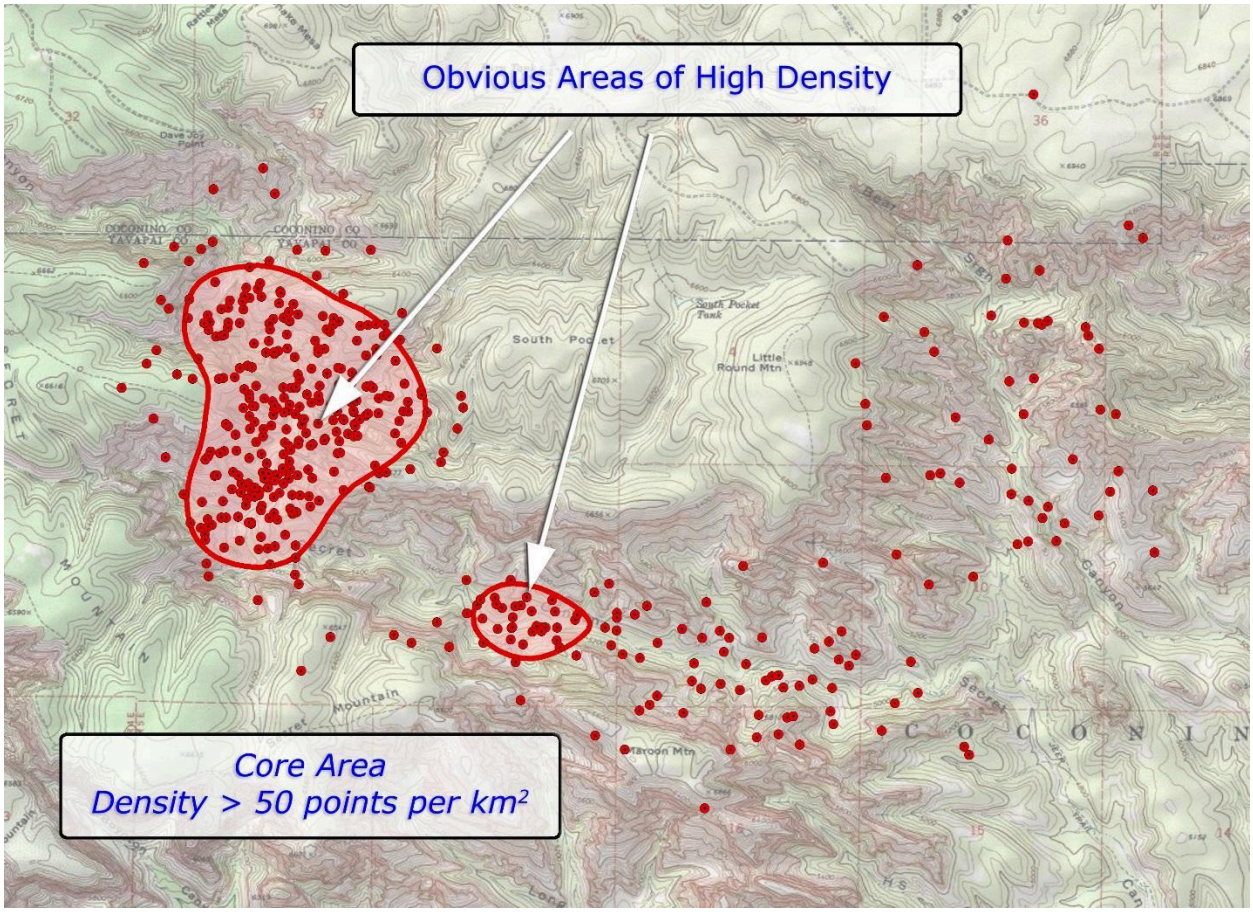
A Kernel Density Bonus: Finding Areas of Highest Use

As we have seen above, kernel density is a useful way to estimate the home range of an animal. It captures the areas where an animal spends most of its time. Unlike the MCP (minimum convex polygon), it specifically excludes areas that an animal avoids even if those areas are inside the overall extent of points.

Even better, we can mark out the core areas where the animal spends the majority of its time simply by marking out the areas of highest density. These high-intensity areas are probably exceptionally important to the animal for some reason, and therefore we might learn something about the animal by studying those areas. If this is a threatened or endangered species, then we might modify management plans to protect these areas.



We would isolate these core area regions the same way we isolated the home range. We would just use a different (and higher) density threshold level. For example, suppose that something about the distribution of contour lines above convinced us that all areas with densities > 50 points per km^2 looked like the highest-value regions. Using the same methods we used to identify the home range polygon (i.e. areas with densities > 5 points per km^2), we identify the following region:



Kernel Density: A Step Farther

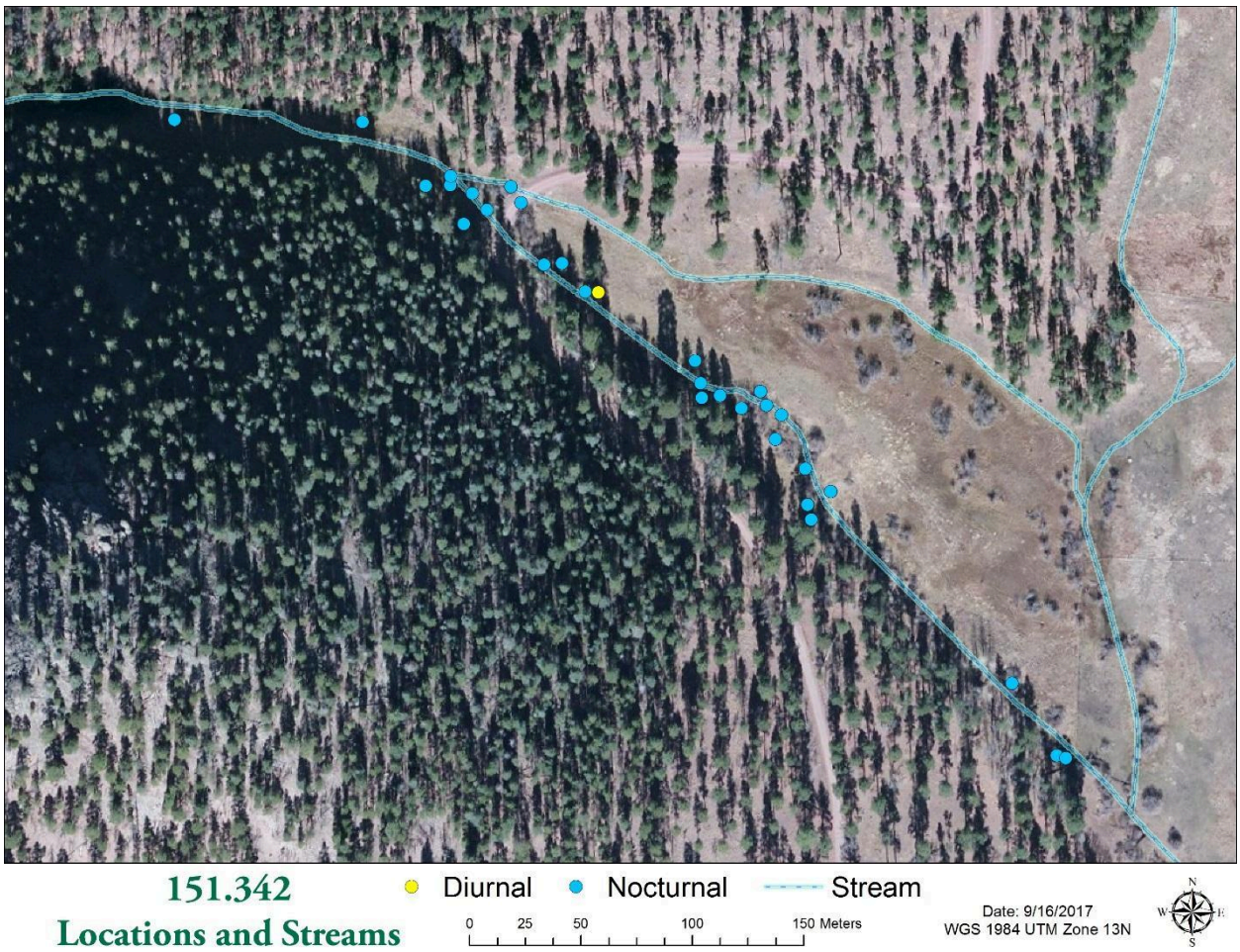
Note: We will not do this in class! This section describes functions that are only available in custom code or 3rd-party tools, which we do not have access to in class. If you think you would like to try this additional step (not in this class, but sometime in your future career), then please contact me and we can discuss ways to do it. For this lab at least, we will have to be satisfied with a more subjective approach based simply on some arbitrary density threshold.

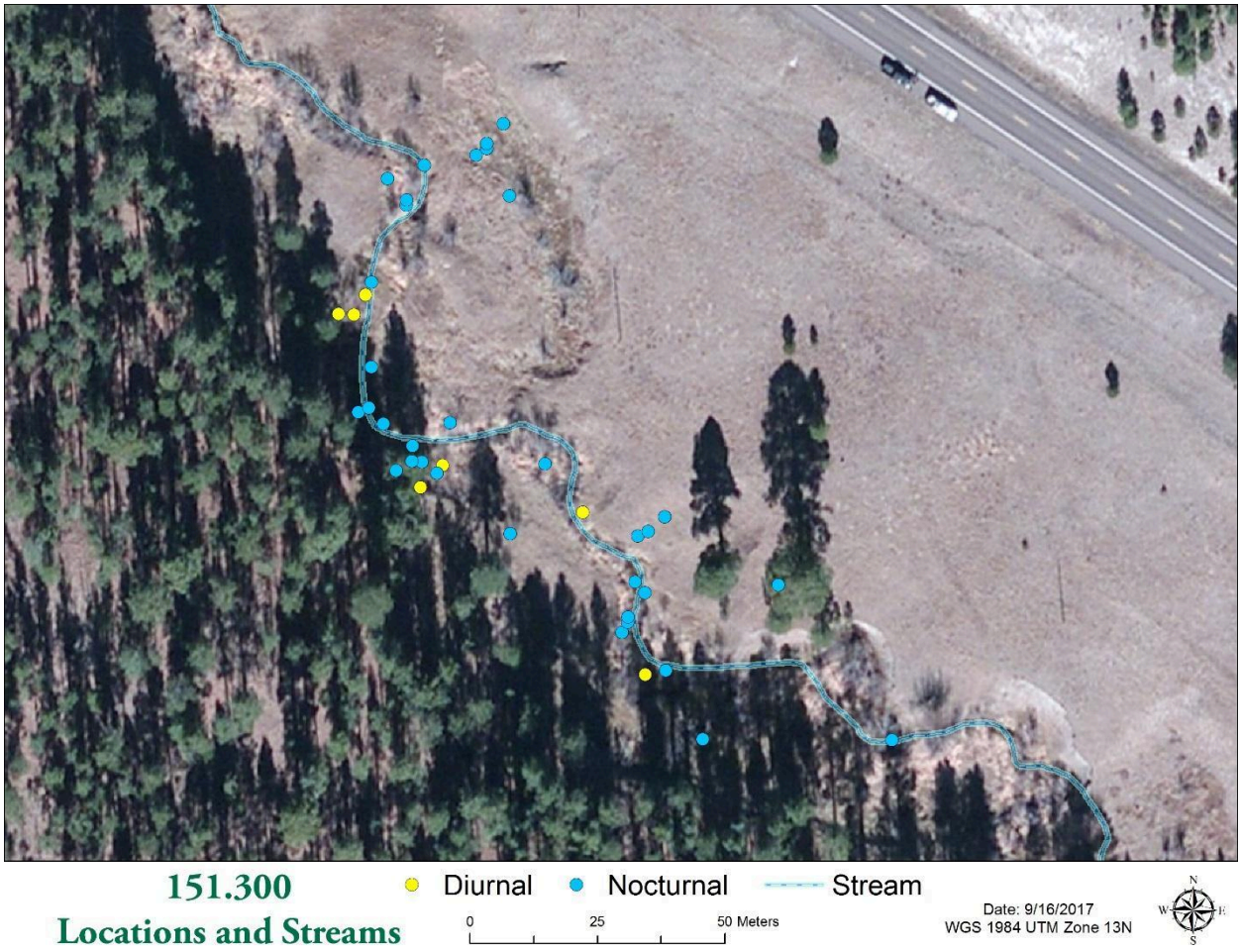
The Problem: The major downside of Kernel Density analysis is that Density units, in *Points per Area*, are difficult to work with. The distribution of density values will rarely be the same between two animals, or between two runs of the density tool on the same animal but using different parameters. This makes it difficult to generate home ranges and core areas using a consistent method. In the example above, we chose a threshold of *5 points per km²* for the home range, and a threshold of *50 points per km²* for the core area. But there is nothing special about those two threshold values. If we had a different sample size, or if we used a different bandwidth to generate the density raster, then we would have had to choose different density thresholds to identify equivalent regions.

The Solution: When we use Kernel Density to generate home ranges and core areas, we generally want to rescale the Density values into "Proportion of Area Under Curve" values. This process essentially converts the density values to probability values showing the probability of an animal being inside a certain area, or equivalently the proportion of time the animal was observed in a certain area. Using these methods, we could simply mark out the area where an animal would be 95% of the time, or 90%

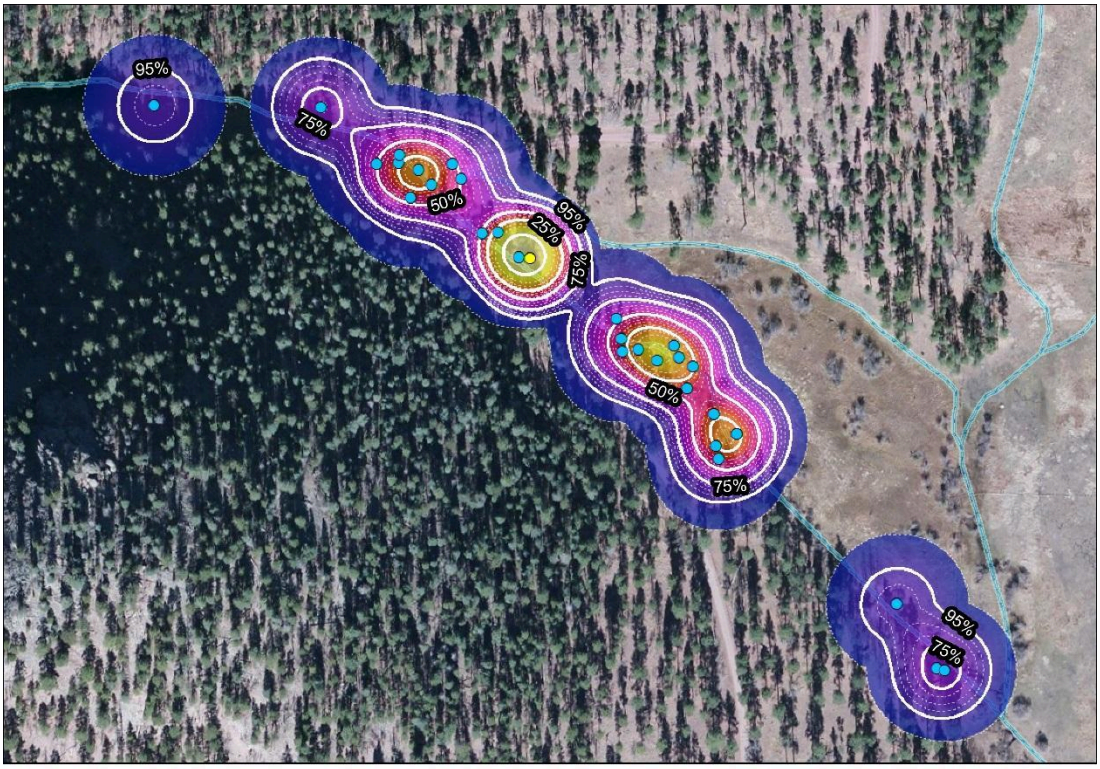
of the time, or whatever probability threshold we want to use. We can now generate home ranges based on consistent activity levels, rather than trying to guess at arbitrary density thresholds.

This method also makes it very easy to compare home ranges for different animals. For example, Dr. Chambers has been studying home ranges of New Mexico jumping mice. Kernel densities do a great job at mapping where each mouse spends its time. Unfortunately, each mouse has a different number of observations and these observations are distributed over differently-sized areas. Therefore the distribution of density values is very different between these two mice, and it is impossible to pick an actual density level that would identify equivalent home ranges and core areas for each.





By rescaling the density values to probability levels, we can now easily extract the 95% highest-use areas for each mouse. This allows us to compare habitat use between different mice using a constant activity level, which is very important when trying to determine how similarly or differently various individuals behave.

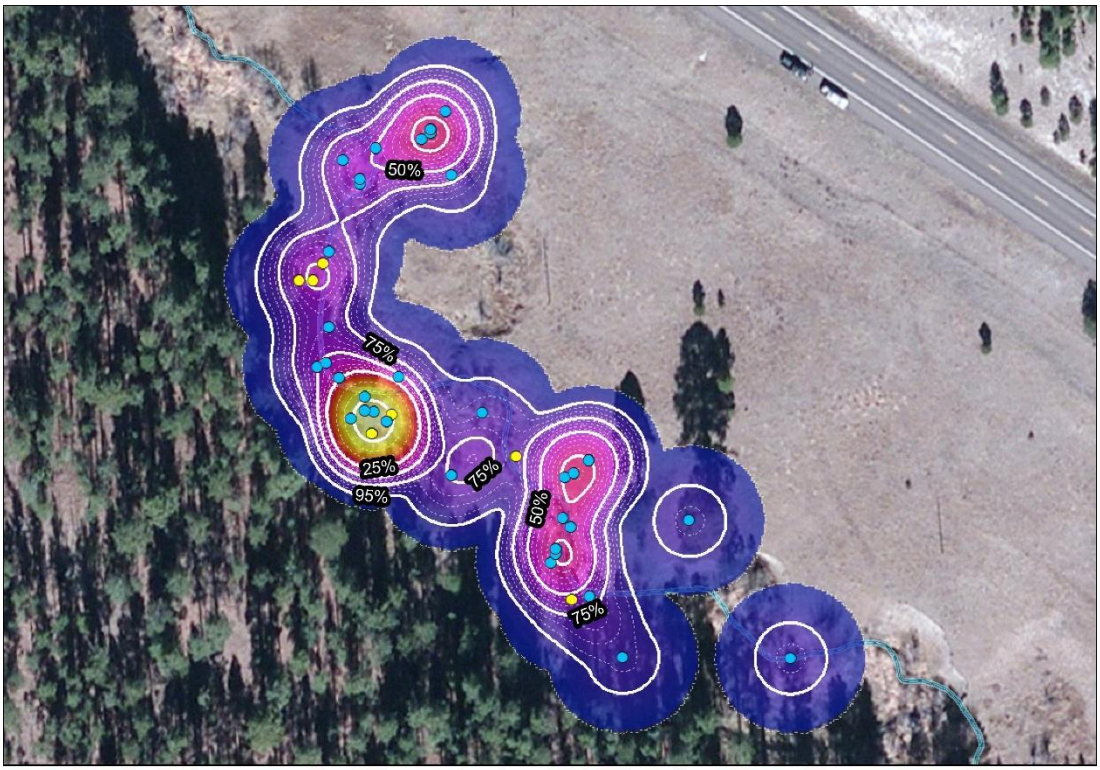


151.342
Activity Probability Levels

Diurnal Nocturnal Stream

0 25 50 100 150 Meters

Date: 9/16/2017
WGS 1984 UTM Zone 13N



151.300
Activity Probability Levels

Diurnal Nocturnal Stream

0 25 50 Meters

Date: 9/16/2017
WGS 1984 UTM Zone 13N

Sidebar: How does ArcGIS calculate the Default bandwidth?

When you run the tool, you have the option to set your own bandwidth. If you don't set one, then ArcGIS sets one for you based on the spatial distribution of points in your input dataset.

ArcGIS goes through a bit of math to determine this default value, so it has the appearance of being reasonable and defensible, but remember that this is only a best guess! ArcGIS does not know anything about your dataset or what the points represent. ArcGIS only knows their spatial distribution, and so the default value is based solely on where the points are relative to each other. If your points are GPS locations from an animal, and you gather a second set of points on the same animal, then ArcGIS will almost certainly come up with a different bandwidth for your second set of points. Therefore you should only treat this default value as a guess, and don't be shy about specifying a different value.

Given that caveat, the default is still sometimes useful, and a reasonable value to use if you don't have anything better. The method is sometimes referred to as "Silverman's Rule of Thumb" and is described on p. 44 – 48 of ADDIN ZOTERO_ITEM CSL_CITATION {"citationID":"a13eii6v12c","properties":{"formattedCitation":"(Silverman 1986)","plainCitation":"(Silverman 1986)","noteIndex":0},"citationItems":[{"id":214,"uris":["http://zotero.org/users/1007170/items/FZUX4V4V"],"uri":["http://zotero.org/users/1007170/items/FZUX4V4V"],"itemData":{"id":214,"type":"book","title":"Density estimation for statistics and data analysis","publisher":"CRC press","volume":"26","author":[{"family":"Silverman","given":"Bernard W"}],"issued":{"date-parts":[["1986"]]}}}],"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"} Silverman (1986), and is based on the distance from each point to the centroid (i.e. center of mass) of all points.

ArcGIS first calculates the centroid of your input points (where the X, Y and possibly Z coordinates of the centroid are calculated as the sum of the respective X, Y and possibly Z coordinates of all the input points, divided by the number of input points), and then calculate the distances from each point to that centroid. You now have a population of "Distance to Centroid" values.

From this centroid and this population of "Distance to Centroid" values, you calculate two statistics:

- The "Standard Distance", calculated as:

- The "Median Distance", which is simply the median of all the "Distance to Centroid" values.

ArcGIS then determines the default bandwidth value based on the lesser of the "Standard Distance" and "Median Distance" values.

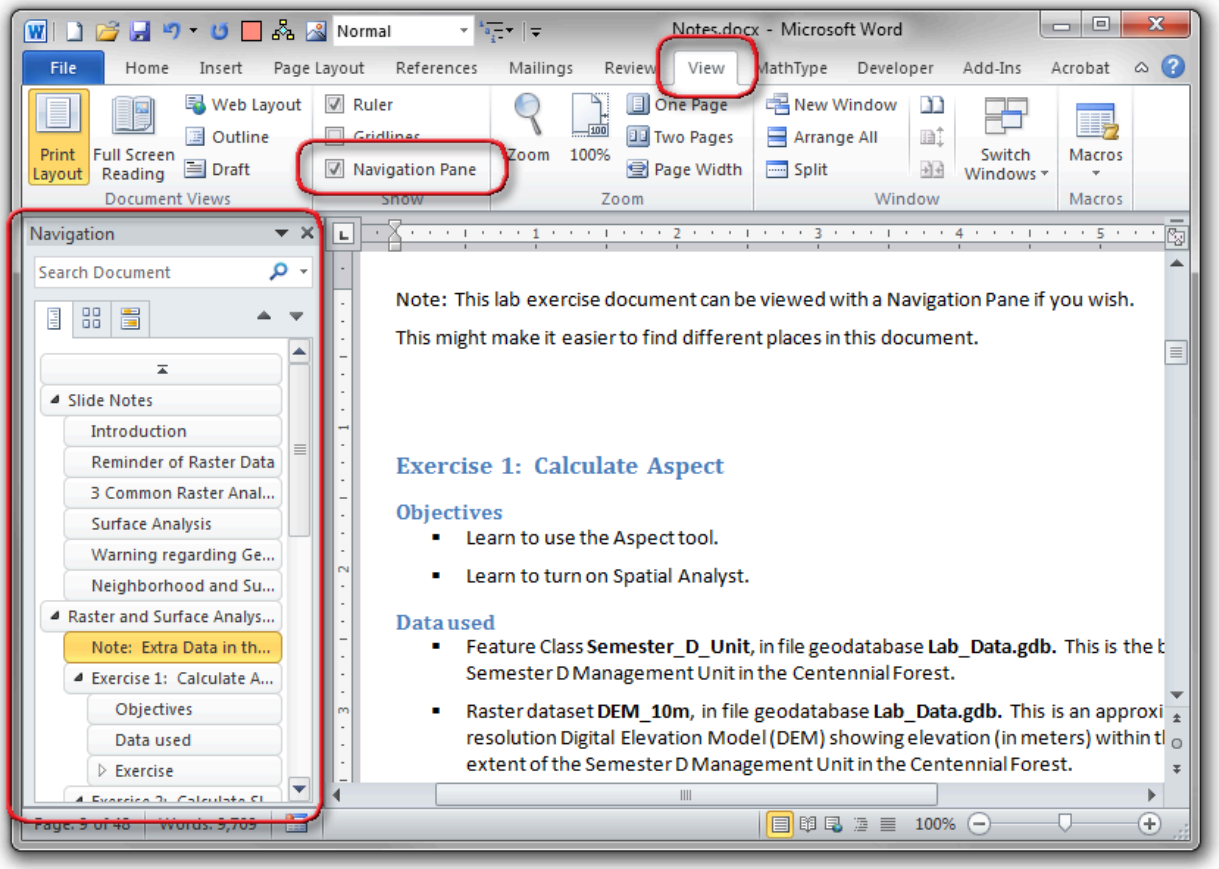
Note: There are some variations to the equations if the input points are weighted. See https://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/how-kernel-density-works.htm and https://pro.arcgis.com/en/pro-app/tool-reference/spatial-statistics/h-how-standard-distance-spatial-statistic-works.htm for details.

Silverman, B. W. 1986. Density estimation for statistics and data analysis. Volume 26. Monographs on Statistics and Applied Probability, CRC press.

Wildlife GIS Lab Exercises:

Note: The Navigation Pane

If you wish, Word includes a navigation pane that might make it easier to find different places in this document.



Exercise 1: General Habitat Analysis

Objectives

- Learn how to identify areas that fall within the specified range of values of multiple datasets. In other words, find the places in the Coconino National Forest that are within the environmental envelope of the Mexican spotted owl.
- Learn how to use the Raster Calculator tool to query multiple raster datasets.
- Observe the consequences of changing the environmental envelope definition.

Data used

- Feature Class **Coconino_NF**, in file geodatabase

  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** This is the boundary of the Coconino National Forest.

- Raster dataset **DEM_Feet**, in file geodatabase

  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** This is a 28m resolution Digital Elevation Model (DEM) showing elevation (in feet) within the Coconino National Forest.

- Raster dataset **Percent_Slope**, in file geodatabase

  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** This is a 28m resolution raster showing slope (in Percent) within the Coconino National Forest.

- Raster dataset **Percent_Canopy_Cover**, in file geodatabase

  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** This is a 30m resolution raster showing percent canopy cover within the Coconino National Forest, and was adapted from Sesnie et. al. (2009).

- Raster dataset **Hillshade**, in file geodatabase

  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** This is a hillshade of the Coconino National Forest.

  - **Note:** This hillshade raster is not actually used in the analysis. I include it because it shows the shape and texture of the landscape, and I just like looking at it.

Homework Assignment:

For your homework, you will need to answer the following three questions (briefly; maybe a couple of sentences each):

a) You created 3 habitat envelopes for Mexican spotted owls (MSO). Which would you use if you were a resource manager and why? **Note:** Don't worry if you don't know much about Mexican spotted owl ecology. I just want you to consider the different outputs, pick one, and give some logic for the one you chose. No right or wrong choice here, as long as you provide some logic.

b) What would you like to know about MSO that would help you answer this question, and what additional information or datasets would you like to have to develop a better habitat envelope for MSO?

Exercise

Based on the slope, elevation and canopy cover data, you will generate 3 Mexican spotted owl habitat maps using the following combinations of habitat criteria:

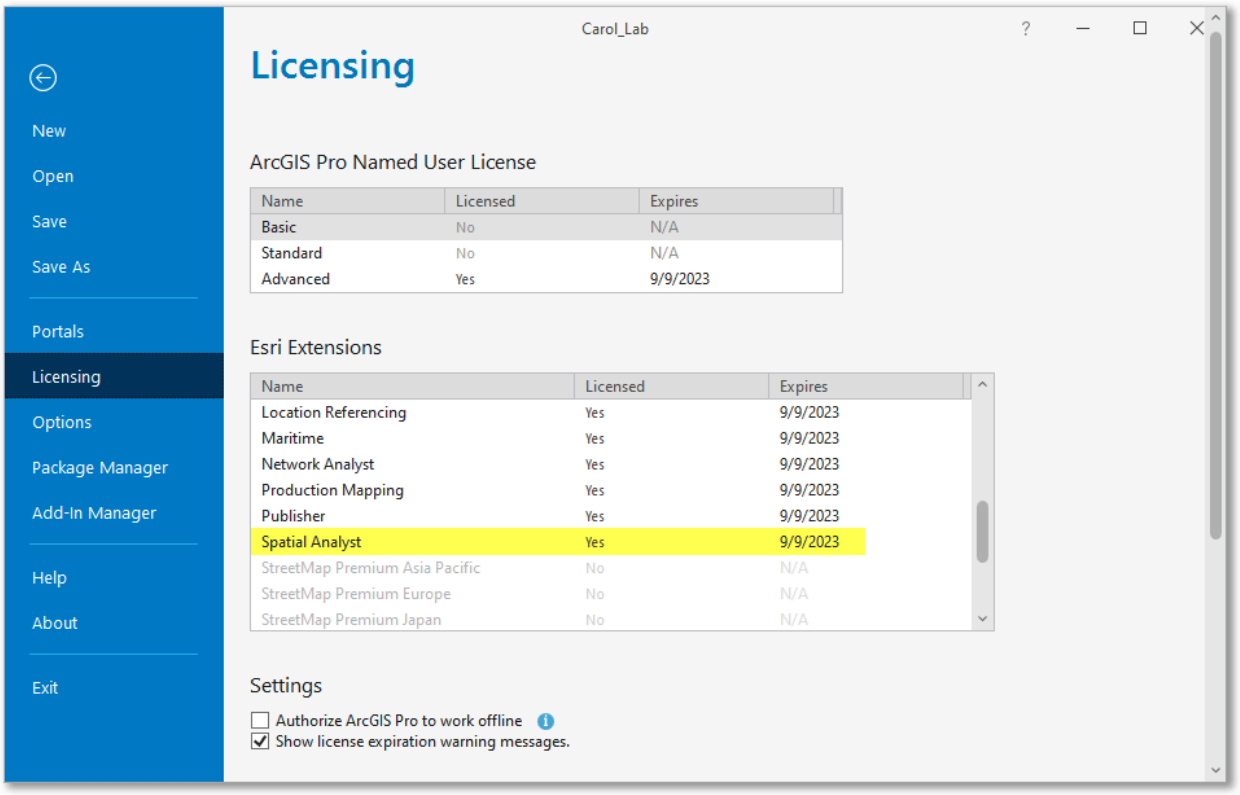
1) Analysis 1: All areas with:
    a. Canopy Cover ≥ 50%.
    b. Slope ≥ 15%
    c. Elevation ≥ 7,000 feet
2) Analysis 2: All areas with:
    a. Canopy Cover ≥ 40%.
    b. Slope ≥ 15%
    c. Elevation ≥ 7,000 feet
3) Analysis 3: All areas with:
    a. Canopy Cover ≥ 40%.
    b. Slope ≥ 15%
    c. Elevation ≥ 5,000 feet

The steps below will explain in detail how to conduct Analysis 1 above (Canopy Cover ≥ 50%, Slope ≥ 15% and Elevation ≥ 7,000 ft). Based on these steps, you should be able to figure out how to Analyses 2 and 3.

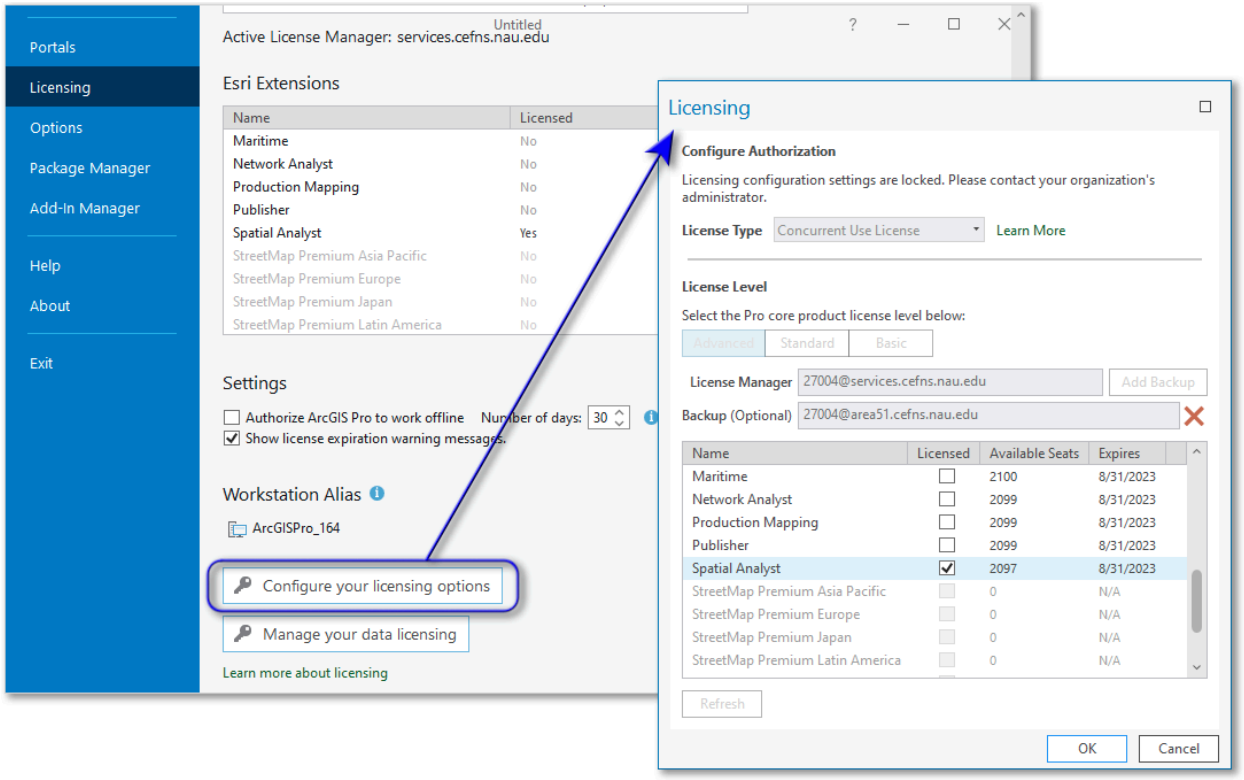
Note: Just FYI, this is a very simplified example of spotted owl habitat ranges. We know a bit more about the owl habitat requirements than just these broad canopy cover, slope and elevation ranges. As you work through the lab exercise, you consider how you would improve it. What habitat variables would you like to include in the analysis?

Prepare your Map and Data:

1) Open a blank map in ArcGIS Pro.
2) Make sure you have the **Spatial Analyst** extension turned on.
    a) Click the "Project" tab, then "Licensing".
    b) In the "Licensing" window, scroll down and make sure you have **Spatial Analyst** turned on.

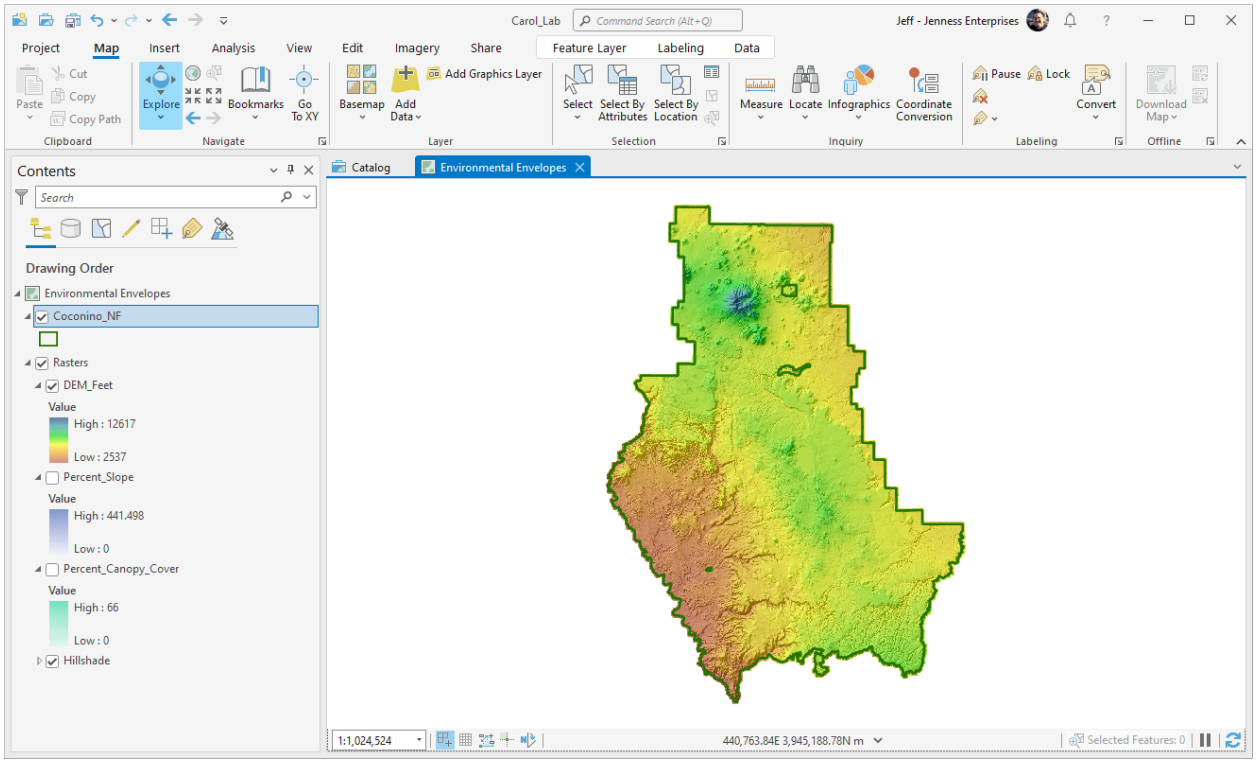


c) If **Spatial Analyst** is not licensed, then scroll down and click the button "Control your Licensing Options", then check the box next to "Spatial Analyst" in the "Licensing" window.



3) Load the **Layer** files **Coconino_NF.lyr** and **Rasters.lyrx** from the folder ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\..

4) If you loaded the Layer files, you should see something similar to the following. Look over the datasets and get to know them. Get a sense for where to find areas with relatively high slopes, elevations and canopy covers.

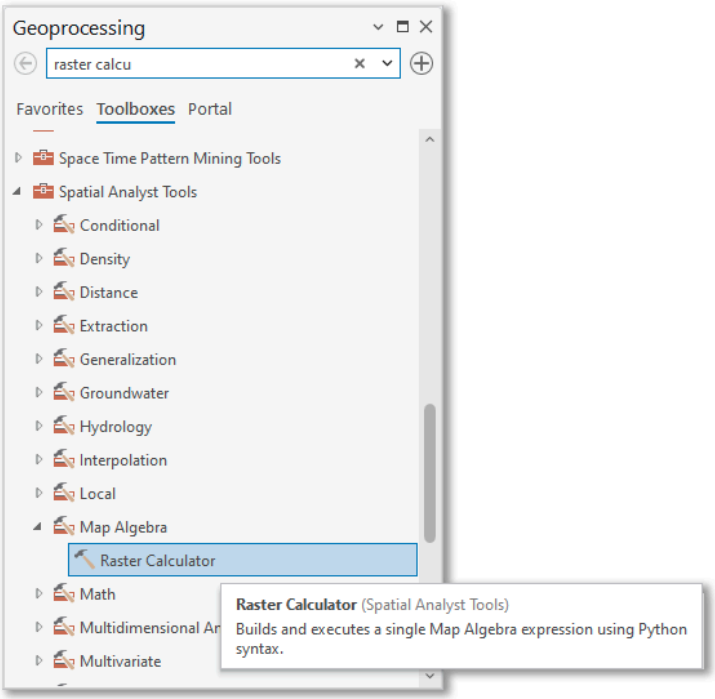


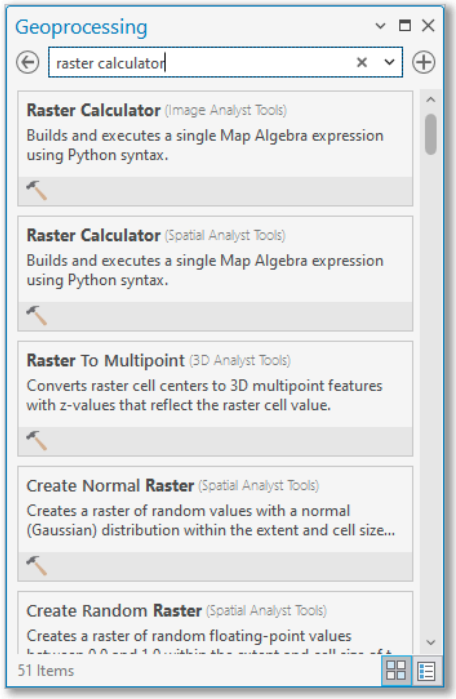
Identify areas that meet the slope, elevation and canopy cover constraints.

We will use the **Raster Calculator** tool to query the Elevation, Slope and Canopy Cover rasters. We can use the Raster Calculator tool to query each raster individually, or all rasters together. This exercise will show you how to do both methods.

Method 1: Query each raster individually

5) Open the "Raster Calculator" tool (in the Geoprocessing Toolboxes --> Spatial Analyst Tools --> Map Algebra --> Raster Calculator).





6) Identify all areas with Canopy Cover ≥ 50%. Fill out the Raster Calculator as follows (and see illustration below):

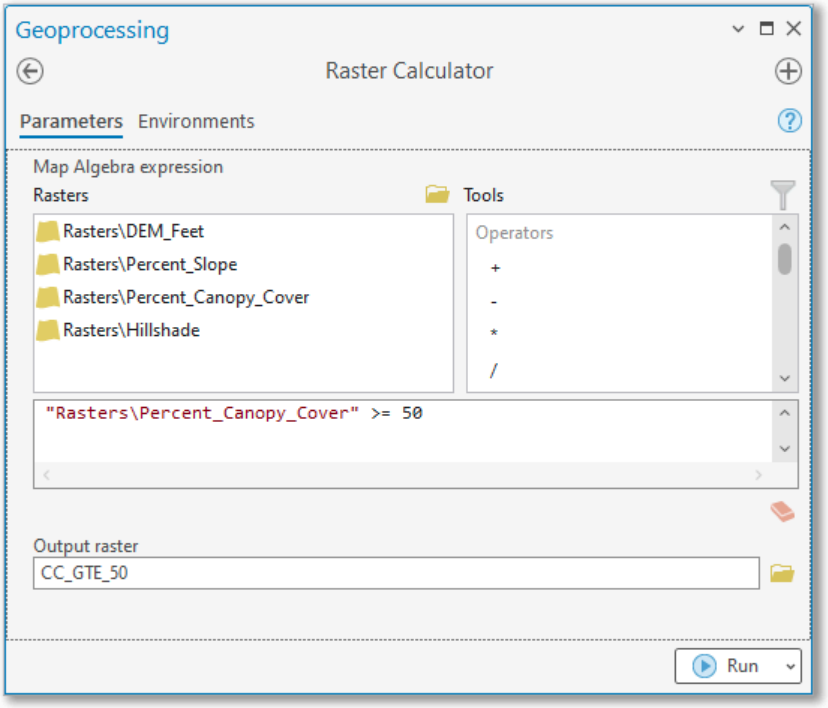
   a) The query string should look like the following:

```
"Rasters\Percent_Canopy_Cover" >= 50
```

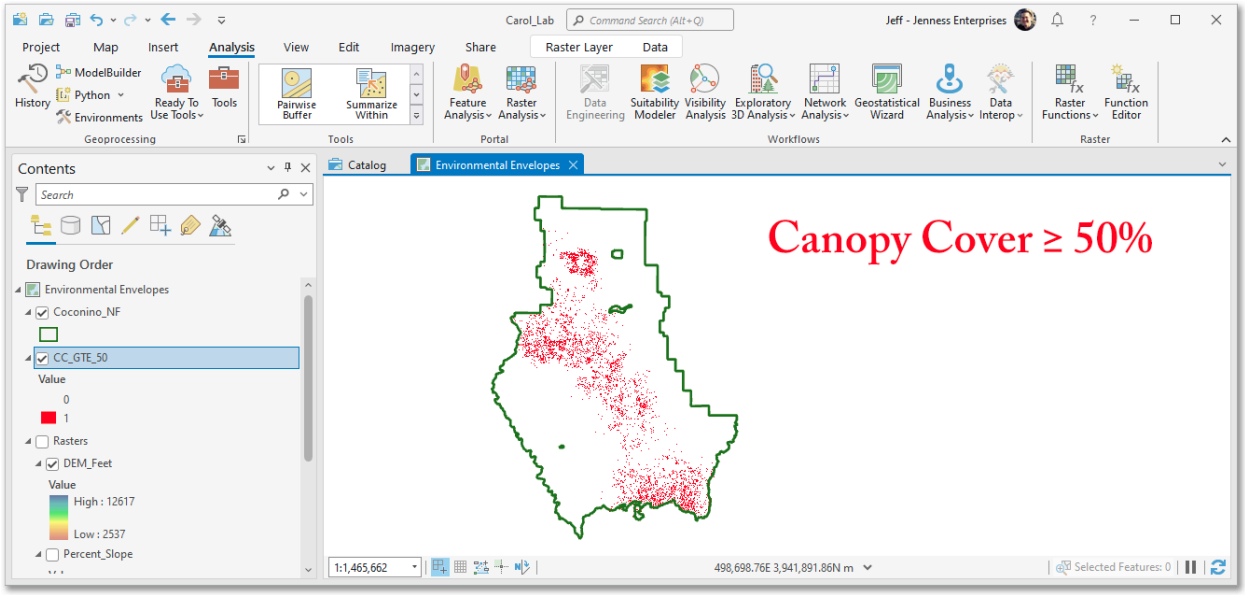
   Note: This query string assumes that you loaded the rasters using the layer file "Rasters.lyrx", which loaded three raster layers into a group layer named "Raster". The reason the **Canopy Cover** layer is specified with the name `"Rasters\Percent_Canopy_Cover"` is because the layer "Percent_Canopy_Cover" is in the group layer named "Raster".

   b) Specify a location and name for your new Canopy Cover Constraint raster. If it helps, I've provided you an empty file geodatabase named "General_Habitat_Data.gdb", which should be in your "Wildlife_Lab_GIS" folder. You don't have to put it here, but if you set this as your default geodatabase then it might help keep all your data organized and make it easier for you to find it later if you need to.

   In this example, I am naming the new raster **CC_GTE_50** so that I will know it is a **C**anopy **C**over raster showing all areas **G**reater **T**han or **E**qual to **50**. You will generate several rasters in this exercise so make sure you know which one is which.



7) When ArcGIS finishes, it will add a new raster of 0 and 1 values to your map. In this raster, 0 means "False" and 1 means "True", so all the "1" values represent areas ≥ 50% Canopy Cover. In the illustration below, I have symbolized "0" with "No Color" and "1" with Red so I only see the areas with ≥ 50% Canopy Cover.

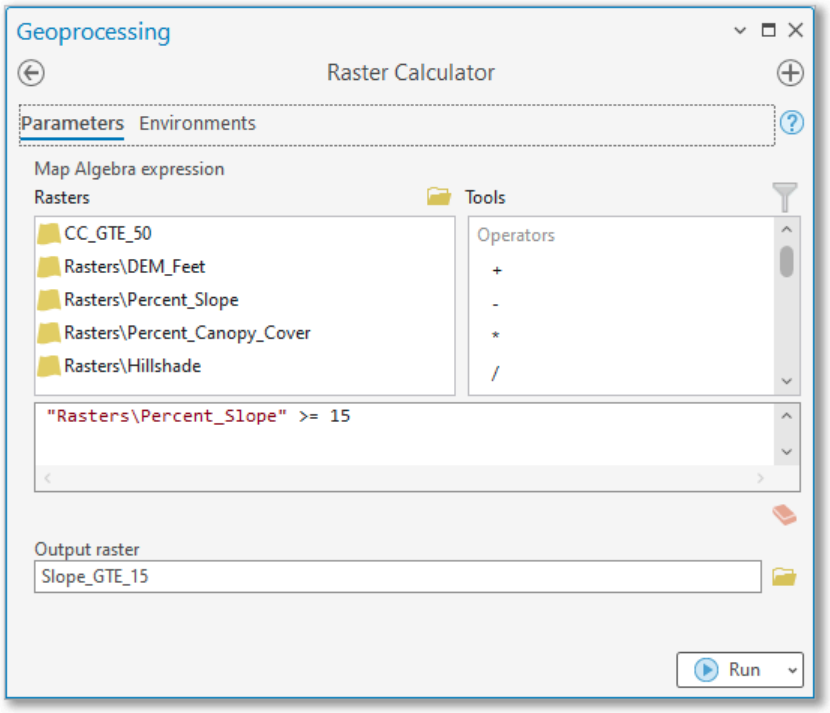


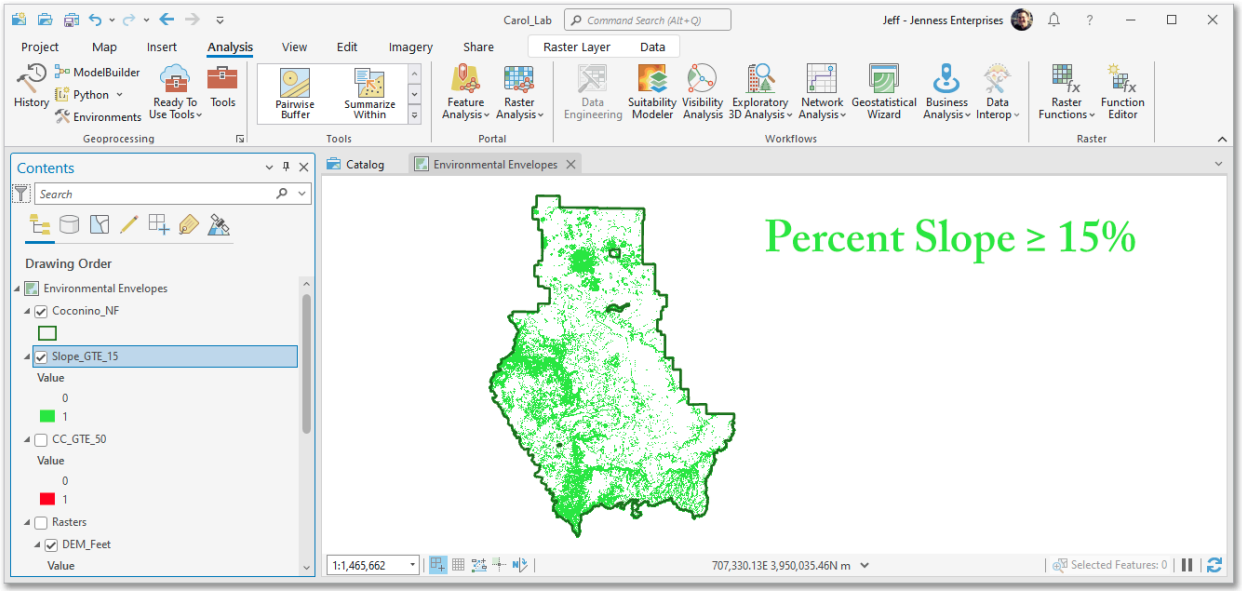
8) Next, identify all areas with Slope ≥ 15%. Fill out the Raster Calculator as follows (and see illustration below):

   a) The query string should look like the following:

```
"Rasters\Percent_Slope" >= 15
```

b) Specify a location and name for your new Canopy Cover Constraint raster. As before, I recommend you save your raster to the file geodatabase "General_Habitat_Data.gdb", which should be in your "Wildlife_Lab_GIS" folder. In this example, I am naming the raster **Slope_GTE_15** so that I will know it is a **Slope** raster showing all areas **G**reater **T**han or **E**qual to **15**.



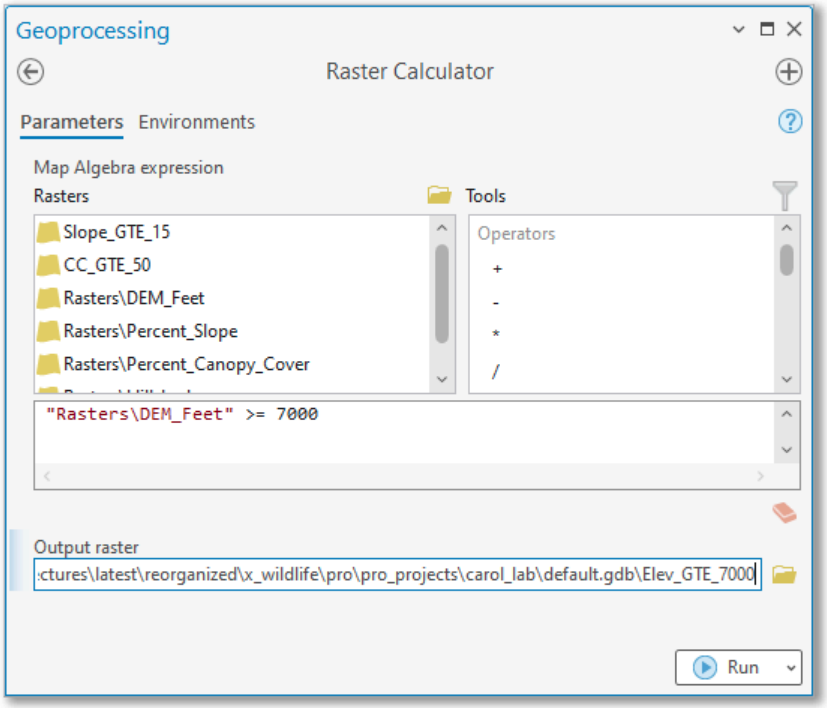


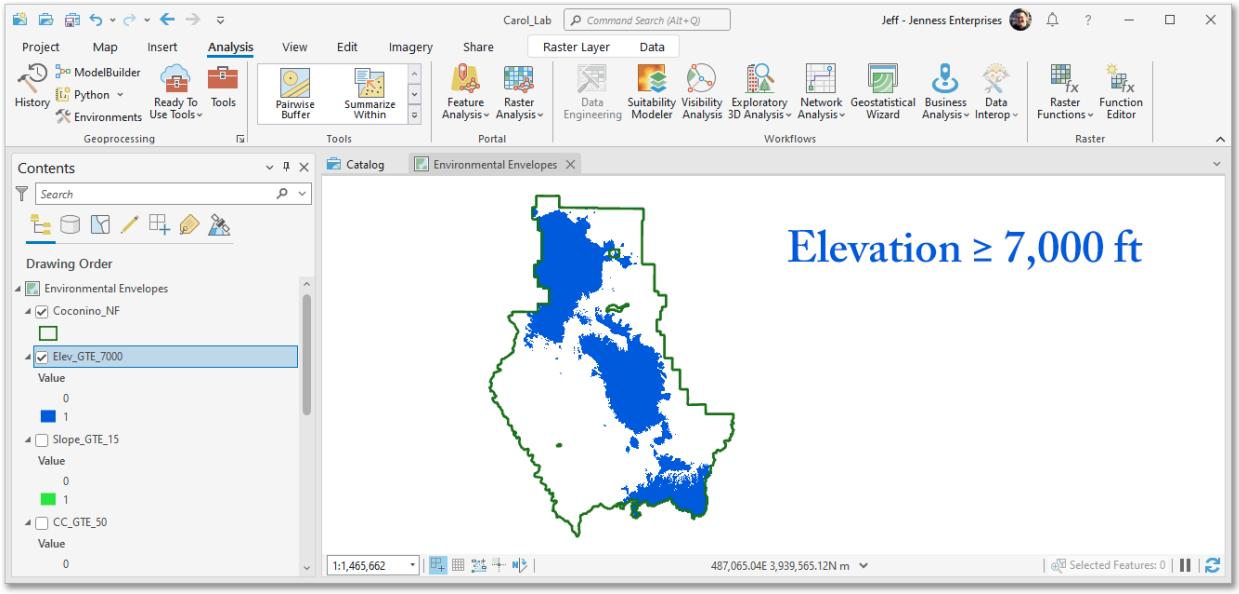
9) Next, identify all areas with Elevation ≥ 7,000 ft. Fill out the Raster Calculator as follows (and see illustration below):

a) The query string should look like the following:

```
"Rasters\DEM_Feet" >= 7000
```

b) Specify a location and name for your new Canopy Cover Constraint raster. As before, I recommend you save your raster to the file geodatabase "General_Habitat_Data.gdb", which should be in your "Wildlife_Lab_GIS" folder. In this example, I am naming the raster **Elev_GTE_7000** so that I will know it is an **Elev**ation raster showing all areas **G**reater **T**han or **E**qual to **7000**.





10) Look over your three results and get a feel for them.

11) Next combine your three results using the Raster Calculator. This time you will use the "&" operator, which basically will ask where "Elev_GTE_7000" is true (i.e. is equal to 1) **And** where "Slope_GTE_15" is true **And** where "CC_GTE_50" is true. Fill out the Raster Calculator as follows (and see illustration below):

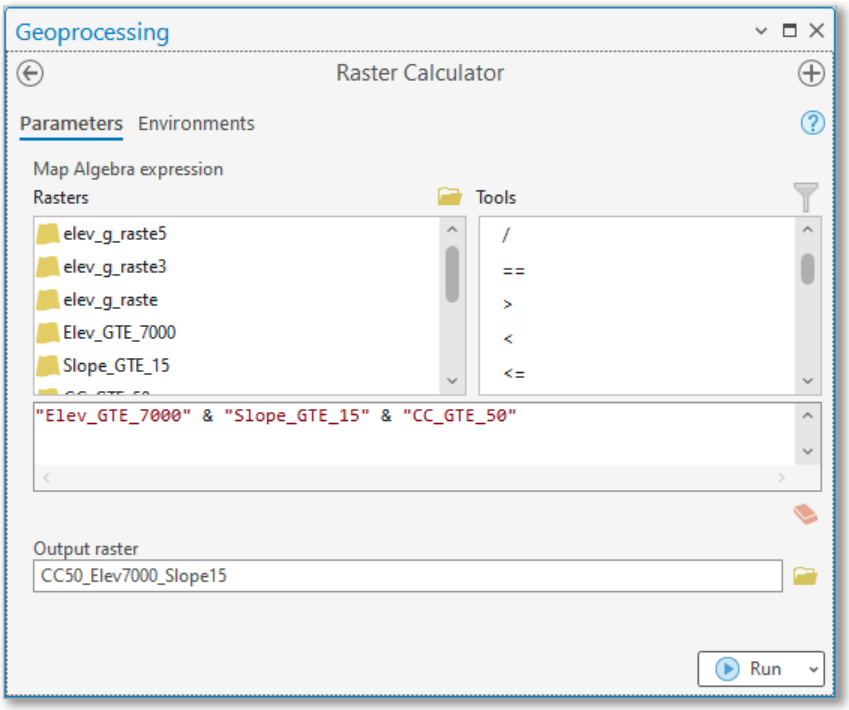
a) The query string should look like the following:

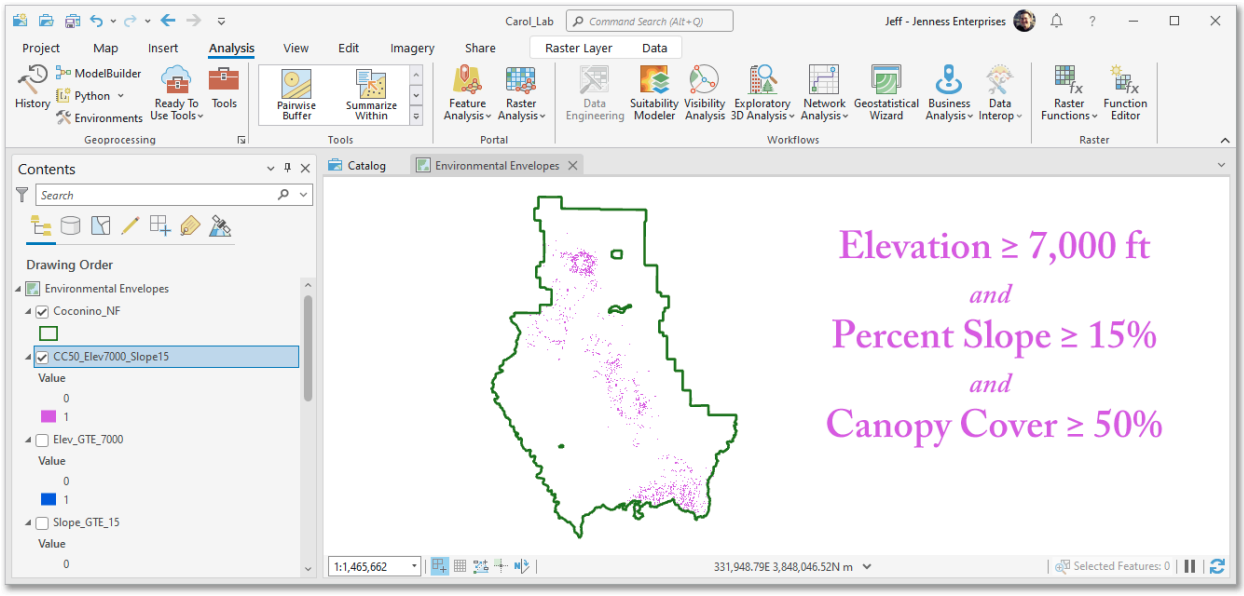
```
"Elev_GTE_7000" & "Slope_GTE_15" & "CC_GTE_50"
```

Note: This query string would also work, but notice each term has to be in parentheses and you have to use two "=" characters to signify equality. In Python, you use two "=" characters is test whether two variables are equal):

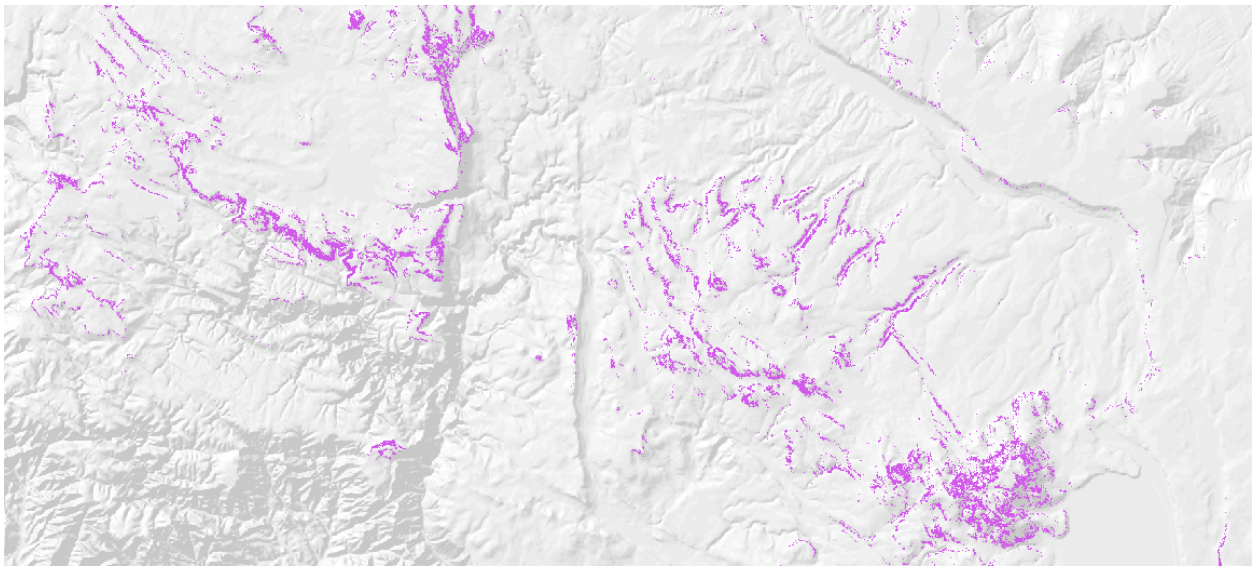
```
("Elev_GTE_7000" == 1) & ("Slope_GTE_15" == 1) & ("CC_GTE_50" == 1)
```

b) Specify a location and name for your new Canopy Cover Constraint raster. As before, I recommend you save your raster to the file geodatabase "General_Habitat_Data.gdb", which should be in your "Wildlife_Lab_GIS" folder. In this example, I am naming the raster **CC50_Elev7000_Slope15**, and hopefully the logic behind this name is clear to you.





12) If we turn on the hillshade, we can zoom in and examine various places that would be defined as potential owl habitat based on this analysis.



Another way to use the Raster Calculator…

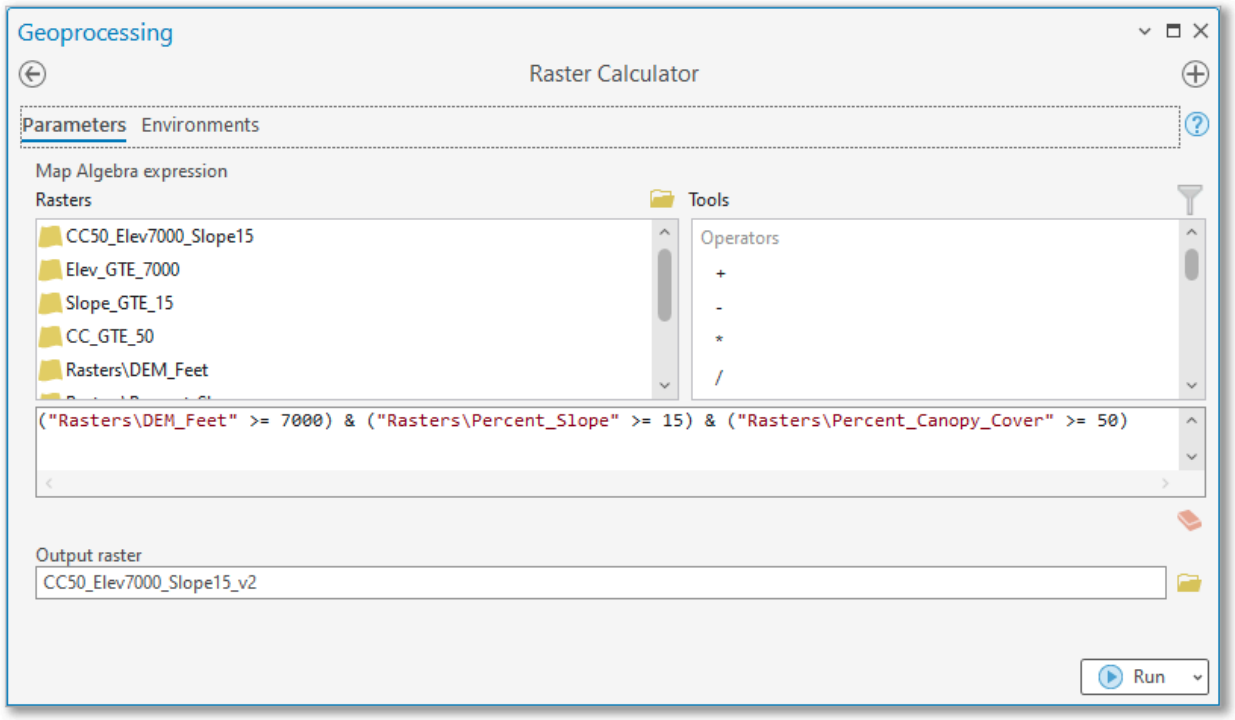
In the steps above, we generated separate rasters representing each of our variable constraints. This is useful when we want to look at each dataset separately. If we wanted, the Raster Calculator actually lets us combine multiple queries into one step. **However**, we must remember to put parentheses around each query! Otherwise the tool will crash.

13) Fill out Fill out the Raster Calculator as follows (and see illustration below):

a) The query string should look like the following (and make sure you include the parentheses!):

```
("Rasters\DEM_Feet" >= 7000) & ("Rasters\Percent_Slope" >= 15) & ("Rasters\Percent_Canopy_Cover" >= 50)
```

b) Specify a location and name for your new Canopy Cover Constraint raster. As before, I recommend you save your raster to the file geodatabase "General_Habitat_Data.gdb", which should be in your "Wildlife_Lab_GIS" folder.



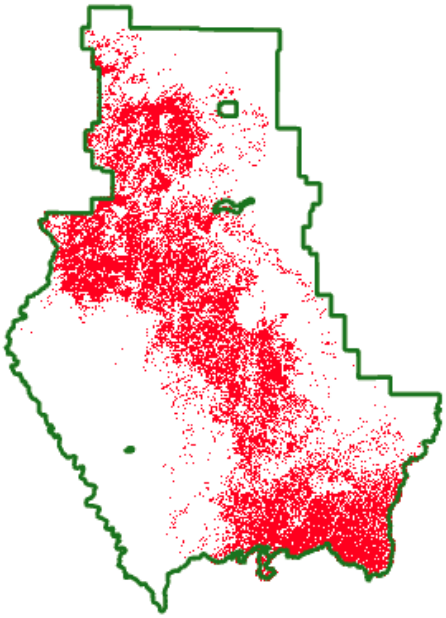
You should get the same result you got earlier when you generated each step separately.

What your output for Analyses 2 should look like:

Analysis 2 asks for:

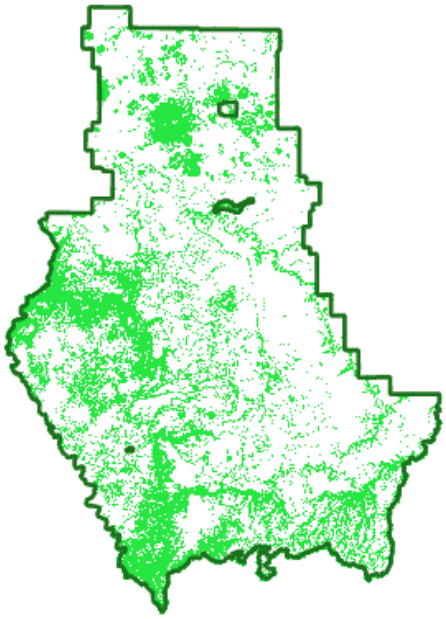
1) Canopy Cover ≥ 40%.
2) Slope ≥ 15%
3) Elevation ≥ 7,000 feet

The map showing Canopy Cover > 40% should look like this:



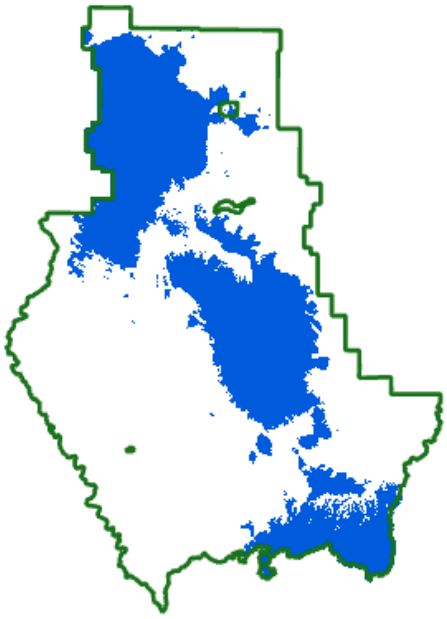
Canopy Cover ≥ 40%

The map showing Slope ≥ 15% is unchanged from Analysis 1, and should look like this:



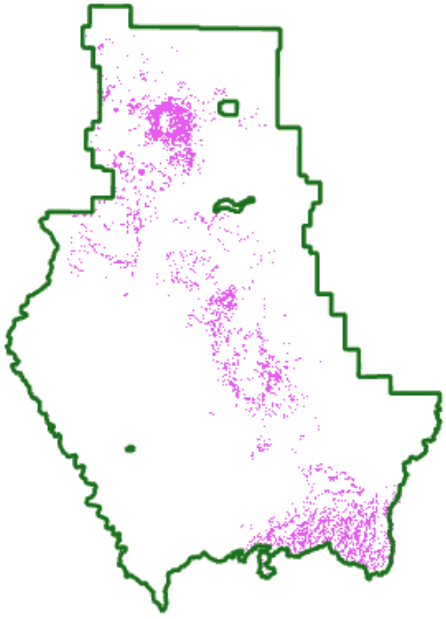
Percent Slope ≥ 15%

The map showing Elevation ≥ 7,000 ft is unchanged from Analysis 1, and should look like this:

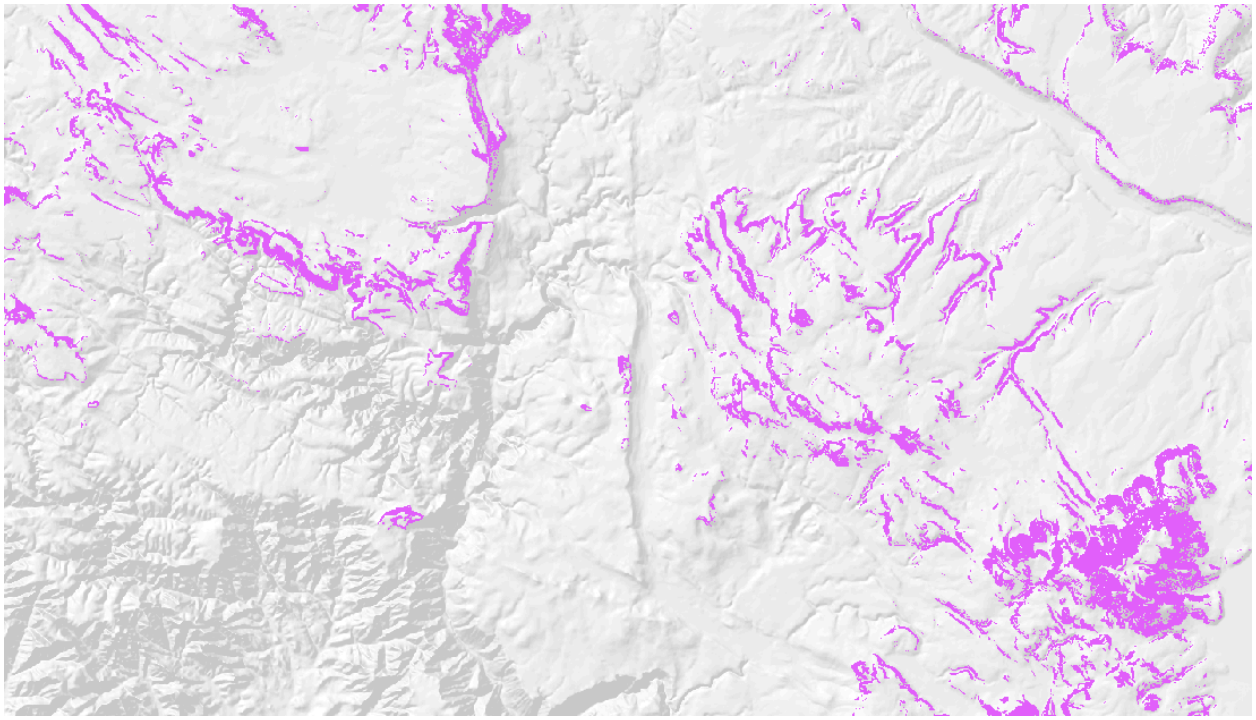


Elevation ≥ 7,000 ft

The map showing Canopy Cover ≥ 40%, **And** Elevation ≥ 7,000 ft, **And** Slope ≥ 15%, should look like this:



Elevation ≥ 7,000 ft
and
Percent Slope ≥ 15%
and
Canopy Cover ≥ 40%

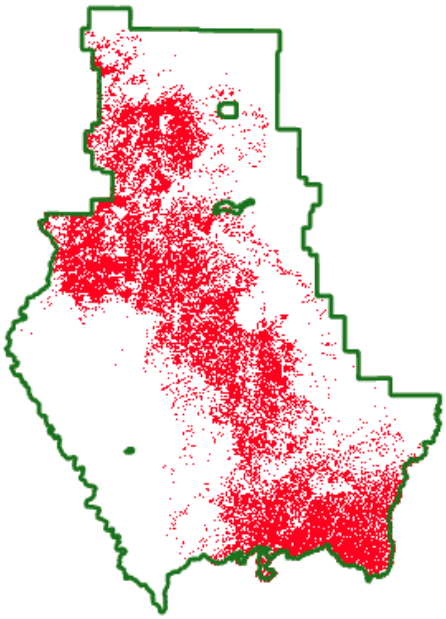


What your output for Analyses 3 should look like:

Analysis 3 asks for:

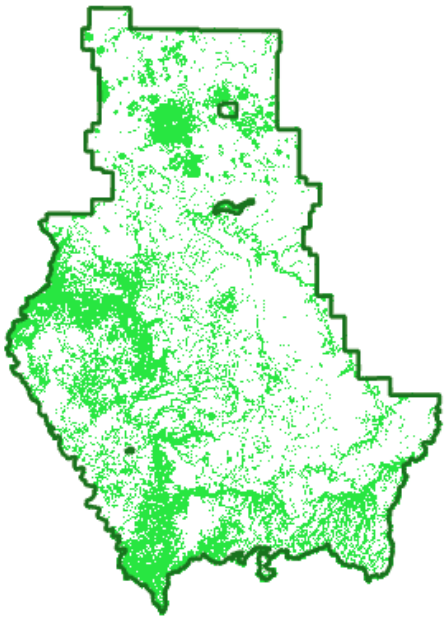
1) Canopy Cover ≥ 40%.
2) Slope ≥ 15%
3) Elevation ≥ 5,000 feet

The map showing Canopy Cover ≥ 40% is unchanged from Analysis 2 and should look like this:



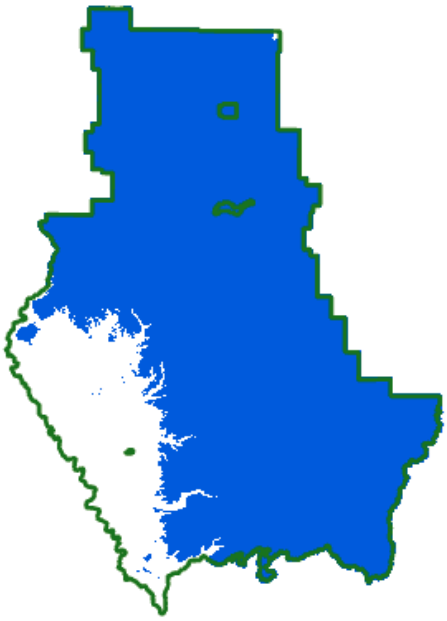
Canopy Cover ≥ 40%

The map showing Slope ≥ 15% is unchanged from Analysis 1, and should look like this:



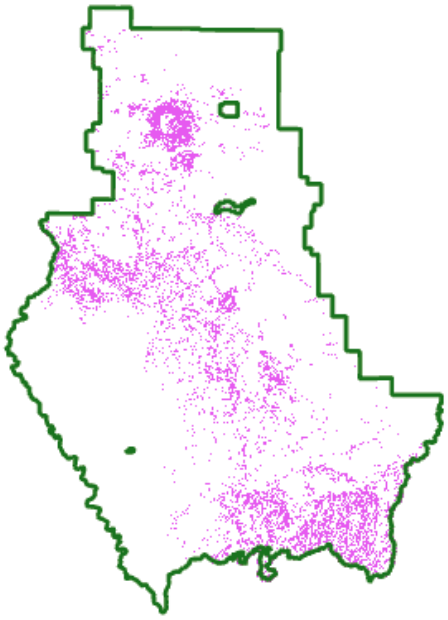
Percent Slope ≥ 15%

The map showing Elevation ≥ 5,000 feet should like this:

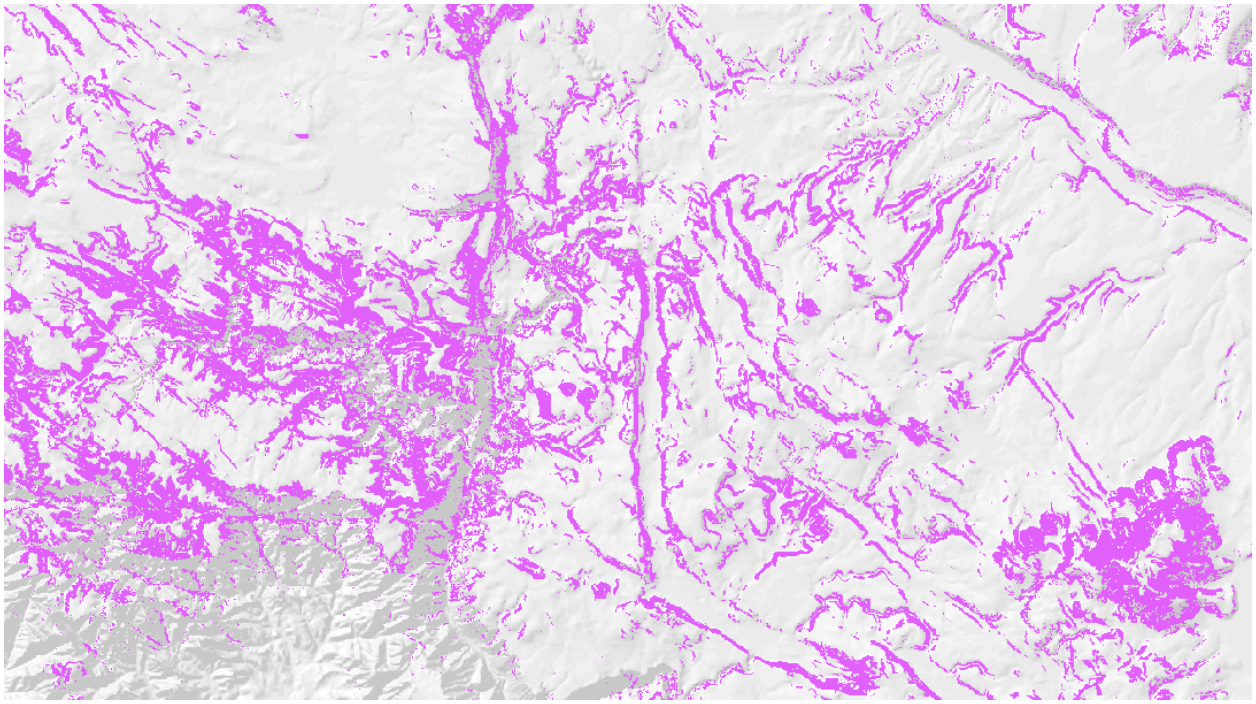


Elevation ≥ 5,000 ft

The final map showing Canopy Cover ≥ 40%, **And** Elevation ≥ 5,000 ft, **And** Slope ≥ 15%, should look like this:



Elevation ≥ 5,000 ft
and
Percent Slope ≥ 15%
and
Canopy Cover ≥ 40%



Exercise 2: Minimum Convex Polygons (MCPs)

Objectives

- Learn how to generate an MCP around **all points** in a point feature class. We will generate MCPs from all telemetry locations for two individual Mexican spotted owls.
- Learn how to generate multiple MCPs **based on attribute values**. We will generate separate MCPs for the day and night locations for each owl.
- Learn how to generate multiple MCPs **based on selected features**. We will generate separate MCPs for the breeding season and nonbreeding season locations for each owl.
- Calculate acreages for each owl MCP. Observe and consider the differences between the MCP sizes for each owl, and between the day and night MCPs.
- Consider when the MCP approach might be a good way to estimate home ranges, and when it might not be. How would you handle an outlier, such as a location that might be incorrect? Can you think of any issues with data collection that might affect the accuracy of your MCP?

Data used

- Feature Class **Owl_6_Points**, in file geodatabase
  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** These are all known locations for Owl #6 (from a previous spotted owl study) between 1992 and 1994.
- Raster image **Owl_6_Image_Background**, in file geodatabase
  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** This is aerial imagery of the region around the locations for Owl #6.
- Raster image **Owl_6_Topo_Background**, in file geodatabase
  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** This is a USGS 24K Topo map of the region around the locations for Owl #6.
- Feature Class **Owl_83_Points**, in file geodatabase
  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** These are all known locations for Owl #83 (from a previous spotted owl study) between 1992 and 1994.
- Raster image **Owl_83_Image_Background**, in file geodatabase
  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** This is aerial imagery of the region around the locations for Owl #83.
- Raster image **Owl_83_Topo_Background**, in file geodatabase
  ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.** This is a USGS 24K Topo map of the region around the locations for Owl #83.

Homework Assignment:

For your homework, you will need to fill in the summary table below:

Geodesic Acreages of Minimum Convex Polygons: Use Geodesic Calculations!					
Owl	All Points	Within Day		By Season	
		Day	Night	Breeding	Non-Breeding
6					
83					

You will also answer the following questions (again briefly!). For these questions, I'm looking for theories based on the biological or behavioral aspects of the birds themselves.

a) You should have seen differences between **day** and **night** in habitat use by MSO (look at home ranges for **day** versus **night** habitat use). During which time period did the owls move over a larger area, and what would be a possible reason to explain why this time period had the larger area?

b) You should have seen differences between **breeding season** and **non-breeding season** habitat use by MSO (look at home ranges for **breeding** versus **non-breeding** habitat use)? During which season did the owls move over a larger area, and what would be a possible reason to explain why this season had the larger area?

c) When using all points, what possible reason might explain the difference in MCP size between owl 6 and 83?

Exercise

Based on the point locations for Owl 6 and Owl 83, you will generate a total of 10 minimum convex polygon feature classes. For each owl, you will generate:

1) An MCP enclosing all the owl locations.
2) An MCP enclosing just the Day locations.
3) An MCP enclosing just the Night locations.
4) An MCP enclosing just the Breeding Season locations
5) An MCP enclosing just the Nonbreeding Season locations.

The steps below will explain in detail how to generate an MCP polygon around all the known locations for Owl 6. Based on these steps, you should be able to figure out how to generate MCPs for each subset of points described above.

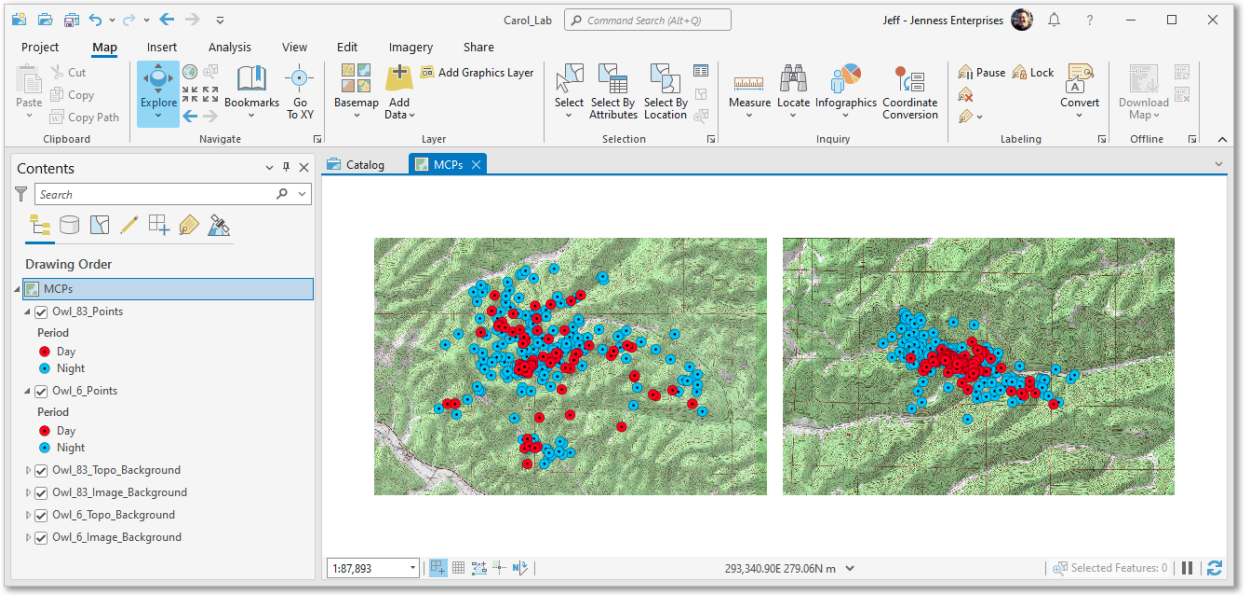
Important Note: If you have **any points selected** when you generate your minimum convex polygon, then the MCP tool will only generate an MCP around those selected locations. **Remember this!** When you want to generate an MCP around the Breeding Season and Nonbreeding Season locations, you will need to select those points before you create the MCP.

Prepare your ArcGIS Pro Project:

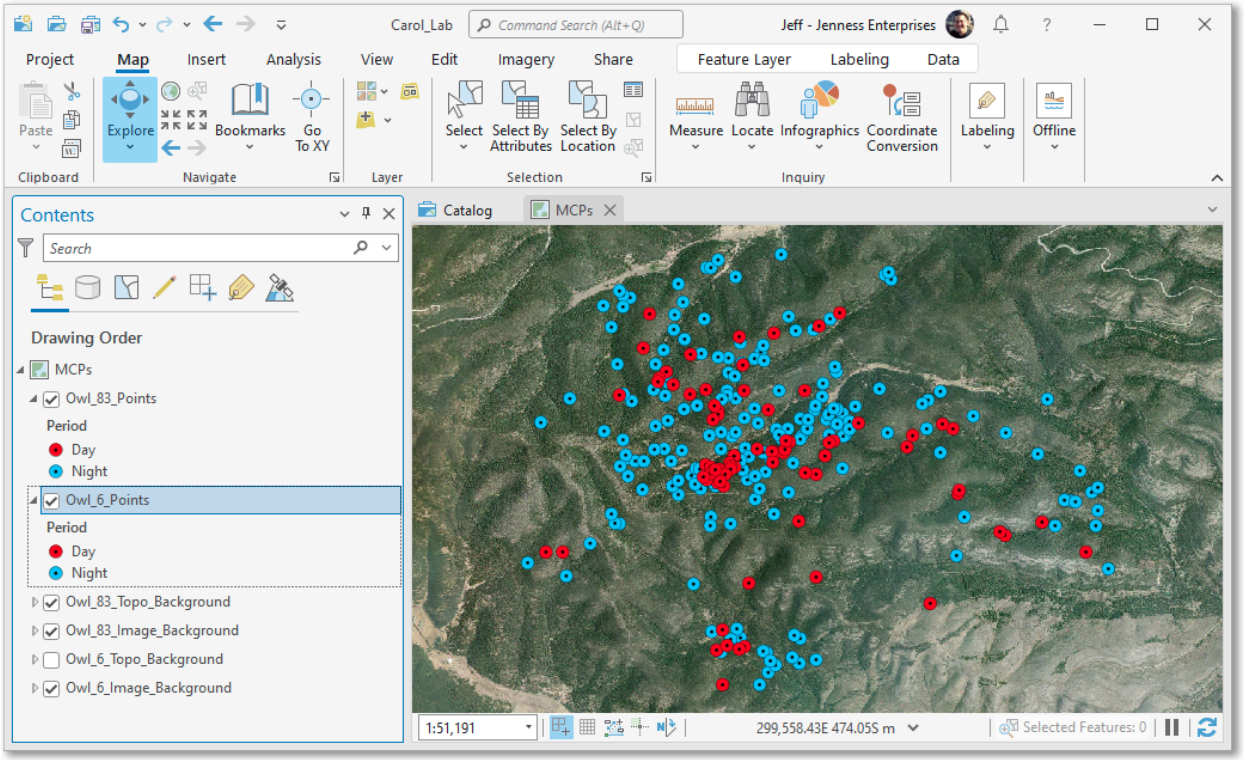
1) Open a blank map. If you have any default basemaps in your map, remove them because they will only distract from this exercise. The datasets used in this exercise have been shifted from their true location because of the conservation status of this species.

2) Load the **Layer** files **Owl_6_Image_Background.lyr, Owl_6_Points.lyr, Owl_6_Topo_Background.lyr, Owl_83_Image_Background.lyr, Owl_83_Points.lyr, Owl_83_Topo_Background.lyr**

3) If you loaded the Layer files, you should see the following. The owl locations are symbolized according to whether they are day or night locations.

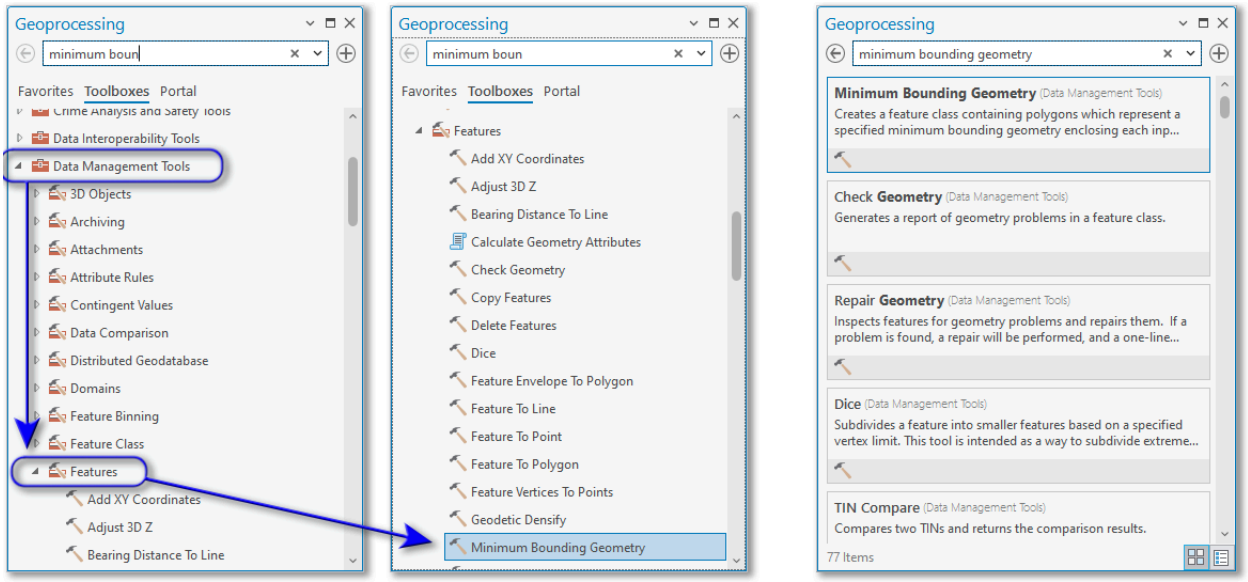


4) Zoom in to the extent of **Owl_6_Points** (Hint: Right-click on layer name and click "Zoom to Layer".



Generate the Minimum Convex Polygon

5) Open the "Minimum Bounding Geometry" tool (in the Geoprocessing Toolboxes --> Data Management Tools --> Features --> Minimum Bounding Geometry).



6) In the "Minimum Bounding Geometry" tool, make sure the tool is filled out as follows:

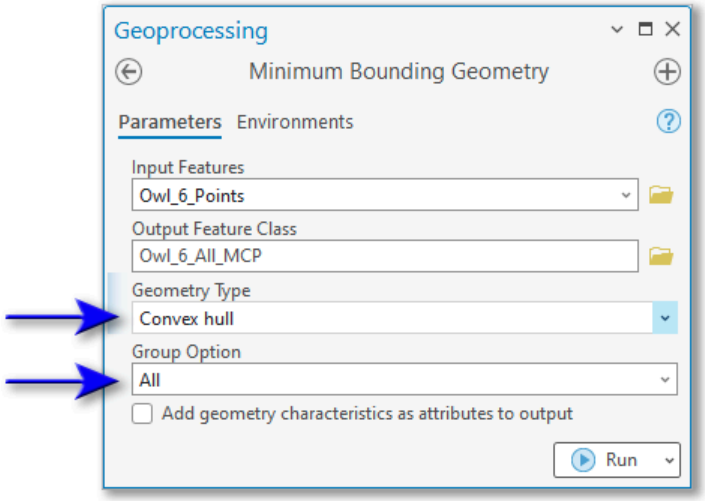
   a) The "Input Features" is set to the feature class **Owl_6_Points**.

   b) **Output Feature Class**: As always, specify a name and location. I recommend saving it to your file geodatabase "MCP_Data", which should be in your "Wildlife_Lab_GIS" folder, just to keep things organized. **Note:** Make sure to give it a name that makes sense, and put it in a location you will remember! In this example, I am saving it as **Owl_6_All_MCP** so that I can easily tell it is an **MCP** feature class generated from **All** points from **Owl 6**.

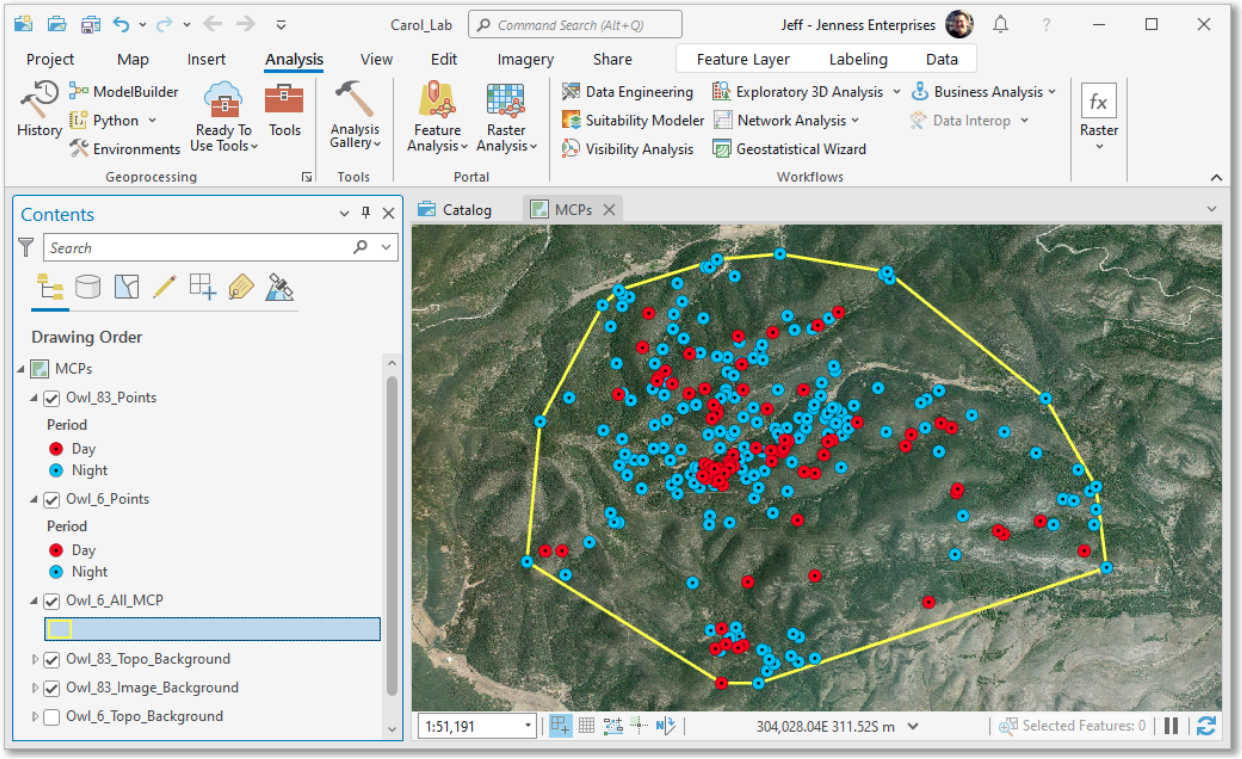
   c) The "Geometry Type" is set to **Convex_Hull**.

   d) The "Group Option" is set to **All**.

If generating an MCP around **All Points**, or **All Selected Points**

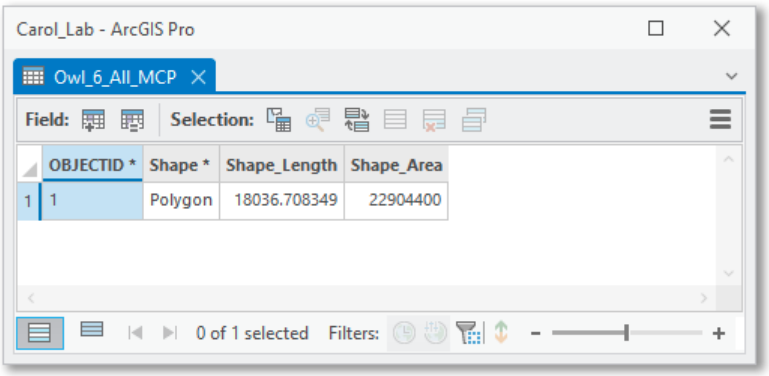


7) Click "OK" and the tool will generate the MCP feature class and add it to your map. You may want to symbolize the polygon by setting the symbol to a Hollow polygon.

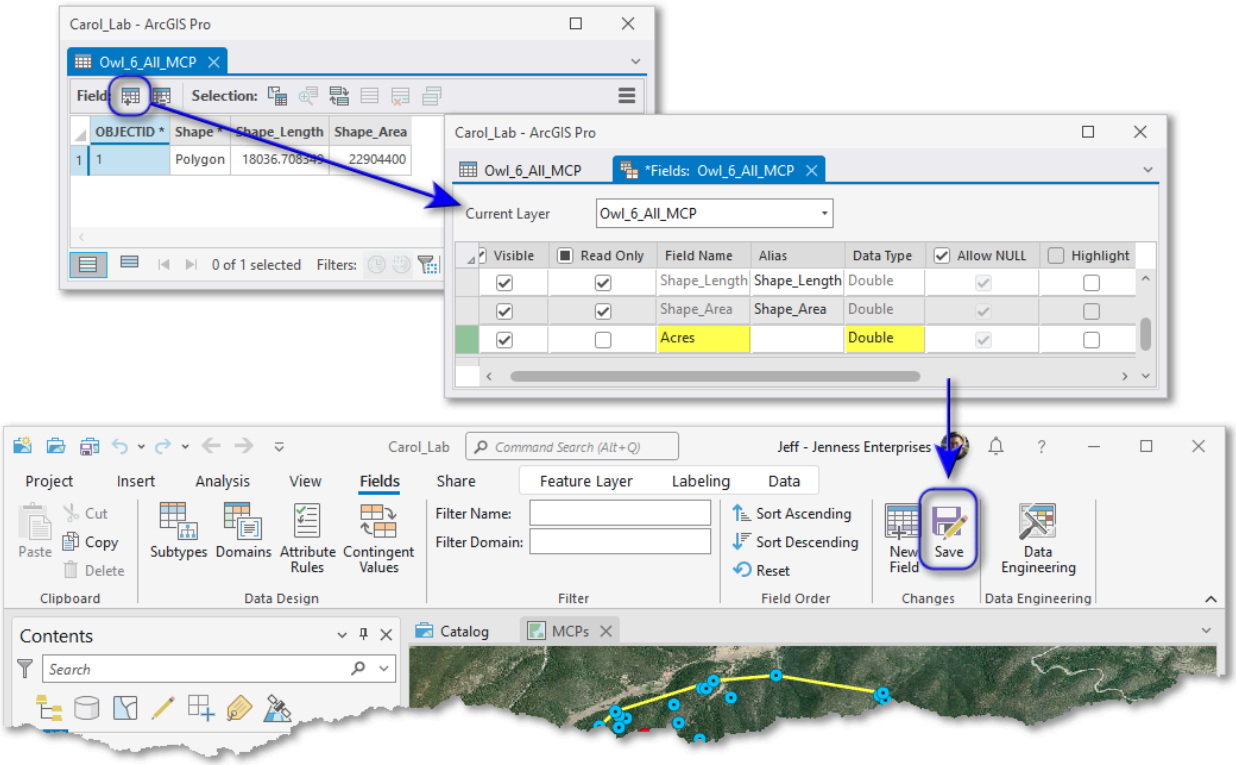


Calculate the Acreage of your MCP

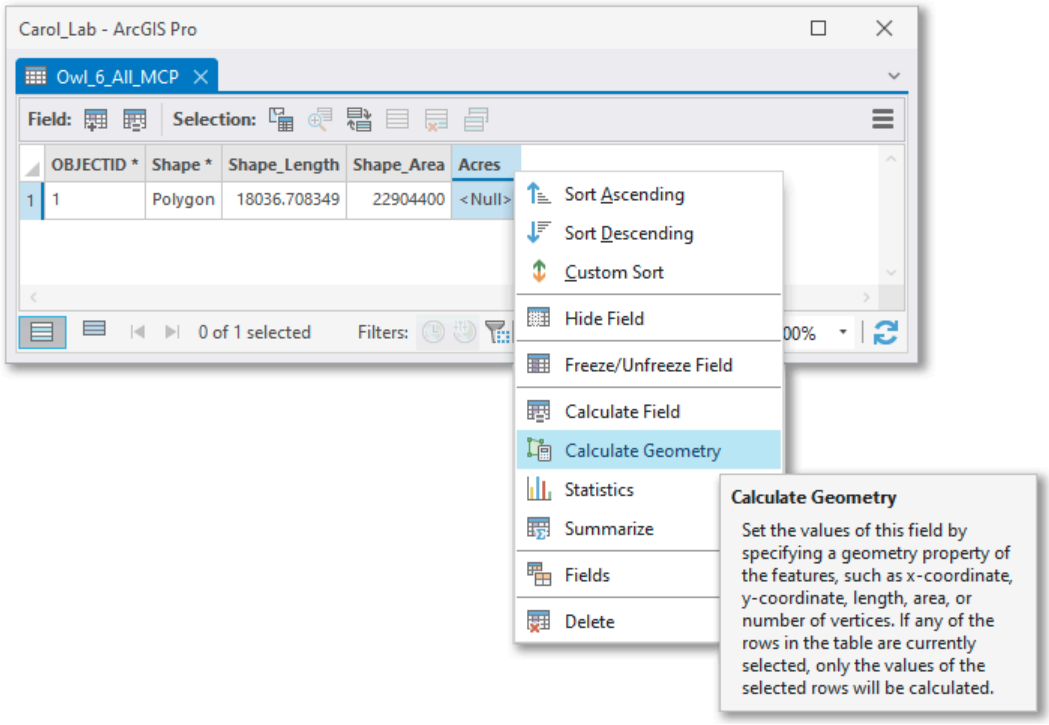
8) Open the attribute of your new MCP layer (Hint: Right-click on the layer and choose "Open Attribute Table")



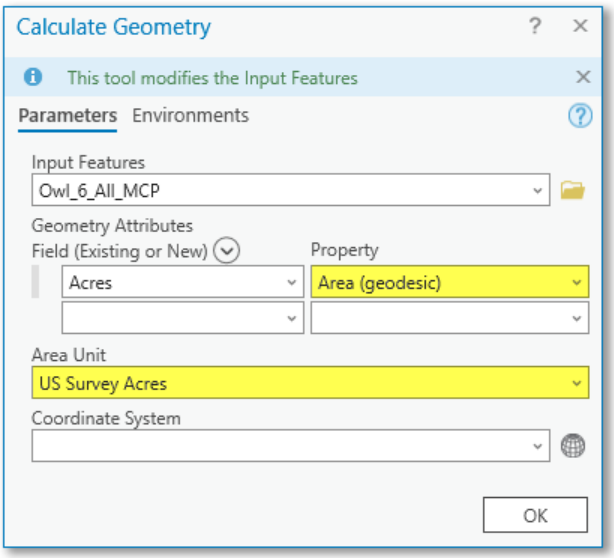
9) Click the “Add Field” and add a double-precision field named “Acres”, then save your edits:



10) Right-click on your new “Acres” field and choose “Calculate Geometry”



11) Make sure your "Property" = **Area (Geodesic)** and your "Units" = **US Survey Acres**. The coordinate system can be left blank because we are using geodesic calculations.



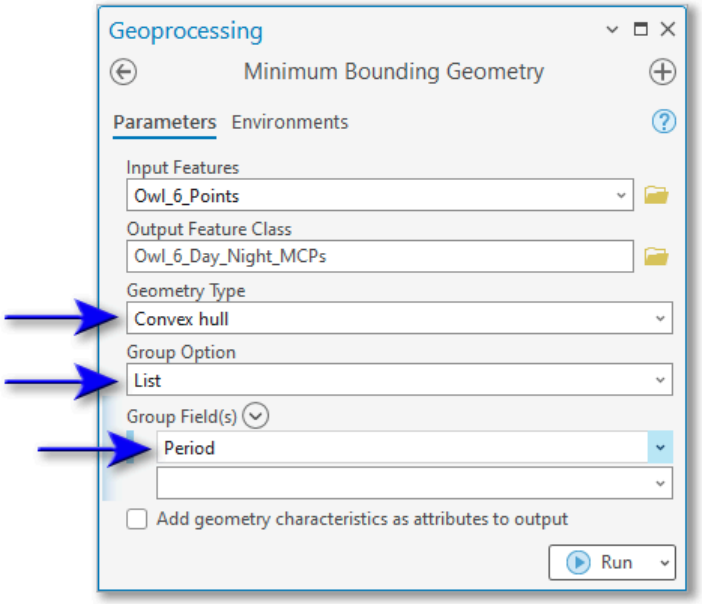
Generate separate MCPs around Day and Night points

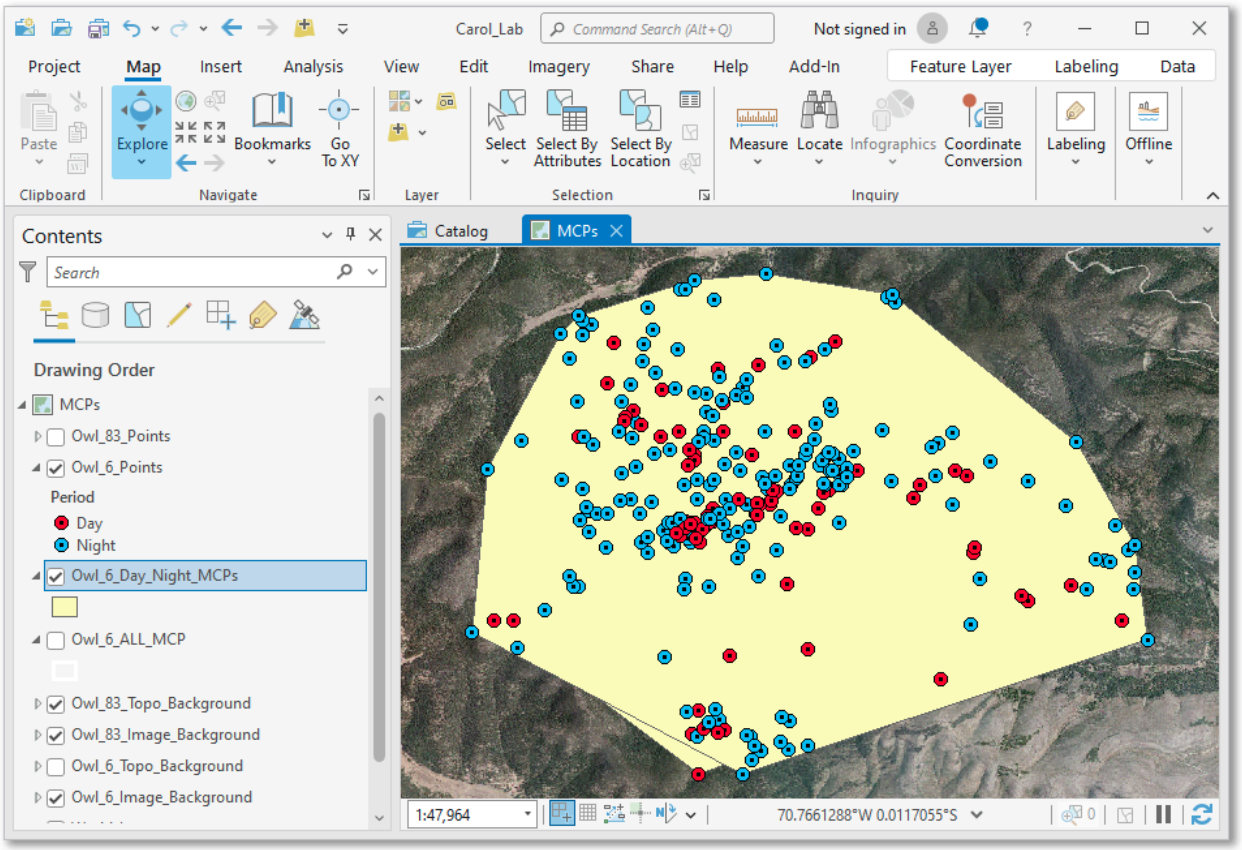
12) Open the **Minimum Bounding Geometry** tool again, but this time set the "Group Option" to **List** and check the box next to "Period"**.** If you do this, then the tool will make separate groups of points for each unique "Period" value. All points have a "Period" value of either "Day" or "Night", so therefore the tool will create a separate MCP for all the "Day" values and another for all the "Night" values. Both MCP polygons would be added to a single feature class, so the output would be a feature class with two polygons.

I suggest naming this new feature class something that describes its contents, like perhaps **Owl_6_Day_Night_MCPs**.

To generate a separate MCP for day and night locations, fill out your dialog like this:

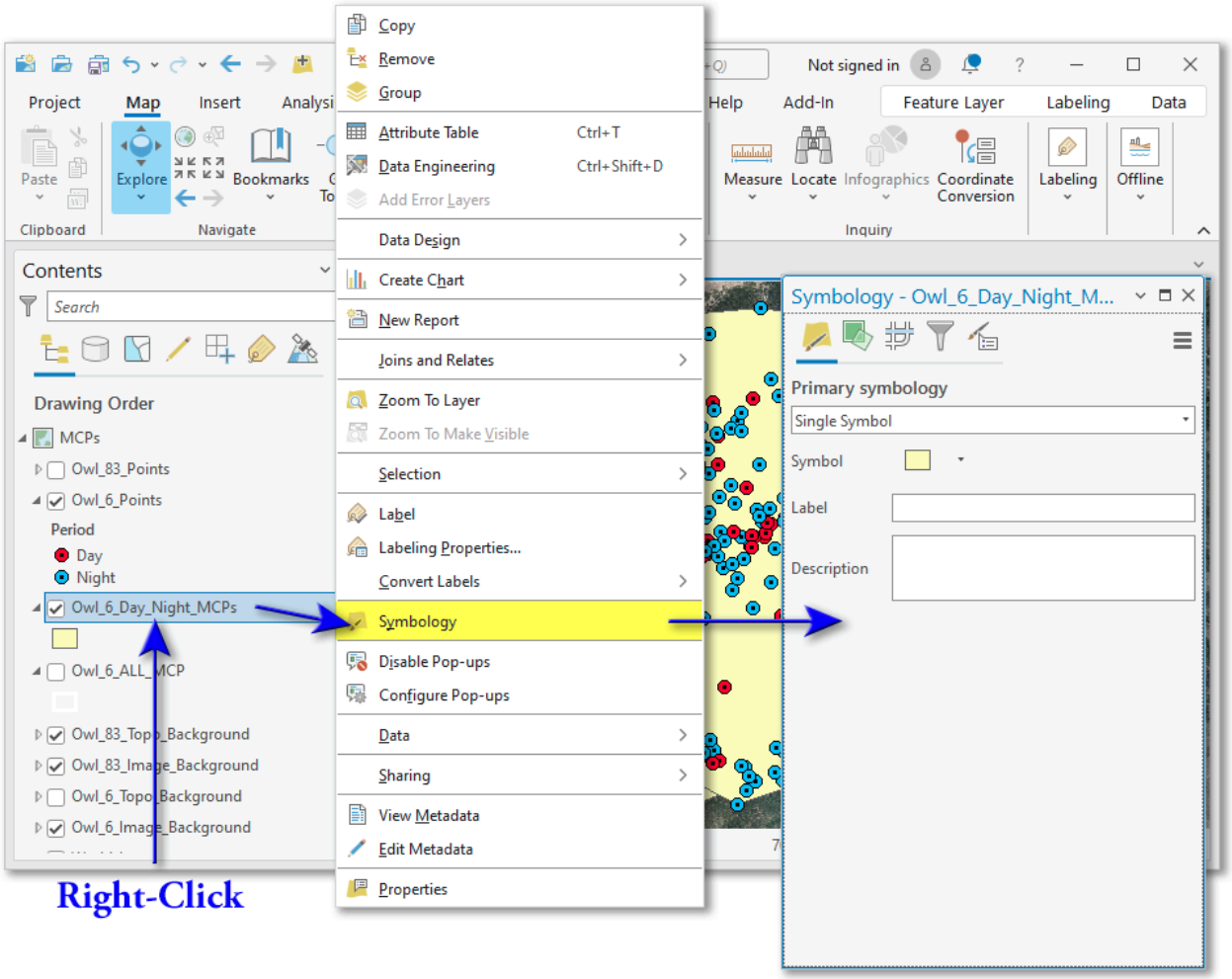
If generating an MCP around **All Points** from each unique **Period** value ("**Day**" or "**Night**")



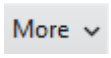


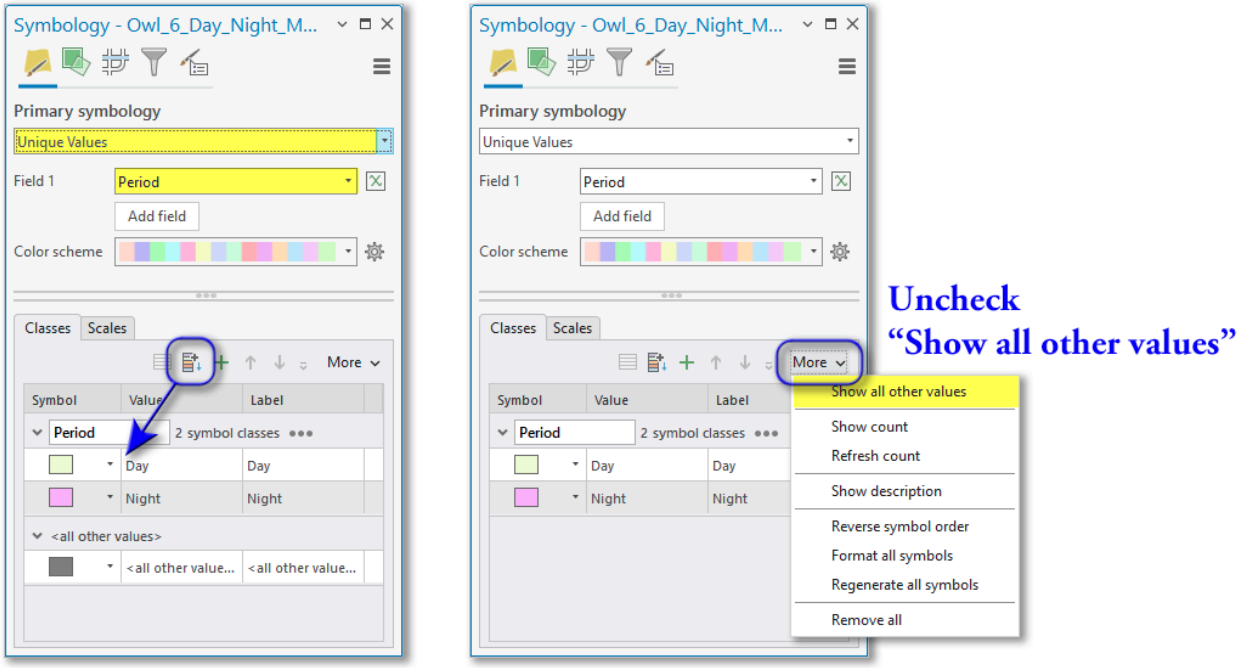
13) The Day and Night polygons are actually easier to see if we symbolize them differently, and especially if we make them hollow so we can see the full Day polygon underneath the Night polygon.

a) Right-click the new **Owl_6_Day_Night_MCPs** layer and open the *Symbology* pane.



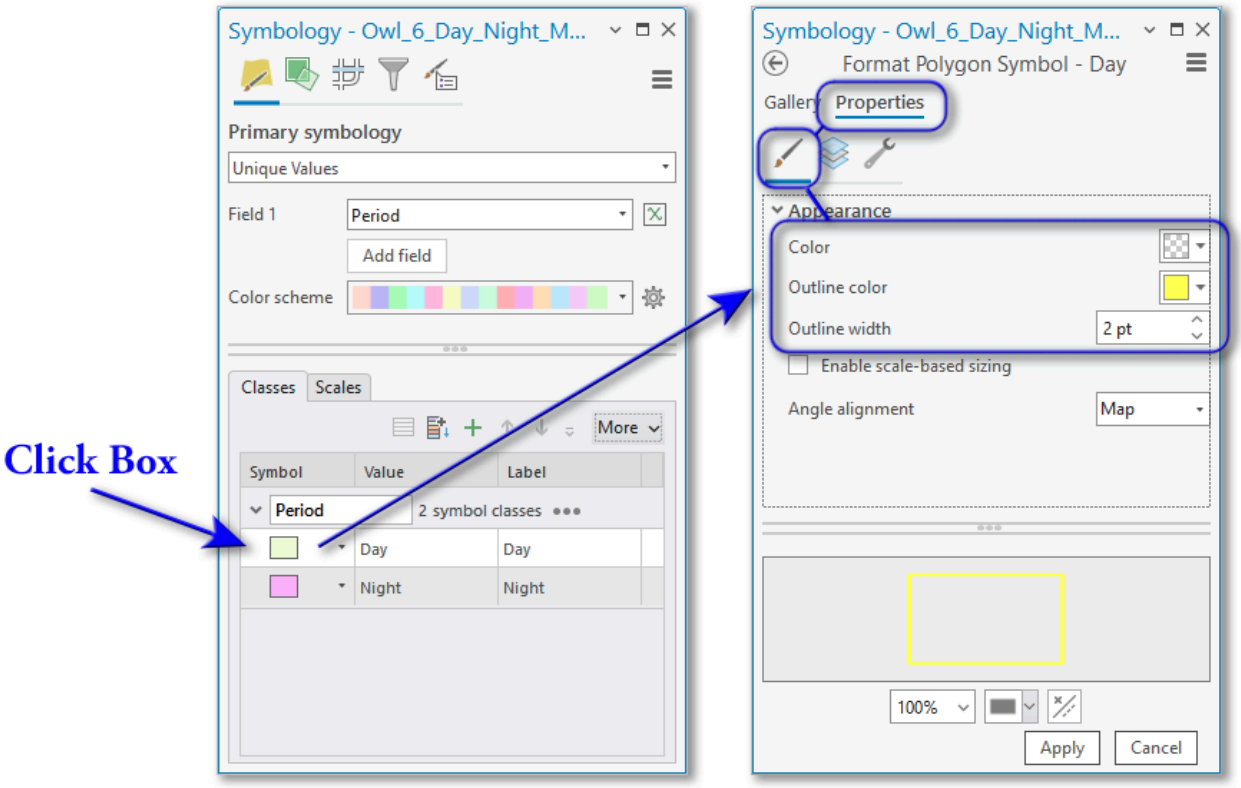
a) In the **Symbology** pane, set the *Primary Symbology* to "Unique Values, and the *Field 1* to "Period". Then click the **Add All Values** button  to add symbols for both the Day and Night polygons.

b) Finally, click the "More" button  and **uncheck** the item "Show all other values". See below for an illustration.

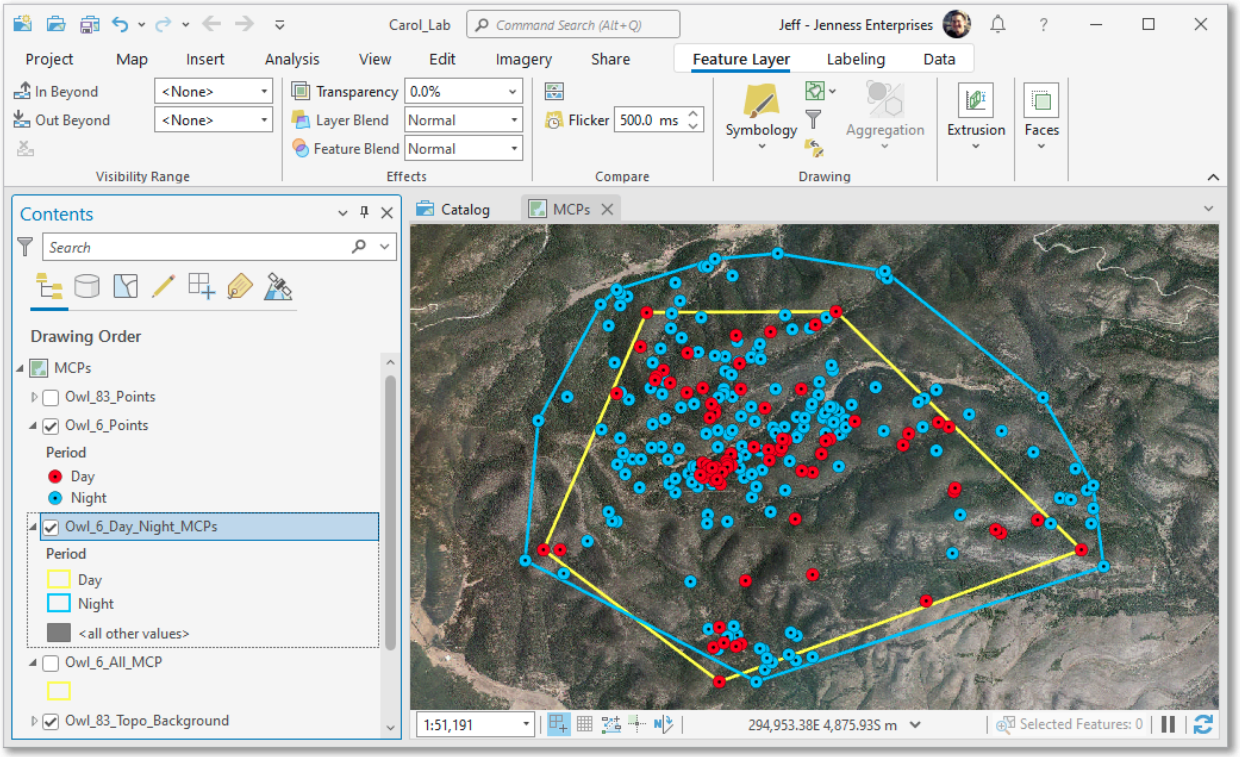


c) Click on the box for the *Day* symbol to open the **Symbology Properties** for that polygon fill symbol. Make sure you have the **Properties** option selected, and the **Symbol** command selected.

d) Set the *Fill color* to be **transparent** (or "**No Colo**r"), the *Outline color* to be **yellow**, and the *Outline Width* to be **2 pt.**



e) Repeat the process for the *Night* symbol, but this time make it a blue outline.



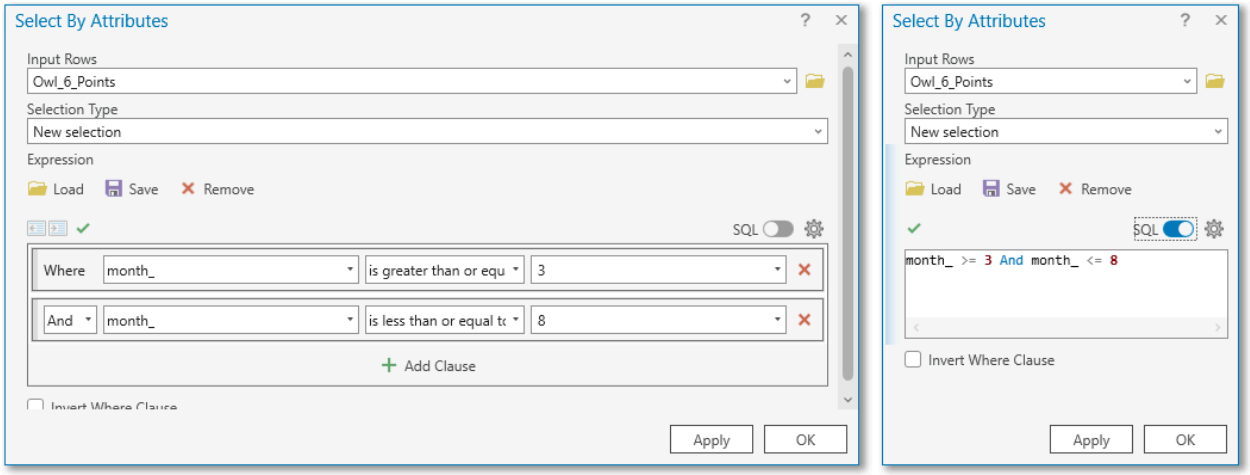
14) Following the steps above, create a new double-precision field named “Acres” and calculate the geodesic area in US Survey Acres.

Generate an MCP around Breeding Season points

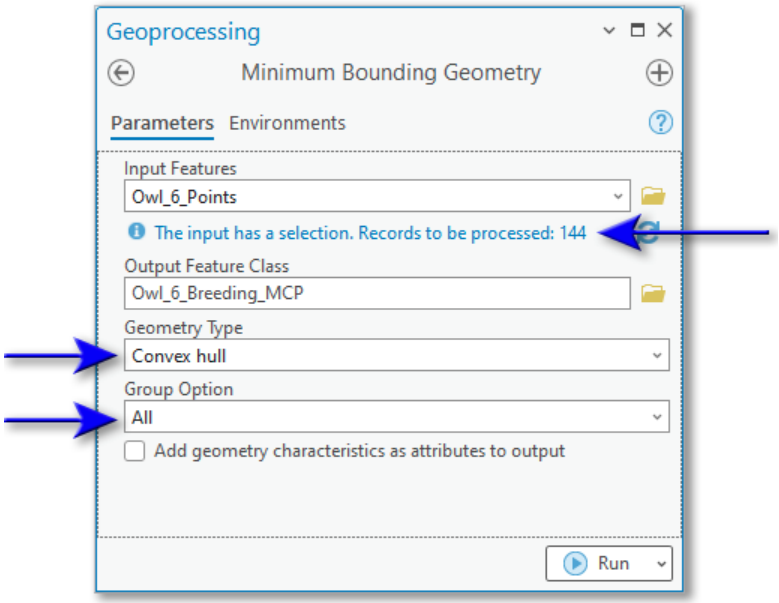
Important Note: When you generate MCPs for breeding and non-breeding season points, you will need to **select** the points before you run the tool. Breeding season for the Mexican spotted owl is from March to August. Therefore you will use your “Select by Attributes” tool to select the points according to the “month_” attribute values.

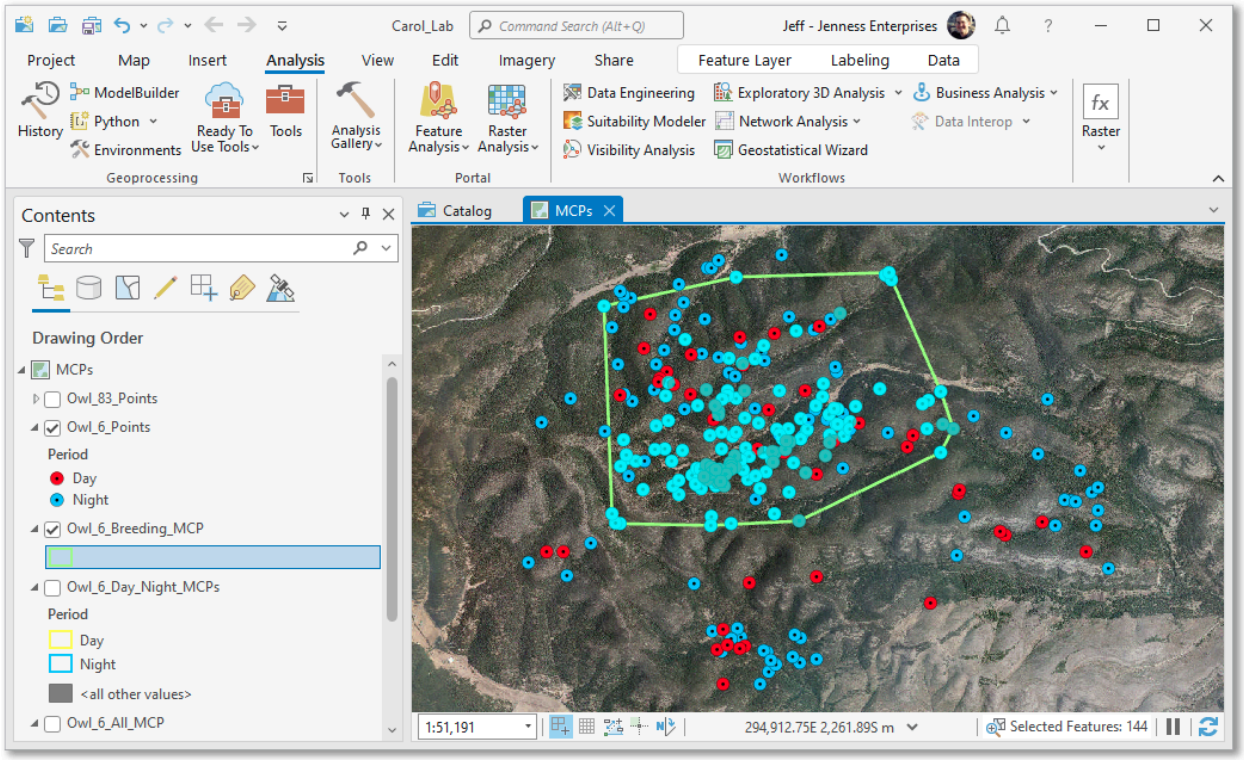
15) To select all the breeding season points, select the months March through August. You can use the following query string (notice that it uses the “AND” operator):

```
"month_" >= 3 AND "month_" <= 8
```



16) With the 144 breeding season points selected, run the Minimum Bounding Geometry tool again using the group option “All”. This will generate an MCP around all the selected points. I recommend naming your new feature class something like **Owl_6_Breeeding_MCP**.

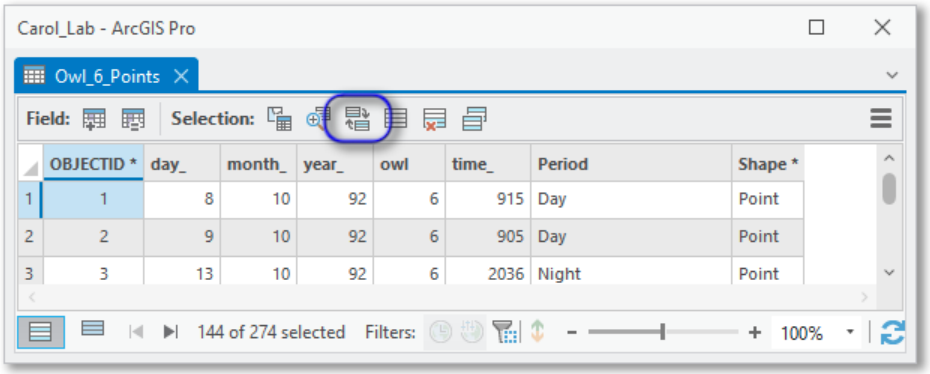




17) Following the steps above, create a new double-precision field named “Acres” and calculate the geodesic area in US Survey Acres.

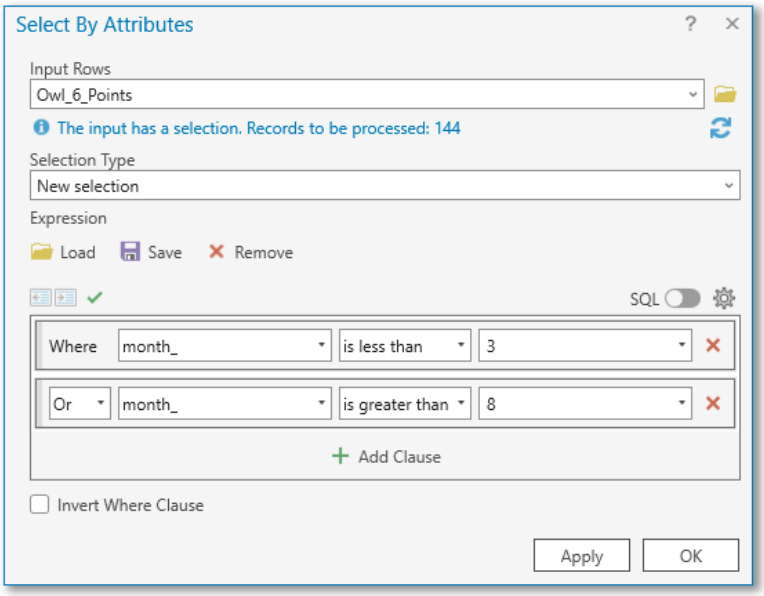
Generate an MCP around Non-breeding Season points

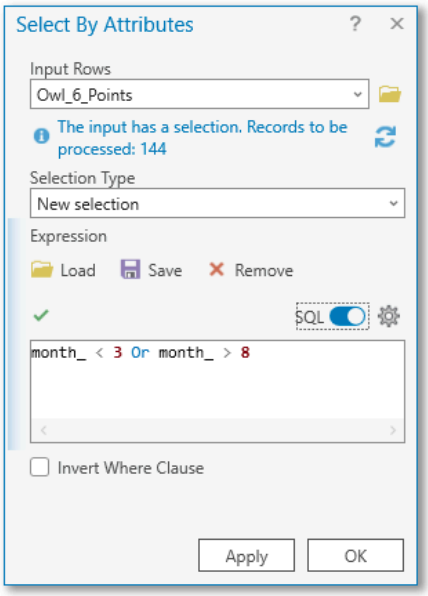
18) First select the owl locations gathered during the non-breeding season (September through February). The non-breeding season is just the opposite of the breeding season, so if you still have your previous selection in place then you can just switch the selection by opening the attribute table and clicking the “Switch Selection” command  :



If necessary, though, you can select the features using the query (and note that this query uses the “OR” operator rather than the “AND” operator):

```
"month_" < 3 OR "month_" > 8
```



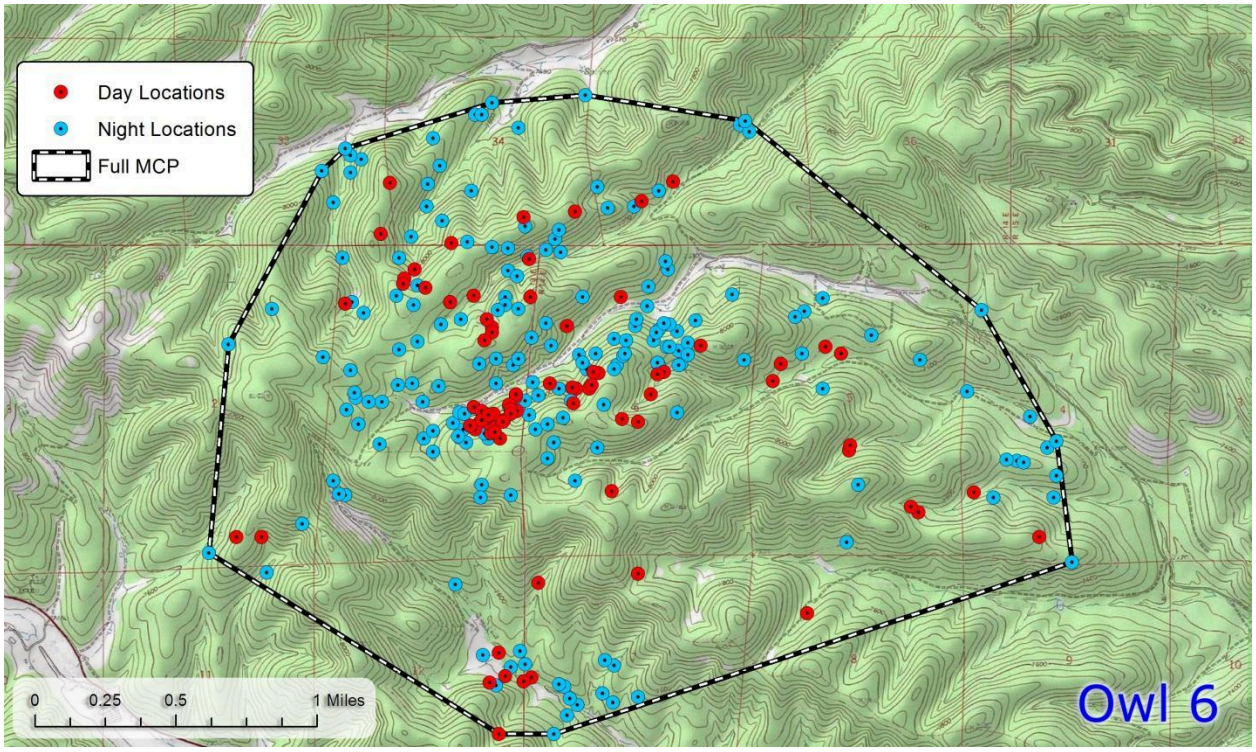


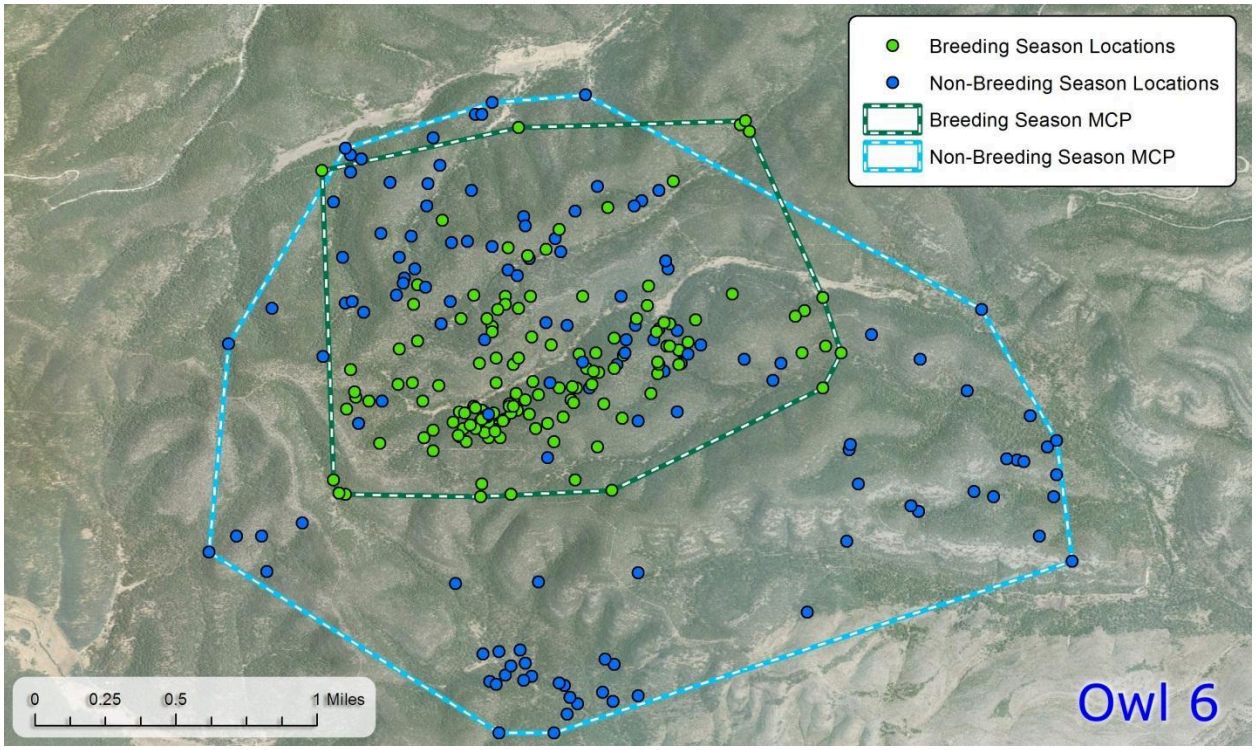
19) This should give you 130 selected points. Using the methods described above, create an MCP for these non-breeding season points, then add a new double-precision attribute field and calculate the area in US Survey Acres.

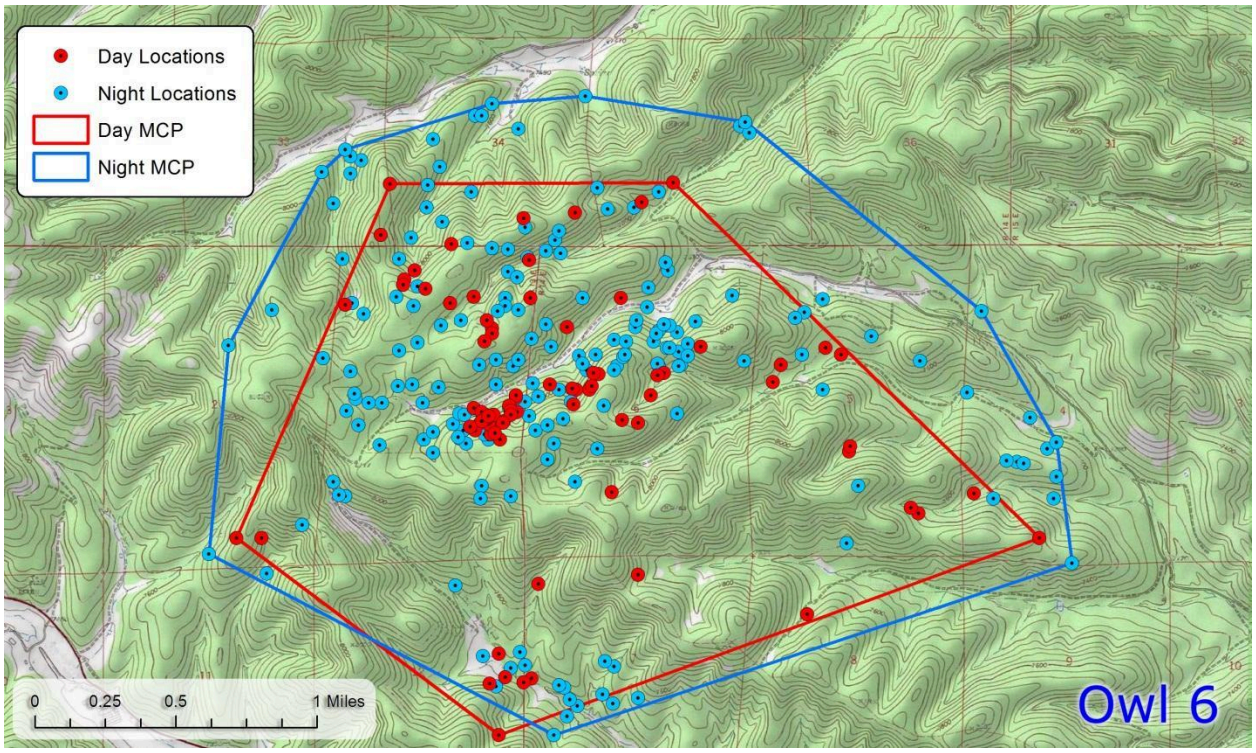
20) After calculating acreages for all MCPs, add those acreage values to the table at the beginning of this document.

What your MCP polygons should look like:

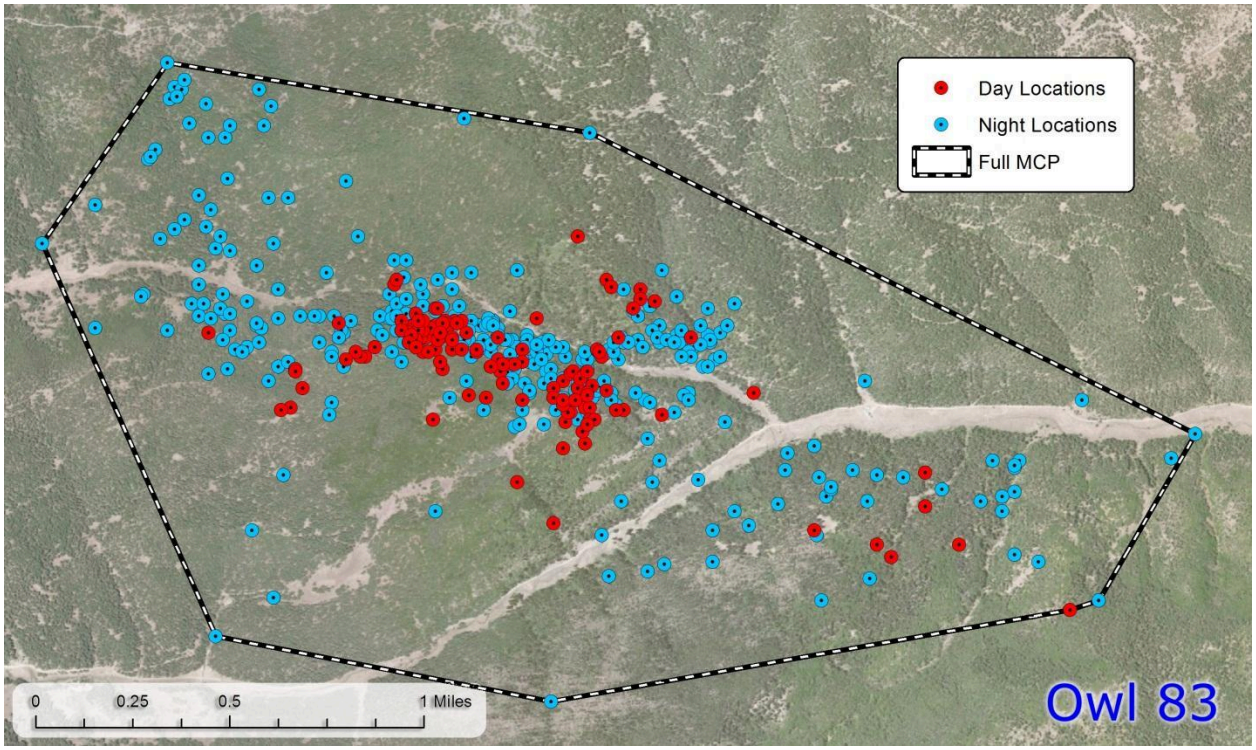
Upon completion, your MCP polygons for Owl 6 should look like this (although you may have symbolized them differently):

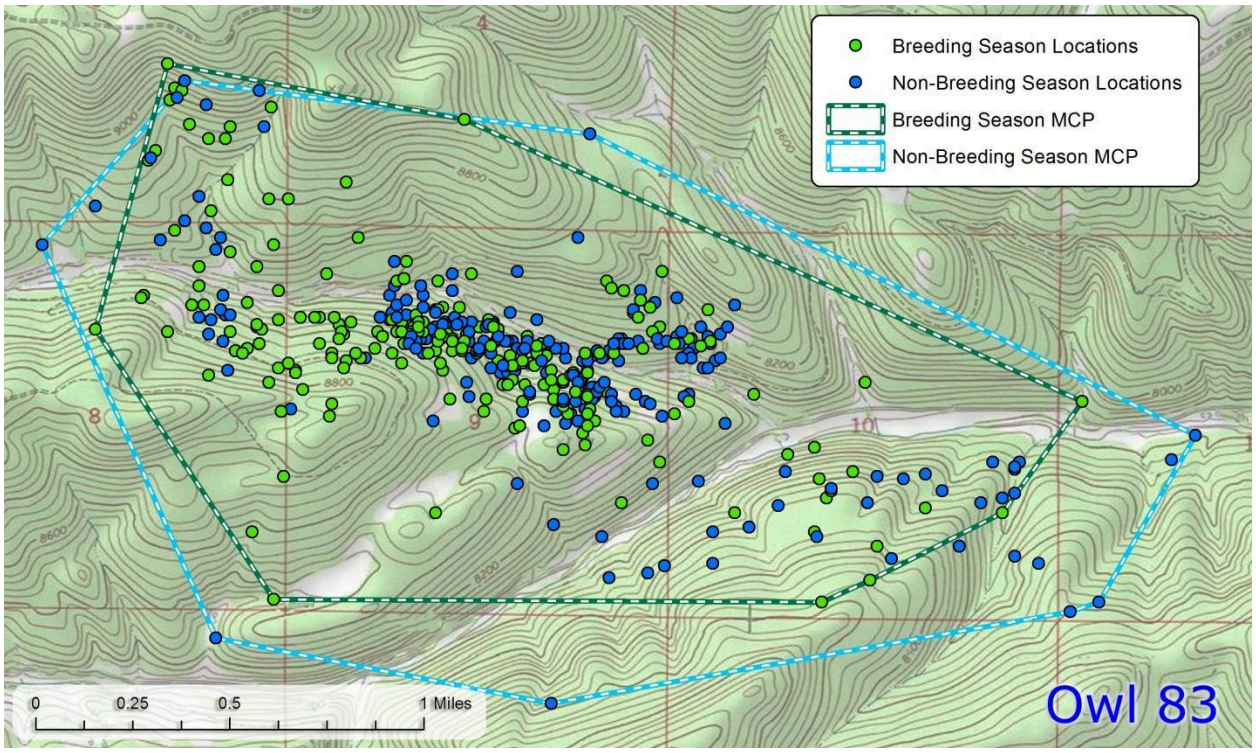


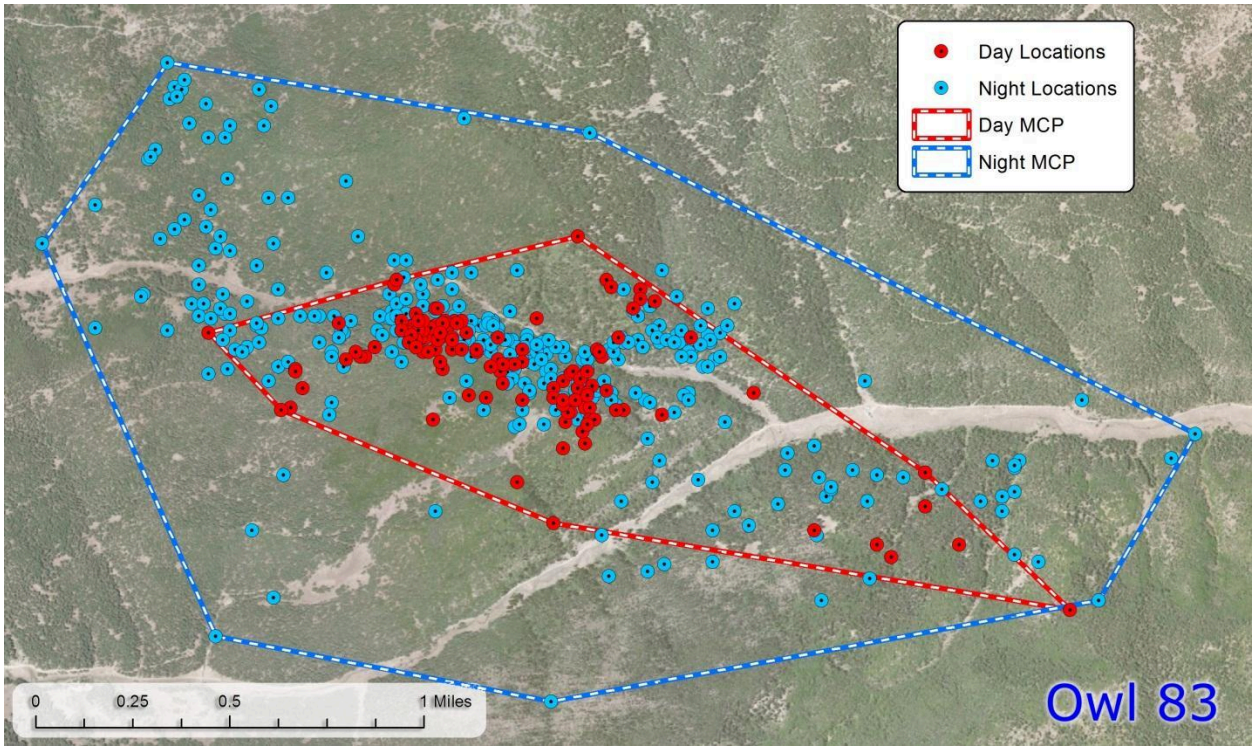




Your MCP polygons for Owl 83 should look like this (although you may have symbolized them differently):


Day Locations
Night Locations
Full MCP
0
0.25
0.5
1 Miles
Owl 83


Breeding Season Locations
Non-Breeding Season Locations
Breeding Season MCP
Non-Breeding Season MCP
0
0.25
0.5
1 Miles
Owl 83


Day Locations
Night Locations
Day MCP
Night MCP
0
0.25
0.5
1 Miles
Owl 83

Exercise 3: Kernel Density

Note: Read this first!

- This lab exercise will demonstrate how to perform a kernel density analysis. It will walk you through how to calculate a kernel density-based home range around all the Owl 6 locations. You will then need to repeat all the steps for each additional analysis.

- Kernel Density is one of those tools that will work only on selected records, if any are selected. For example, to do a kernel density analysis on **breeding** locations, you just need to **select the breeding locations first** and then **redo all the kernel density steps**. So be prepared to go through these steps more than once!

Objectives

- Learn how to generate a kernel density surface around **all the locations** in a feature class. We will generate a kernel density surface for each set of owl locations.

- Learn the effects of using different kernel sizes. The maps on p. - show the kernel density surface you will calculate, as well as kernel density surfaces generated from larger and smaller kernels. Observe the effects of **large and small kernel sizes**. Consider how each might be informative for different questions. **Note:** In the interest of time, this lab will only ask you to create kernel densities using a single kernel size. We are providing maps showing results from other kernel sizes so you can see the effects without having to do all the work yourself.

- Learn how to generate kernel densities for **selected subsets** of the data. We will generate separate kernel density surfaces for the **day and night locations** for each owl.

- Again, based on selected subsets of the data, we will generate separate kernel density surfaces for the **breeding and non-breeding season locations** for each owl.

- Learn how to generate contour lines around the kernel density surface. Observe how these contour lines can guide us as we consider how to define the home range polygon.

- Learn how to use the Spatial Analyst **Logical Operator** tools (specifically the "Greater Than Equal" tool) to extract the portion of the density surface that will represent the home range, core area or some other area of concentration.

- Learn how to use the Data Conversion tool **Raster to Polygon** to convert the extracted raster into a polygon feature class.

- Calculate acreages for each home range polygon. Observe and consider the differences between the MCP sizes and the kernel density home range sizes for each owl.

- Consider when the kernel density approach might be a good way to estimate home ranges, and when it might not be. As with the MCP analysis, can you think of any issues with data collection that might affect the accuracy of your kernel density surface?

Data used

- Feature Class **Owl_6_Points**, in file geodatabase ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.**
- Raster image **Owl_6_Image_Background**, in file geodatabase ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.**
- Raster image **Owl_6_Topo_Background**, in file geodatabase ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.**
- Optionally, feature Class **Owl_83_Points**, in file geodatabase ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.**
- Optionally, raster image **Owl_83_Image_Background**, in file geodatabase ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.**
- Optionally, raster image **Owl_83_Topo_Background**, in file geodatabase ..\Class_GIS_Data\Wildlife_Lab_GIS_Data\Wildlife_GIS_Data.gdb**.**

Homework Assignment:

You will calculate the **Home Range** and **Core Area** acreages using all locations for **Owl 6.** Then, select some subset of points (either the **Day**, **Night**, **Breeding** or **Non-Breeding** points), redo the density analysis, and calculate the area again. **To be clear**, there are 6 empty "acreage" cells in the table below. You need to fill out 3 of them. You need to fill out both values for "All Points", and then pick one of the others to answer.

You will use a 500m bandwidth, but you will have to make your own judgment on what density threshold to use to define home range or core area, so **tell me what density threshold you used** in addition to the acreages.

- **Note:** For your reference, I have provided the 500m kernel density acreage values for Owl 83, and the 250m and 1000m kernel density acreage values for both owls below. Please see the maps at the end of the lab document to see what these home range polygons look like.

Geodesic Acreages of Home Range Polygons derived from 500m Kernel Density Surfaces							
Owl		**All Points**		**Within Day**		**By Season**	
		Home Range	**Core Area**	**Day**	**Night**	**Breeding**	**Non-Breeding**
		Do this one	**Do this one**	**Do one of these four: Your choice**			
6	*Acreage*						
	Density Threshold						
83	*Acreage*	1,046	225	348	953	688	633
	Density Threshold	20	140	20	20	20	20

For your information, if you try other bandwidths (not part of your homework) Acreages of Additional Kernel Density Surface Polygons			
Owl		**All Kernel Density Surfaces derived using All Points**	
		Home Range from 250m Kernel	**Home Range from 1000m Kernel**
6	**Acreage**	*2,042*	*3,533*
	Density Threshold	*10*	*5*
83	**Acreage**	*874*	*1,314*
	Density Threshold	*20*	*20*

You will also answer the following question (again briefly!):

What are **advantages** and **disadvantages** of using Minimum Convex Polygons and Kernel Density Surface Polygons as home range estimates? I'm looking for positive and negative aspects to both MCPs and KDs.

Exercise

Based on the point locations for **Owl 6**, you will generate a total of 3 home range and core area polygon feature classes. Specifically, you will generate:

1) A **Home Range** polygon based on a 500m Kernel Density, using **all the owl locations**.
2) A **Core Area** polygon based on a 500m Kernel Density, using **all the owl locations**.

You will also generate **one** of the following. You may choose which one is most interesting to you.

1) A polygon representing the **area of concentration for night-time locations**, based on a 500m Kernel Density using **just the Night locations**.
2) A polygon representing the **area of concentration for day-time locations**, based on a 500m Kernel Density using **just the Day locations**.
3) A **Breeding Season Home Range** polygon based on a 500m Kernel Density, using just the **Breeding Season locations**.
4) A **Non-Breeding Season Home Range** polygon based on a 500m Kernel Density, using just the **Non-Breeding Season locations.**

Optionally, if you want additional practice at kernel density analysis, you can run the same analyses using the Owl 83 data. The homework tables include the correct home range acreage values for Owl 83 based on a density threshold of 20 owl locations per square kilometer, and a core area based on a density threshold of 140 locations/km^2.

Also optionally, try calculating the kernel density home range for each owl based on a 250m kernel and a 1000m kernel. The homework tables include the correct home range acreage values for these kernel sizes given a few density threshold values. It is instructive to see how the shape of the home range polygons change based on the bandwidth.

Note: Unlike with the MCP analysis, the Home Range and Core Area polygons you derive here are a little subjective and you may not get the same answer as your neighbor. Do not worry about this, as long as your polygons make sense to you.

The steps below will explain in detail how to generate a Kernel Density-based home range polygon based on a 500m kernel using all the known locations for Owl 6. Based on these steps, you should be able to figure out how to generate home range and core areas polygons for each subset of points described above.

Important Note: If you have **any points selected** when you generate your kernel density surface, then the density surface will reflect **only** those selected points. **Remember this!** When you want to generate kernel densities for Breeding Season and Nonbreeding Season locations, and again for Day and Light locations, you will need to **select those points** before you create the density surface.

Prepare your ArcGIS Pro Project:

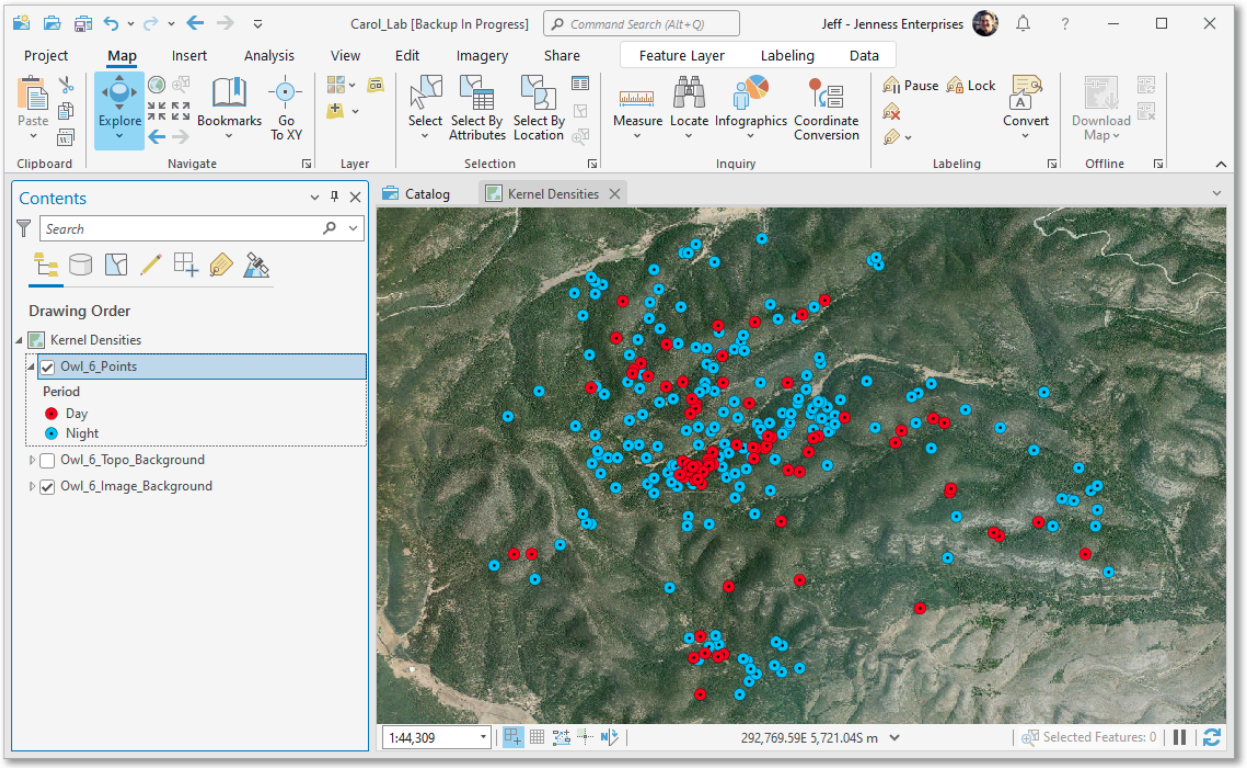
1) Open a blank map. If you have any default basemaps in your map, remove them because they will only distract from this exercise. The datasets used in this exercise have been shifted from their true location because of the conservation status of this species.

2) Make sure you have the **Spatial Analyst** extension turned on. If you try to run a tool and get an error message stating that the tool is not licensed, then you just need to turn on Spatial Analyst. See p. , or view the short video at https://youtu.be/JHMZYkbn7PI, for instructions on how to do this.

3) Load the **Layer** files **Owl_6_Image_Background.lyr, Owl_6_Points.lyr, Owl_6_Topo_Background.lyr.**

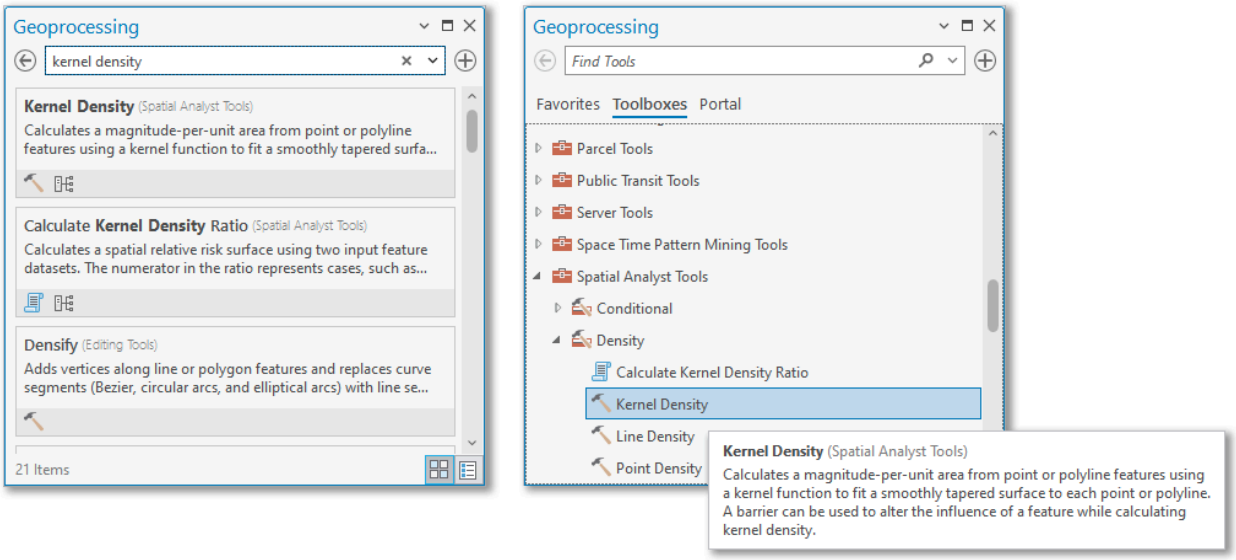
   a) **Optionally,** you may also load the Owl 83 data (Owl_83_Image_Background.lyr, Owl_83_Points.lyr, Owl_83_Topo_Background.lyr). If you want to continue practicing your Kernel Density skills, then you can try these Owl 83 points.

4) Zoom in to the extent of **Owl_6_Points** (Hint: Right-click on layer name **Owl_6_Points** and click "Zoom to Layer". You should see the following. The owl locations are symbolized according to whether they are day or night locations.

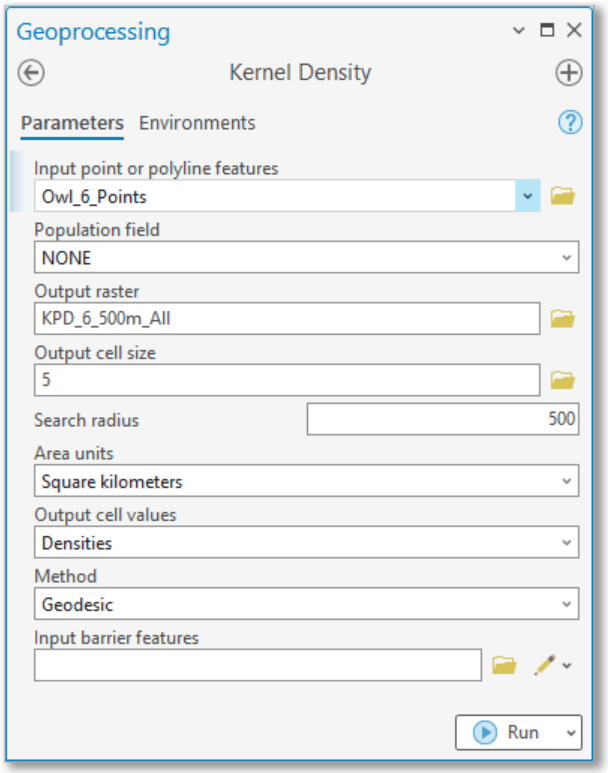


Generate the 500m Kernel Density Surface for All Owl 6 Points

5) Open the Kernel Density tool (in the Geoprocessing Toolboxes --> Spatial Analyst Tools --> Density --> Kernel Density):

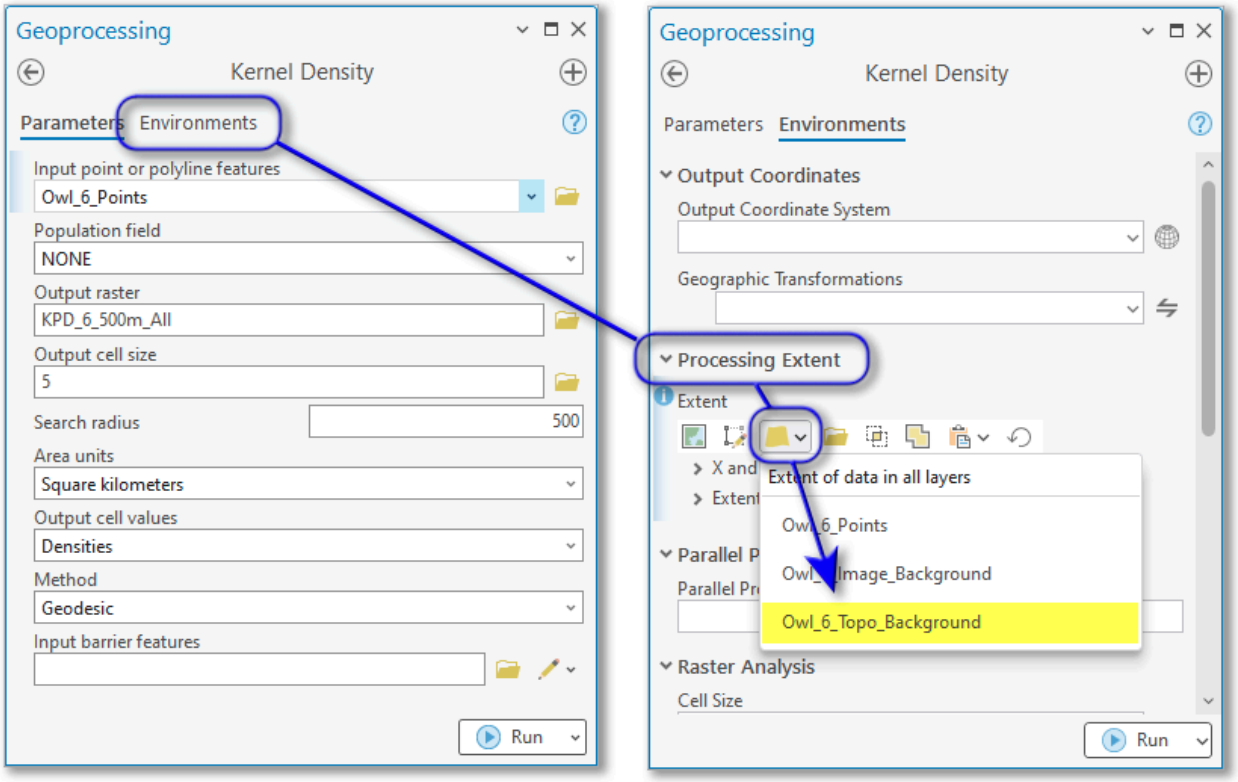


6) In the "Kernel Density" tool window, set the following parameters (and see illustration below):
   a) "Input point or polyline features" = **Owl_6_Points**
   b) "Population Field" = **NONE**
      i) Just FYI regarding the "Population Field": If we wanted to weight the points differently, so that perhaps some points count more than others, then we could specify an attribute field here that would weight the points accordingly. In this exercise we will treat all points the same.
   c) Specify a location and name for your new Kernel Density raster. I recommend you save your raster to the file geodatabase "KPD_Data", which should be in your "Wildlife_Lab_GIS" folder. In this example, I am naming the raster **KPD_6_500m_All** so that I will know it is a **K**ernel **P**oint **D**ensity raster for Owl **6**, based on a **500m** kernel, using **All** points. You will generate several kernel density rasters so make sure you know which one is which.
   d) Set the "Output cell size" to be **5** (meaning that your new raster will have a 5m cell size).
   e) Set the "Search Radius" to be **500** (meaning the kernel will be a circle with a 500m radius).
      i) **Note:** If you redid this with a 250m or 1000m kernel, you would set this value to 250 or 1000 respectively.
   f) Set the "Area units" to be **SQUARE_KILOMETERS**. This means that the density values you get will be in "owl locations per square kilometer".
   g) **DO NOT RUN THE TOOL YET!** Your dialog should currently look like this:



h) **Right now, if you ran the tool**, you would get a Kernel Density surface that is exactly as large as the extent of all the points. Take a look at the video demonstrating this lab to see what I mean by this. We want the kernel density raster to be larger than the extent of the input datasets, so we need to set the Processing Extent environmental parameter before we run the tool.

i) Click the "Environments" button on the "Kernel Density" window, go to "Processing Extent", click the "Extent of Layer" dropdown list , and select either the **Topo** or the **Image** background. This will force ArcGIS to make the density surface raster the same size as your background imagery, which is large enough to include density values outside the rectangular extent of all the points.

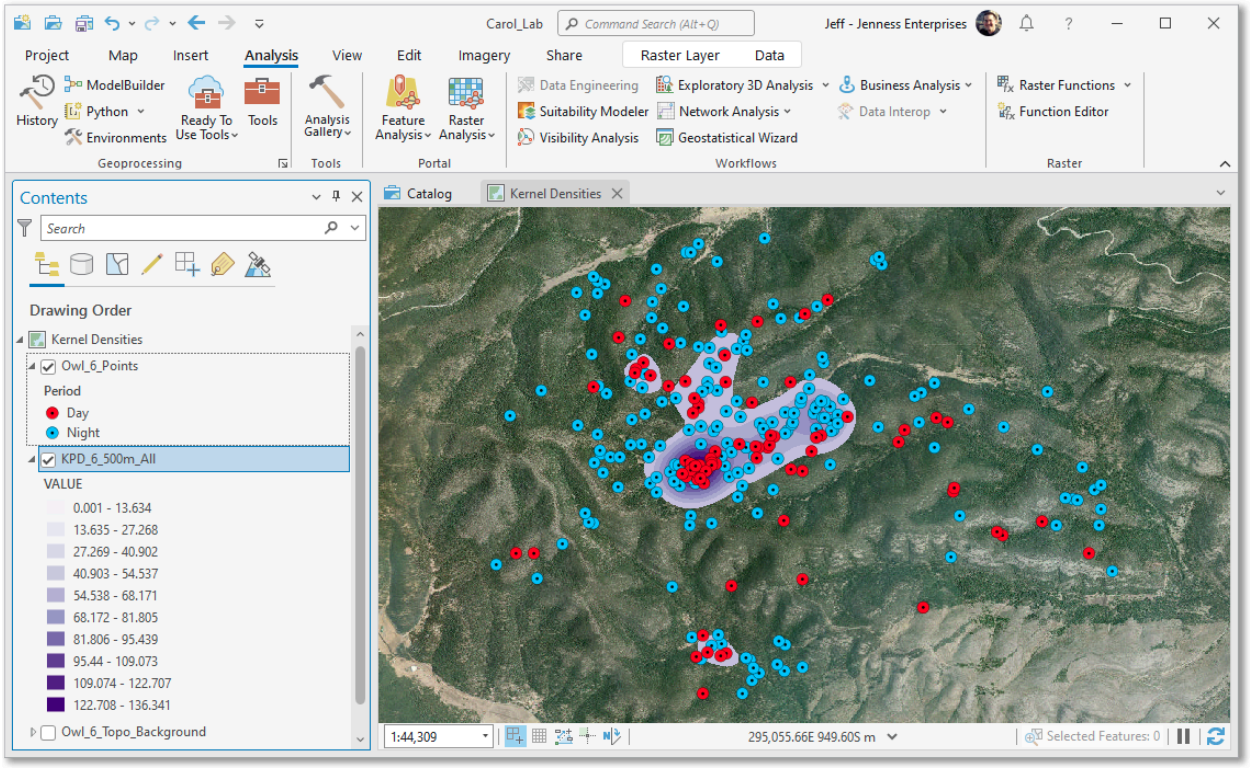


j) Click "Run" to run the tool.

Note: Read This! You will also run this tool on a few subsets of the points (Daytime, Nighttime, Breeding Season and Non-Breeding Season locations). When you are ready to do these other analyses, you only need to **select** those points from the owl location feature class before you run this tool. If any points are selected, then this tool will only analyze those selected points.

Symbolize your Density Surface Layer

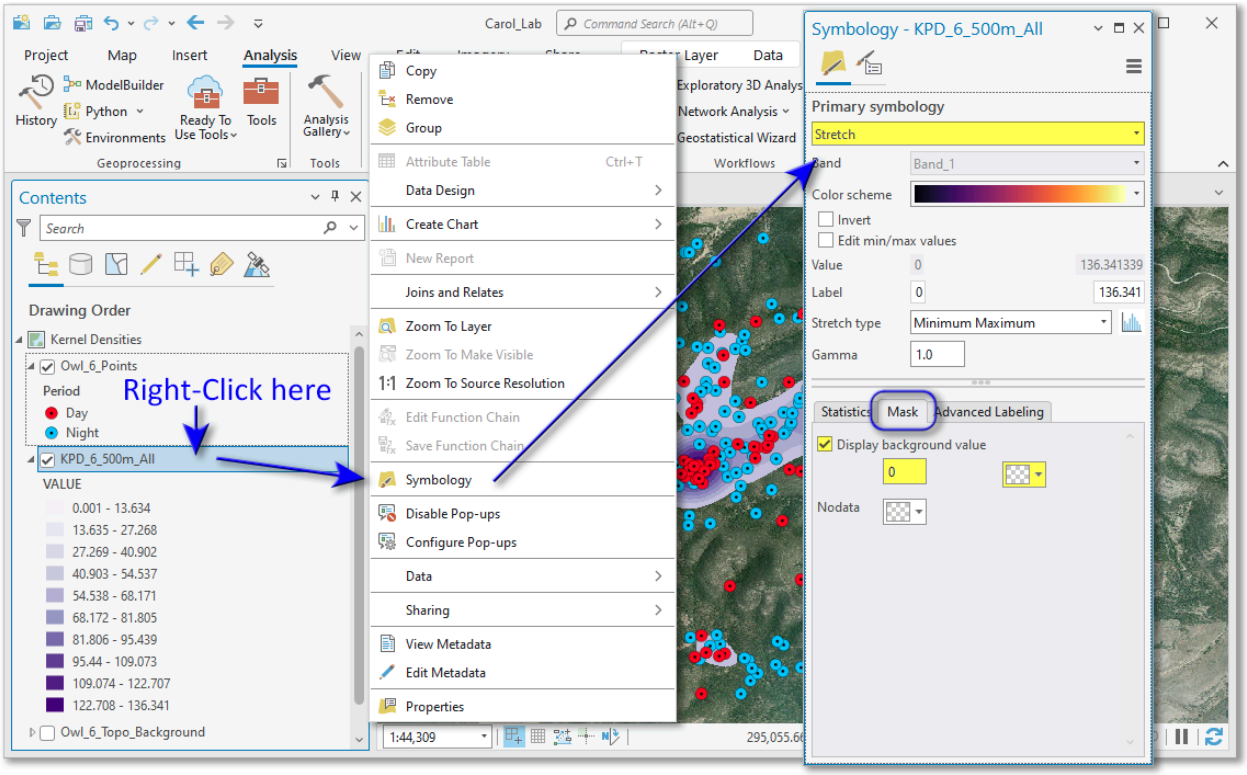
7) Upon completion, you should see something that looks like the following appear in your map.



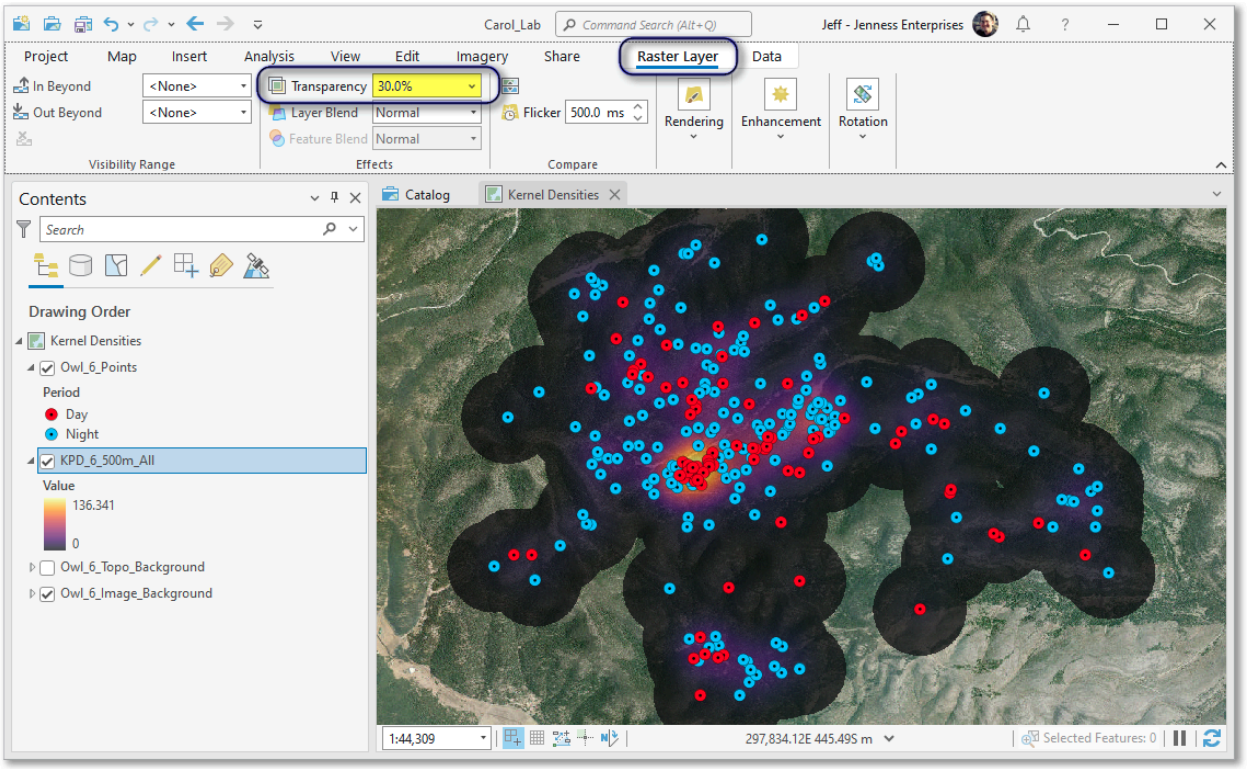
8) If it looks like this, then it is badly symbolized. The programmers made some bad choices when they decided how the new raster would be displayed, so we need to fix it.

   a) Right-click on the layer, go to “Symbology”, and change the symbology to a “Stretch” type. Pick any color scheme you like.

   b) Also click the “Mask” tab and tell it to set all “0”-value cells to have no color. These are the regions with a kernel density of 0, meaning there are no owl locations within the threshold distance. We can just turn the symbology off for those regions.

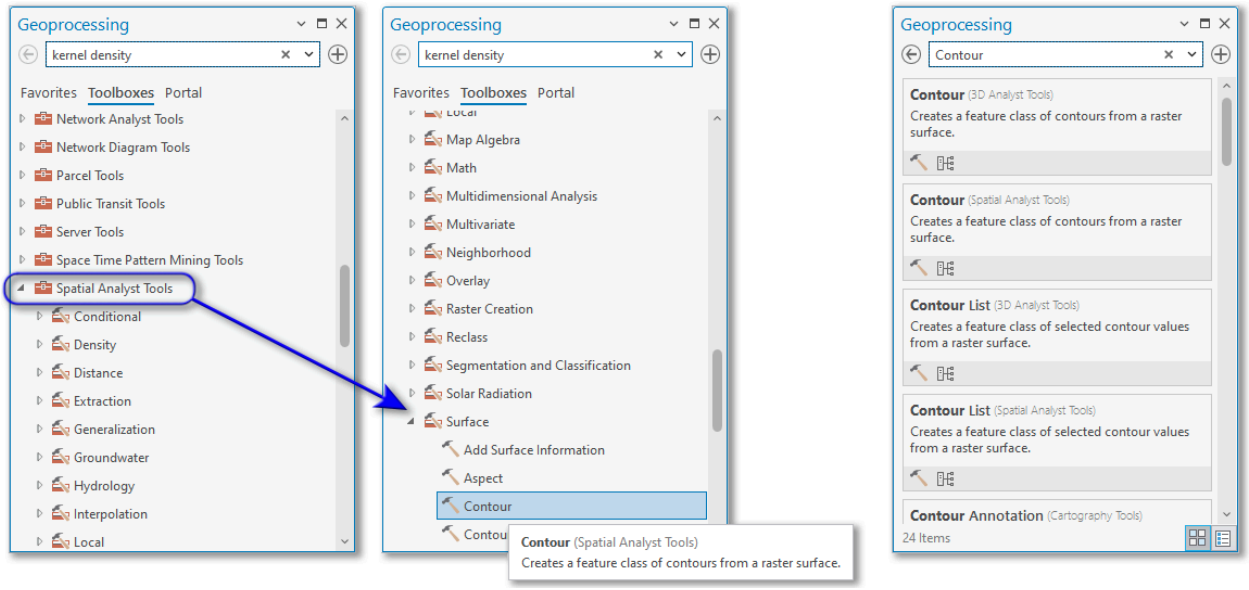


9) **Optionally**, set the layer to be partially transparent so you can see the landscape underneath.



Generate Contour Lines over your Density Surface:

10) Open the "Contour" tool (in the Geoprocessing Toolboxes --> Spatial Analyst Tools --> Surface --> Contour):



11) Fill out the "Contour" window as follows (and see illustration below):

a) "Input Raster" = **KPD_6_500m_All** (or whatever the name of your density raster is).

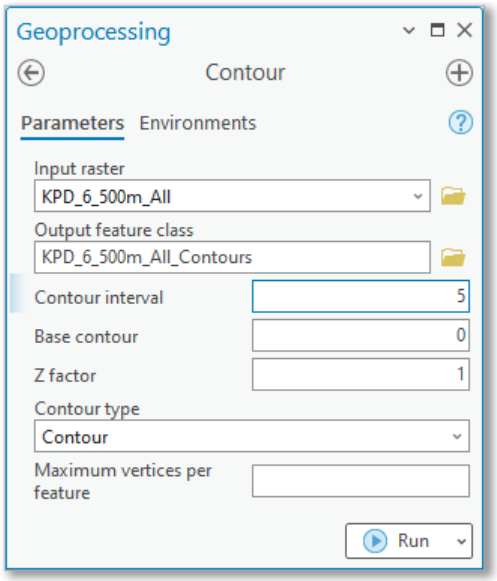
b) For "Output polyline features", specify a location and name for your new contour line polyline feature class. I recommend you save it to the file geodatabase "KPD_Data", which should be in your "Wildlife_Lab_GIS" folder. In this example, I am naming the new feature class **KPD_6_500m_All_Contours** so that I will know it is a **Contour** feature class derived from the **K**ernel **P**oint **D**ensity raster for Owl **6**, based on a **500m** kernel, using **All** points. You will generate several contour feature classes so make sure you know which one is which.

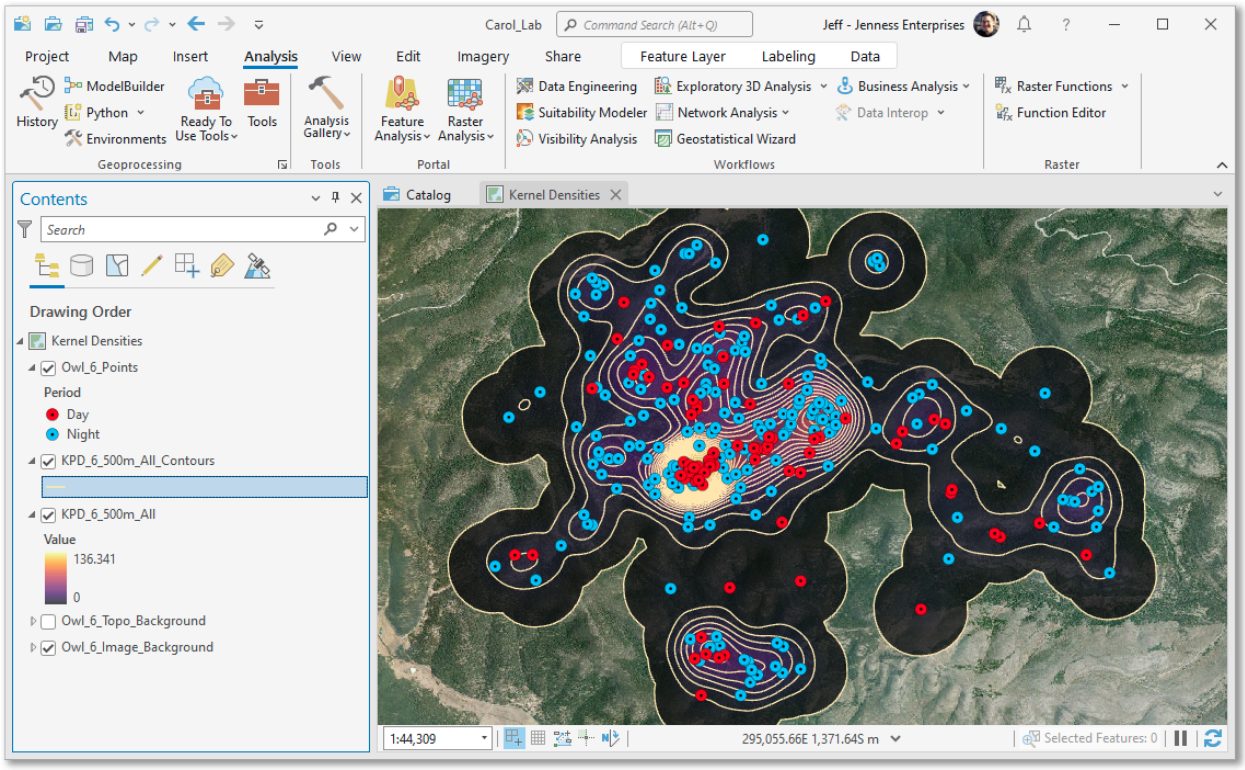
c) Decide on a Contour Interval. **Hint:** I recommend the following intervals for the various analyses:

i) For the **250m Kernel Density** for the points from **Owl 6**, use an interval of "10" (meaning a contour line for every 10-pt-per km^2 increase in density).

ii) For all the other **Kernel Densities** for the points from **Owl 6**, use an interval of "5".

iii) For all the **Kernel Densities** for the points from **Owl 83**, use an interval of "20".



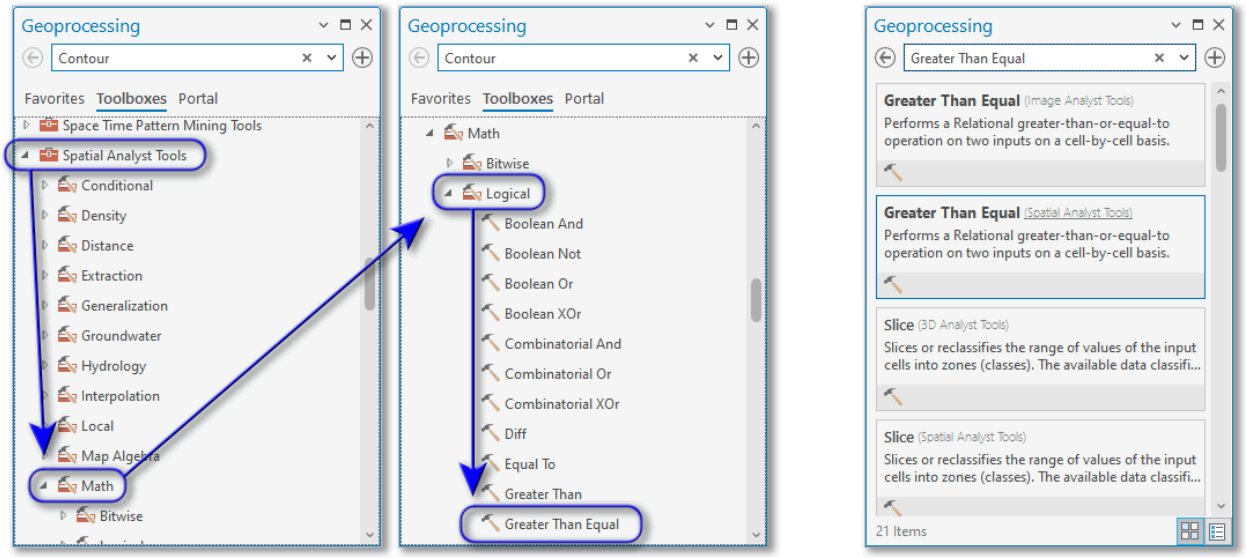


Decide on a Contour Level to Represent your Home Range:

This is a subjective step on your part and is completely based on your opinion. You want to decide on a contour level that will surround most or all of the points, or at least the highest density of points. Based on the contours you have generated, it is easy to see that a contour level of 0 points per km^2 (the outermost line) will contain all the points, but this might mark out more area than the owl needs. A contour level of 5 points per km^2 gets the great majority of points and reduces the necessary area significantly, so this example will show how to extract the region corresponding with a density level of 5 points per km^2.

Extract the areas where Density is greater than or equal to your contour level:

12) Open the "Greater Than Equal" tool (in the Geoprocessing Toolboxes --> Spatial Analyst Tools --> Math --> Logical --> Greater Than Equal).



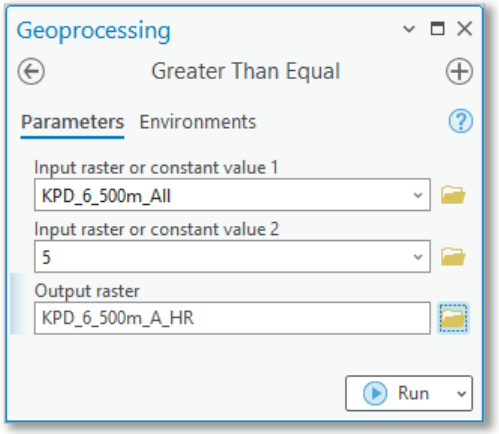
13) This is a simple tool. All it does is produce a raster of 1's and 0's, where the 1 values represent all those places on your density raster that are ≥ to some value. We will use it to identify all areas ≥ 5 points per km^2.

14) Fill out the tool window as follows (and see illustration below):

a) "Input Raster or constant value 1" = **KPD_6_500m_All** (or whatever you have named your Density raster).

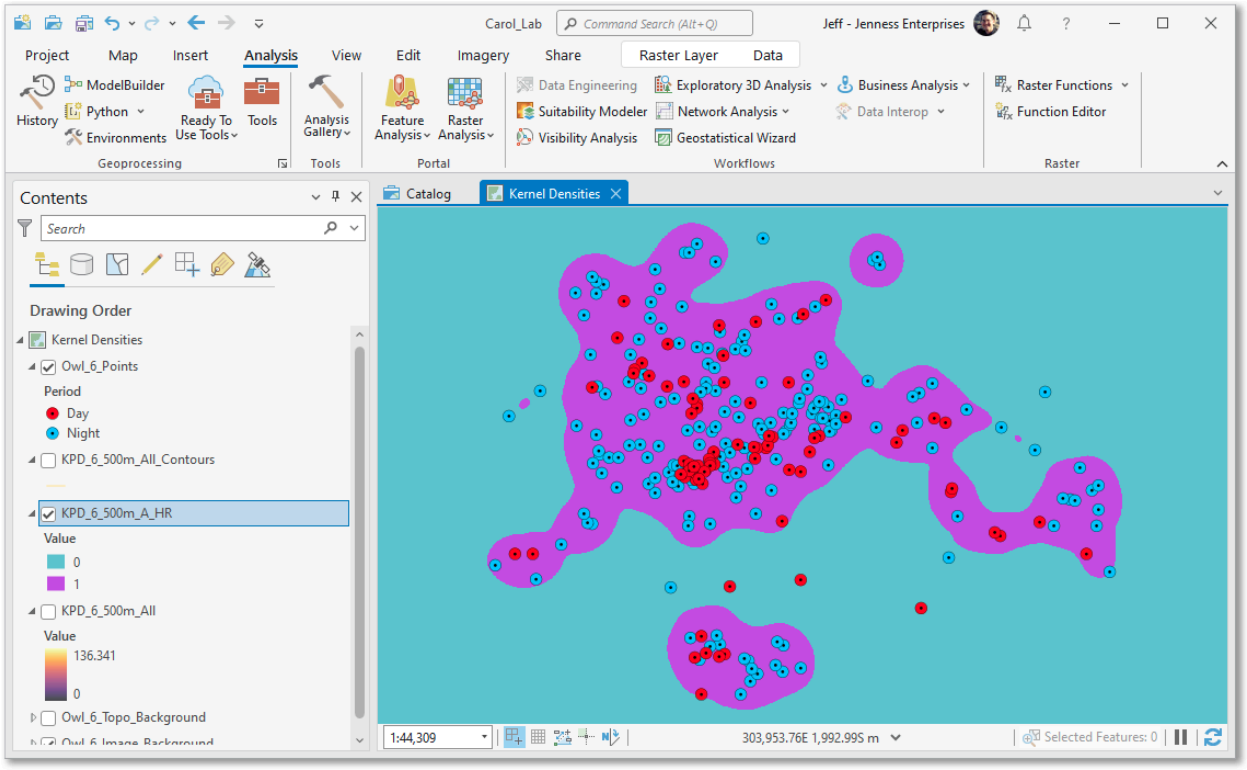
b) "Input Raster or constant value 2" = **5** (meaning we want to find all areas with ≥ 5 points per km^2.

c) "Output Raster": Pick a name and place you will remember. As before, I recommend you save it to the file geodatabase "KPD_Data". In this example, I name the raster **KPD_6_500m_A_HR**, meaning it is the **H**ome **R**ange raster from the **KPD_6_500m_All** density raster.



15) Hit OK and ArcGIS will produce your new raster. Notice that the new raster has "0" values for all regions where the original density surface was < 5 points per km^2, and "1" values for all regions

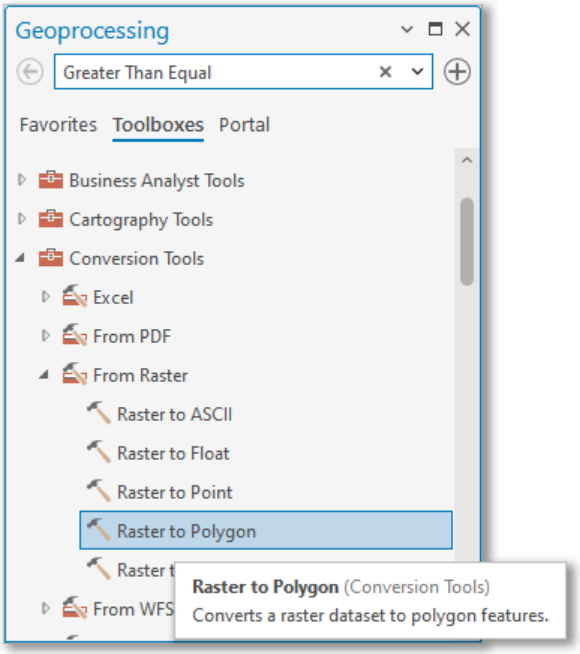
where the original density surface was ≥ 5 points per km^2. Notice also that it the "1" region does not catch all the original points. Presumably our logic that led us to pick a threshold value of 5 points per km^2 convinced us that these locations were so rarely used that we didn't consider them to be truly part of the home range of the owl.

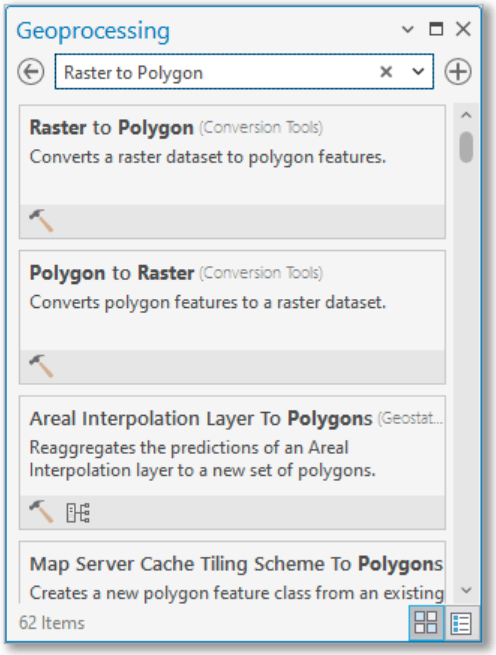


Convert your extracted areas to a Polygon feature class and calculate the area:

Your home range area is currently in Raster format, but we want it in Vector format. Therefore we will convert it to a polygon feature class.

16) Open the "Raster to Polygon" tool (in the Geoprocessing Toolboxes --> Conversion Tools --> From Raster --> Raster to Polygon).





17) Fill out the tool parameters as follows (and see illustration below):

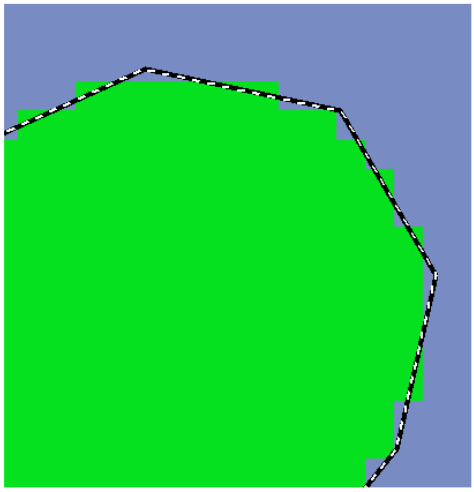
a) "Input Raster" = **KPD_6_500m_A_HR** (or whatever you named your raster showing regions ≥ 5 points per km^2).

b) "Field" = **Value** (This means the attribute field from **KPD_6_500m_A_HR**. By choosing the field **Value**, we will make sure ArcGIS transfers the "1" and "0" values to our new polygon feature class.

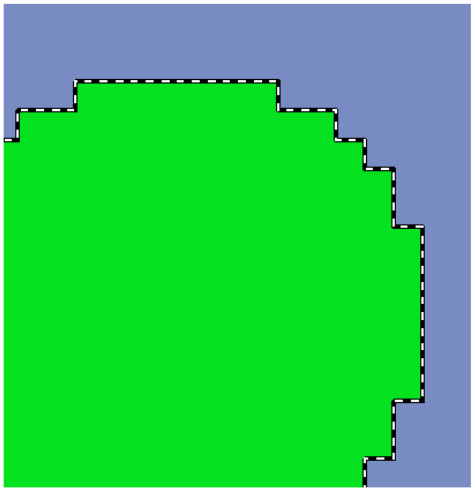
c) "Output polygon features": As always, specify a name and location. I recommend saving it to your file geodatabase "KPD_Data" so that everything will be organized and in one place. In this example, I am naming the new feature class **HR_Poly_6_500m_All** to tell me that it is a **H**ome **R**ange **Poly**gon created from the **500m** KDP surface generated from **All** the locations for Owl **6**.

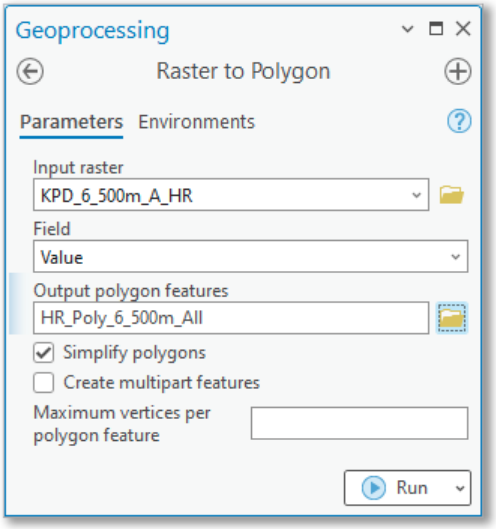
d) "Simplify polygons" = **True**. This actually doesn't matter that much for our purposes. For your information, though, remember that a raster is composed of square pixels. If you do **not** simplify a polygon, then converting a raster to a polygon will result in a polygon that follows the pixel edges exactly and resemble a stair-step pattern (see below on right). If you **do** simplify a polygon, then the polygon will trim off the stair-step corners.

Simplify Polygon = "True"

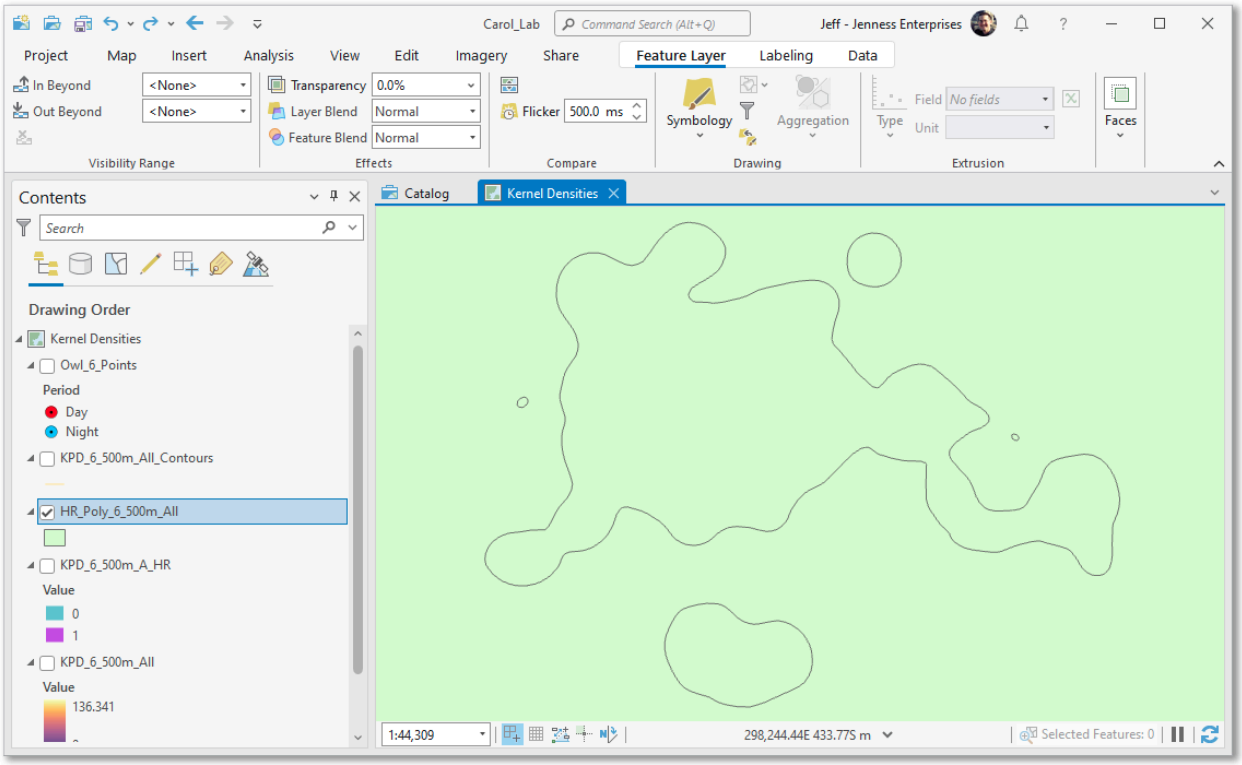


Simplify Polygon = "False"



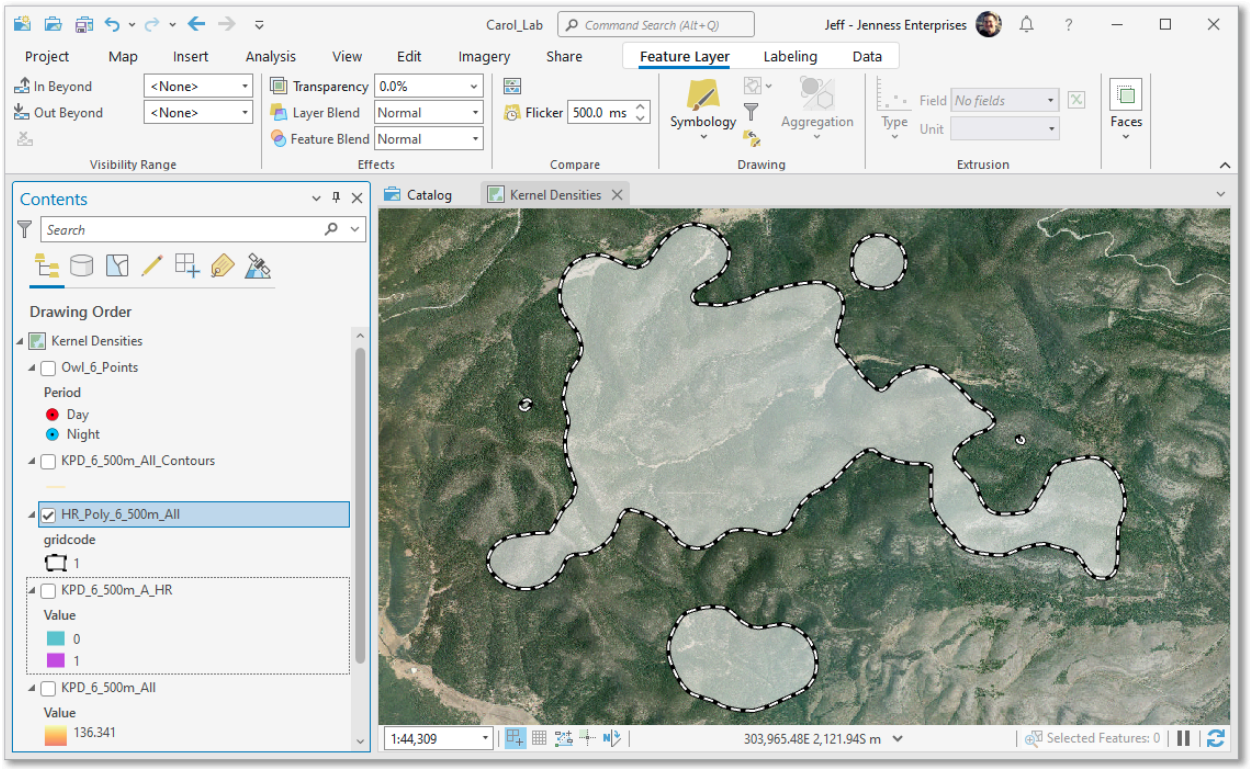


18) When the tool finishes, you will have a polygon feature class with polygons for both the "0" and the "1" values.



19) You may want to symbolize them so that you can see the difference. In this example, I will remove the "0" areas (where density was < 5 pts per km2, and thus outside my home range area) entirely. I will symbolize the home range area as a semi-transparent white polygon.

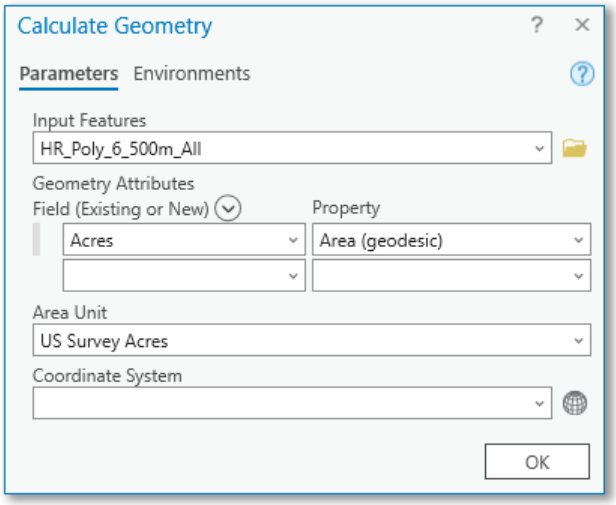
    a) **Note:** The "1" and "0" values are in an attribute field named "Grid_Code". When converting rasters to polygons, ArcGIS always creates an attribute field named "Grid_Code" to put the raster values in.



20) And this is what I would now call a home range polygon for Owl 6 (or at least a first draft! In real life we might modify it a bit, possible deleting or connecting the outer islands, or perhaps adding in known good habitat).

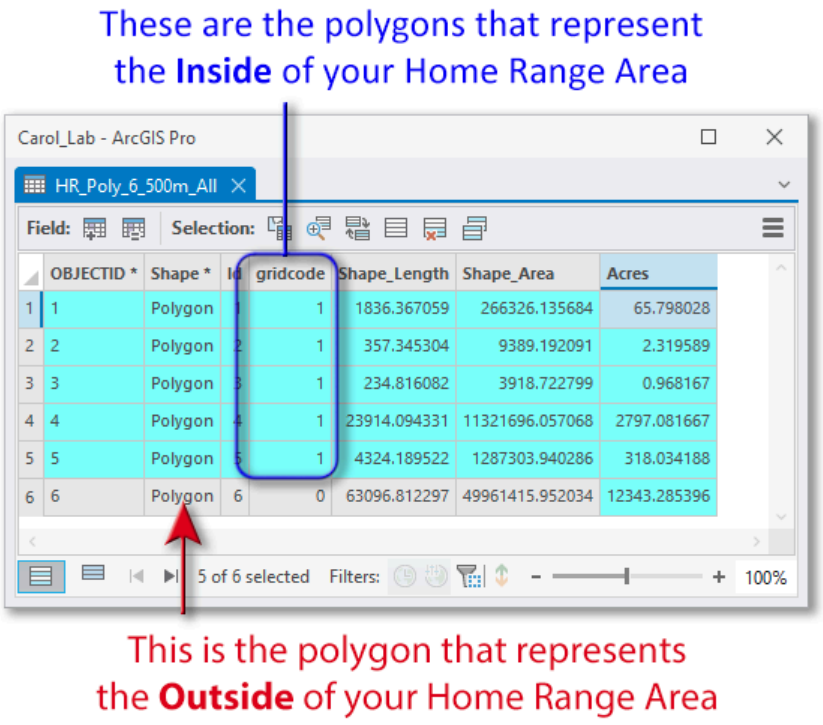
Calculate the Acreage of your new Home Range polygon(s):

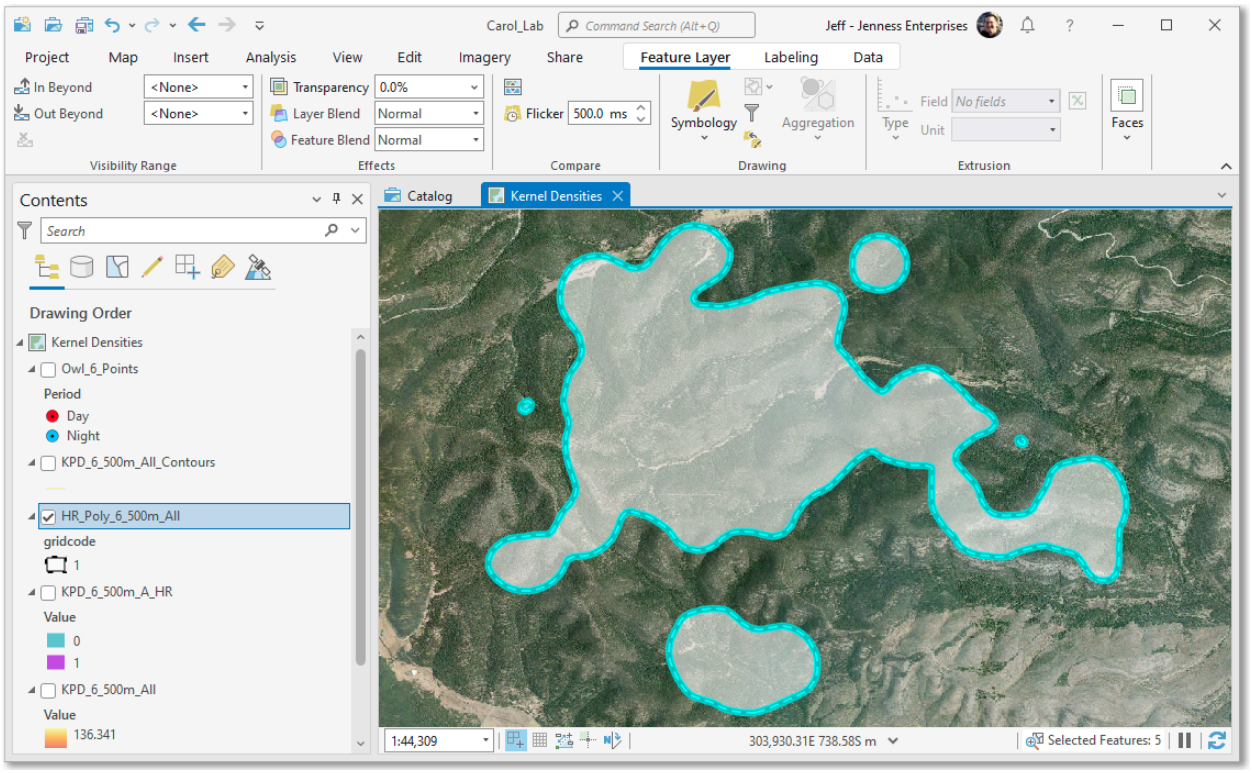
21) If you do not remember how to do this, please refer back to the instructions on calculating acreages of MCP polygons back on p. . Make sure you calculate the geodesic area, and in units of US Survey Acres!



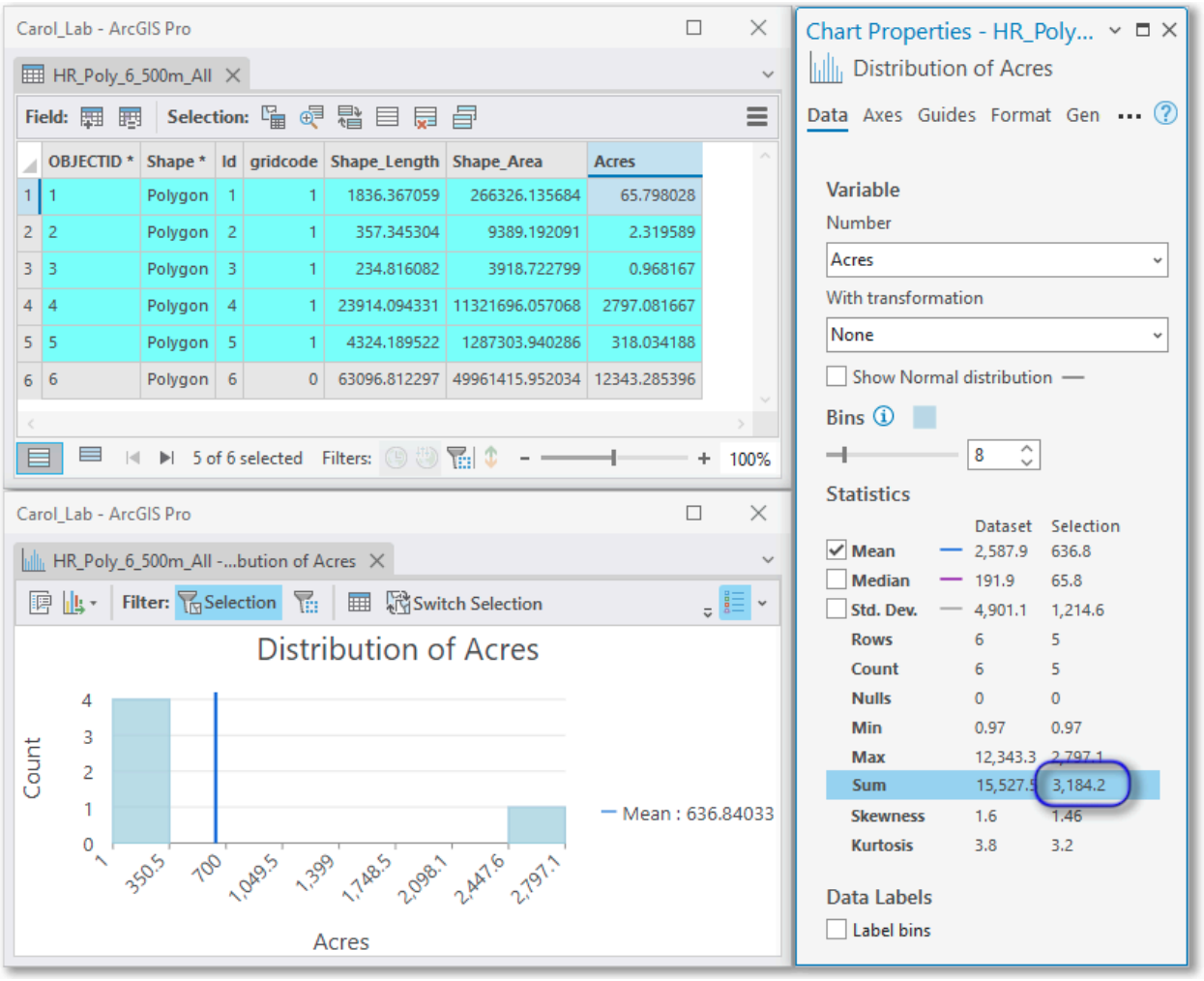
22) If you have more than one polygon representing the home range (as in the illustration above; there are actually 5 islands that have density values ≥ 5 pts per km^2), then you will need to add up the acreages of all the home range islands.

a) **Note:** Remember that your new polygon feature class contains polygons for both inside and outside the Home Range region! You will probably calculate the acreage values for both regions, but remember that the Home Range interior has a "Grid_Code" value of 1! When you summarize your acreage values, you will only be concerned with the actual Home Range area, not the area outside the home range. Ignore the polygons that have a "Grid_Code" value of 0.





b) Remember that to calculate the sum of all the home range polygons, you must first select them (as illustrated above), then right-click on your "Acres" field, then choose **Visualize Statistics**. The statistics will be calculated from only the selected records. Your "Sum" statistic is therefore the total area of all 5 home range island polygons.



23) In this example, using a threshold density of 5 points per km^2, the size of the Home Range Polygon is 3,184.2 acres.

Rinse and Repeat:

Next calculate the acreage of your **Core Area** polygon. Remember that the Core Area is based on the Kernel Density calculated on all the polygons, so you can (and should) use the same kernel density surface you already calculated [back on p. –]. You'll just use a different (and higher) density threshold value. The density threshold value you use is up to you. Take a look back at your contour lines and pick a line that encloses an area you feel would capture the area **most used** by the owl. You will then:

1. Run the "Greater Than Equal" tool to classify that portion of the Kernel Density raster that lies above your **Core Area** threshold level, then
2. Run the "Raster to Polygon" tool to convert your True/False raster into polygons, then
3. Calculate the area in US Survey Acres using Geodesic areas, then
4. Write your value back into the table above.

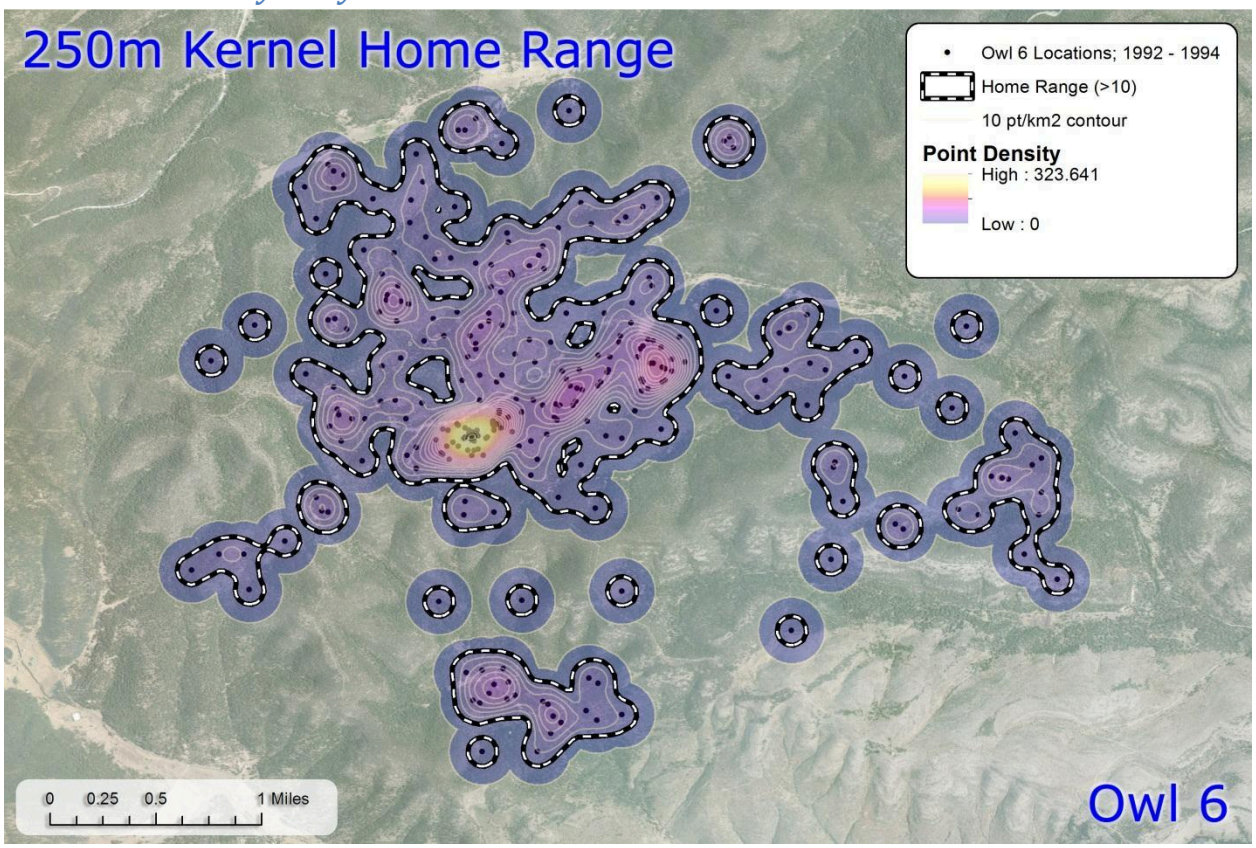
Then, calculate the acreage of either the **Day**, **Night**, **Breeding Season** and/or **Non-Breeding Season** locations. For these, you'll need to **select those points first**, then:

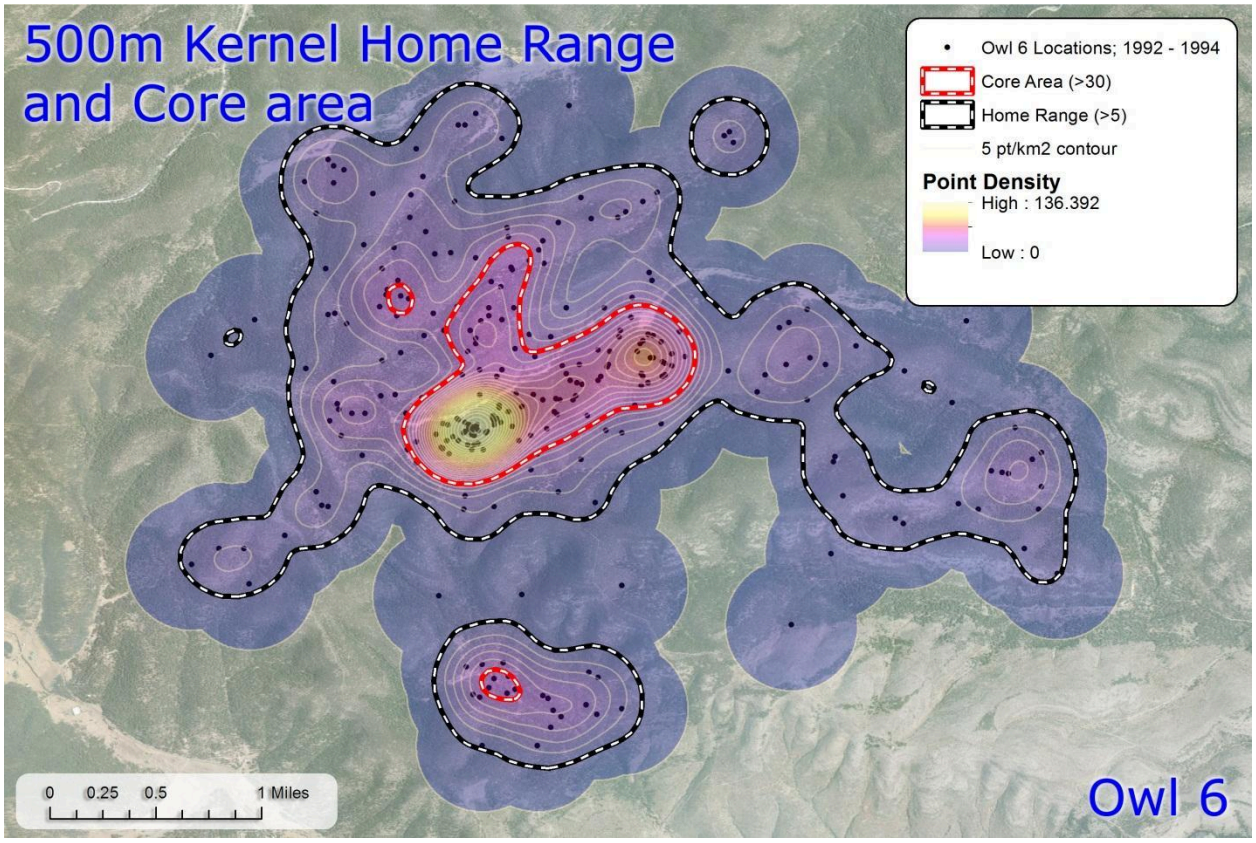
1. Generate the Kernel Density surface (remember to set your Processing Extent environmental parameter!), then
2. Generate contour lines to help you visualize the densities, then
3. Pick a contour level you feel captures that activity, then
4. Run the "Greater Than Equal" tool to classify that portion of the Kernel Density raster that lies above your threshold level, then
5. Run the "Raster to Polygon" tool to convert your True/False raster into polygons, then
6. Calculate the area in US Survey Acres using Geodesic areas, then
7. Write your value back into the table above.

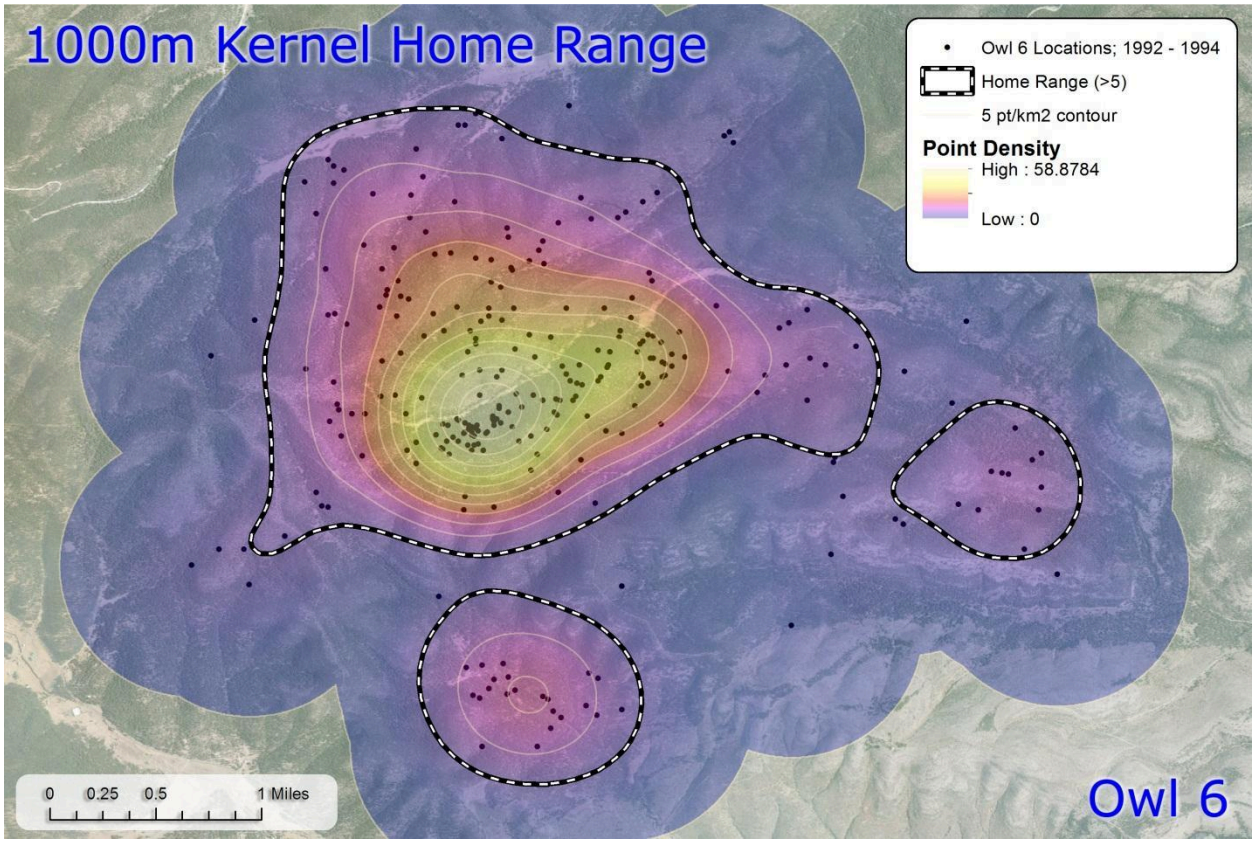
What your Kernel Density Surfaces and Polygons should look like:

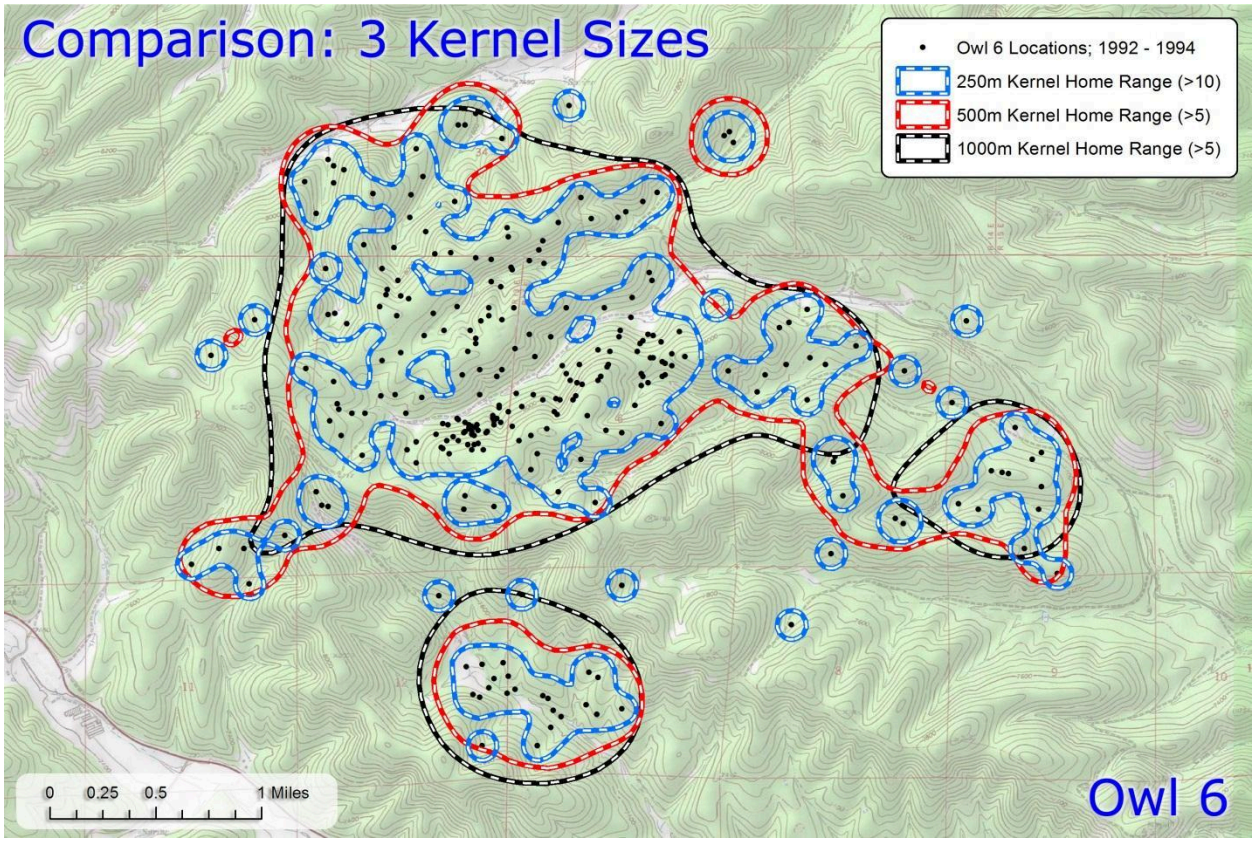
Upon completion, your Kernel Density surfaces, Home Range Polygons and Core Area Polygons for Owls 6 and 83 should look like the illustrations in the following pages (although you may have symbolized them differently). Remember that the final home range or core area polygon might have a different size if you used a different threshold. This is fine, as long as you used some logic to decide on your threshold.

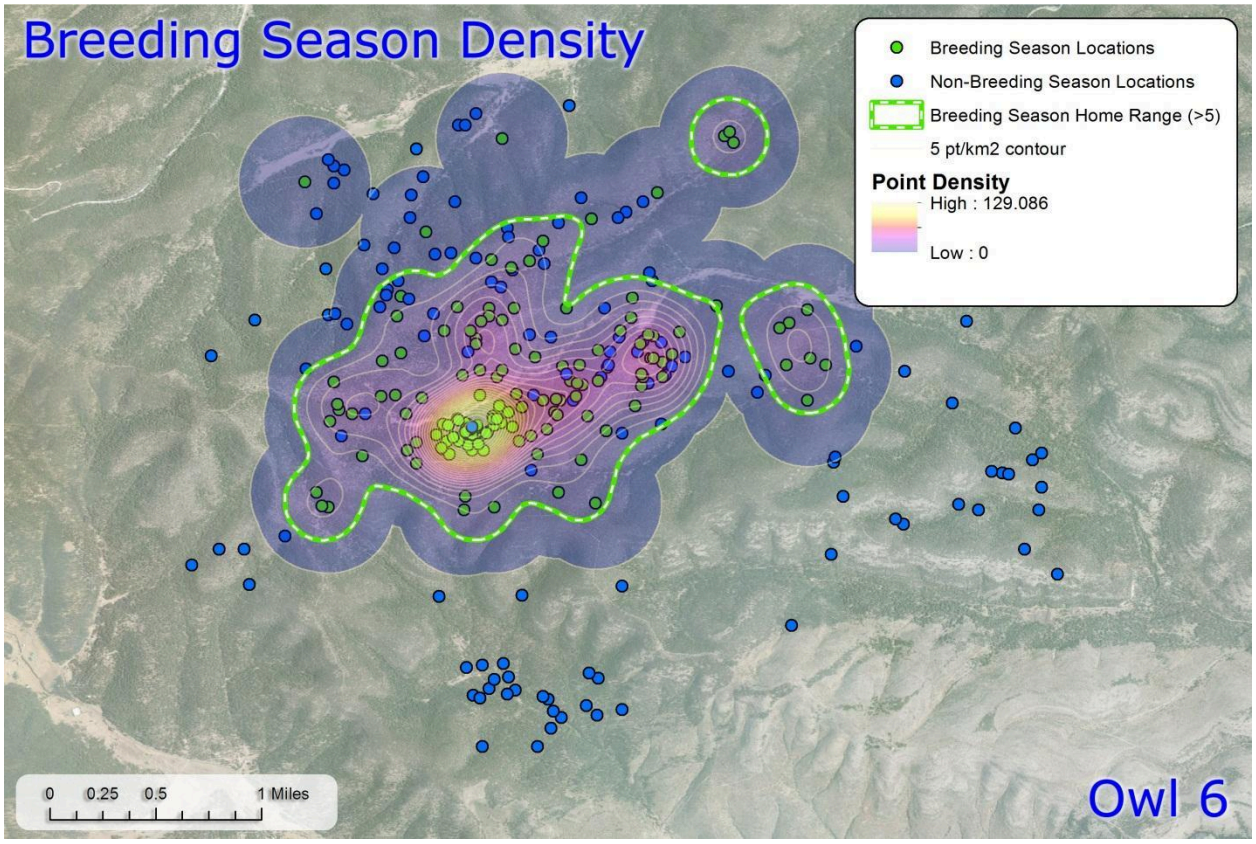
Owl 6 Kernel Density Analysis

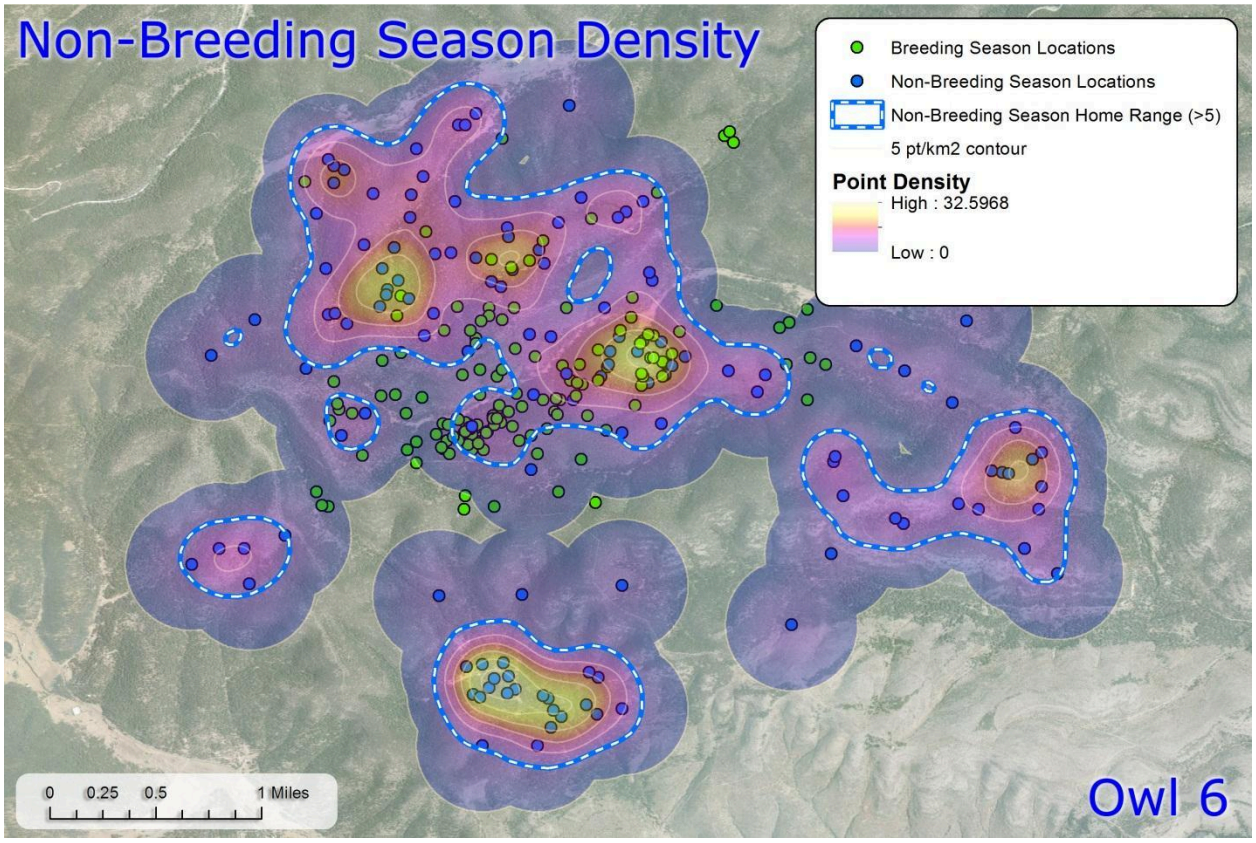


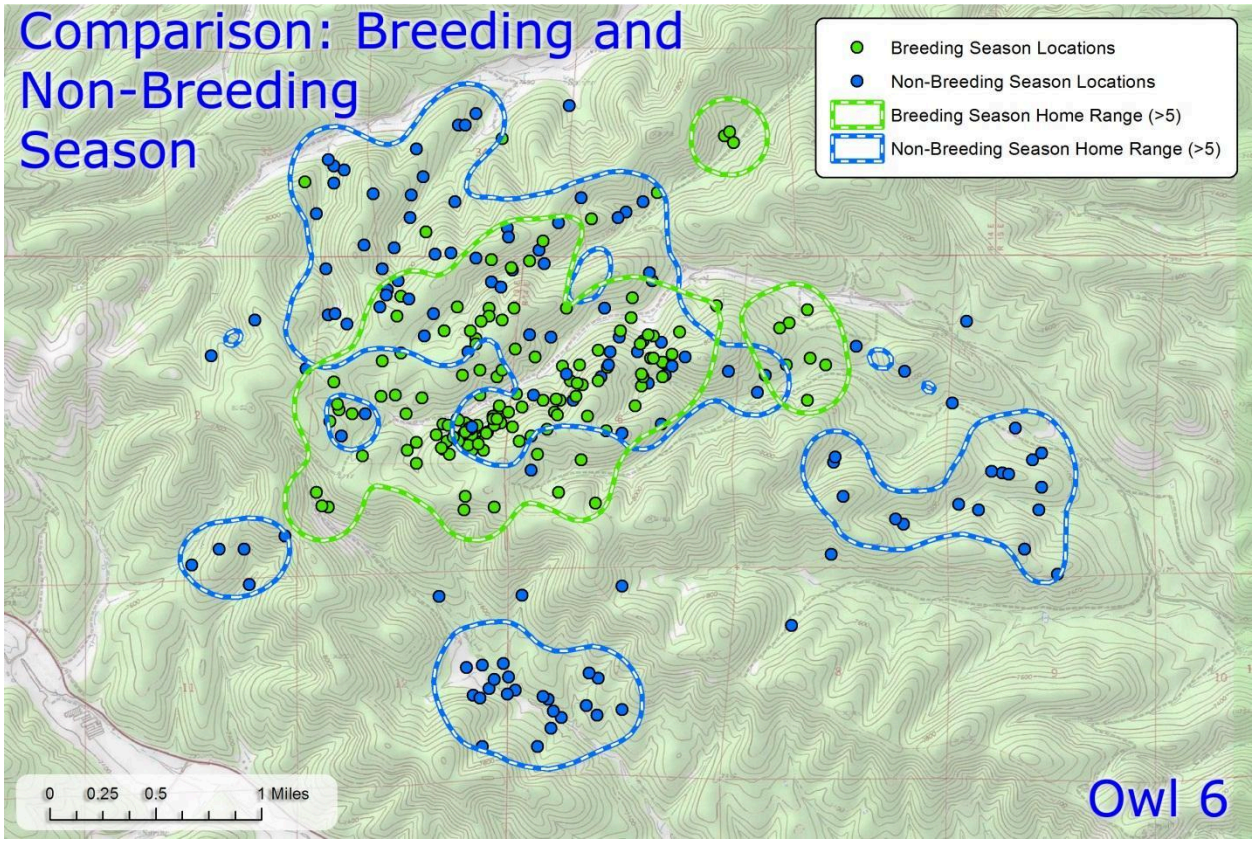

500m Kernel Home Range
and Core area
Owl 6 Locations; 1992 - 1994
Core Area (>30)
Home Range (>5)
5 pt/km2 contour
Point Density
High : 136.392
Low : 0
0 0.25 0.5 1 Miles
Owl 6

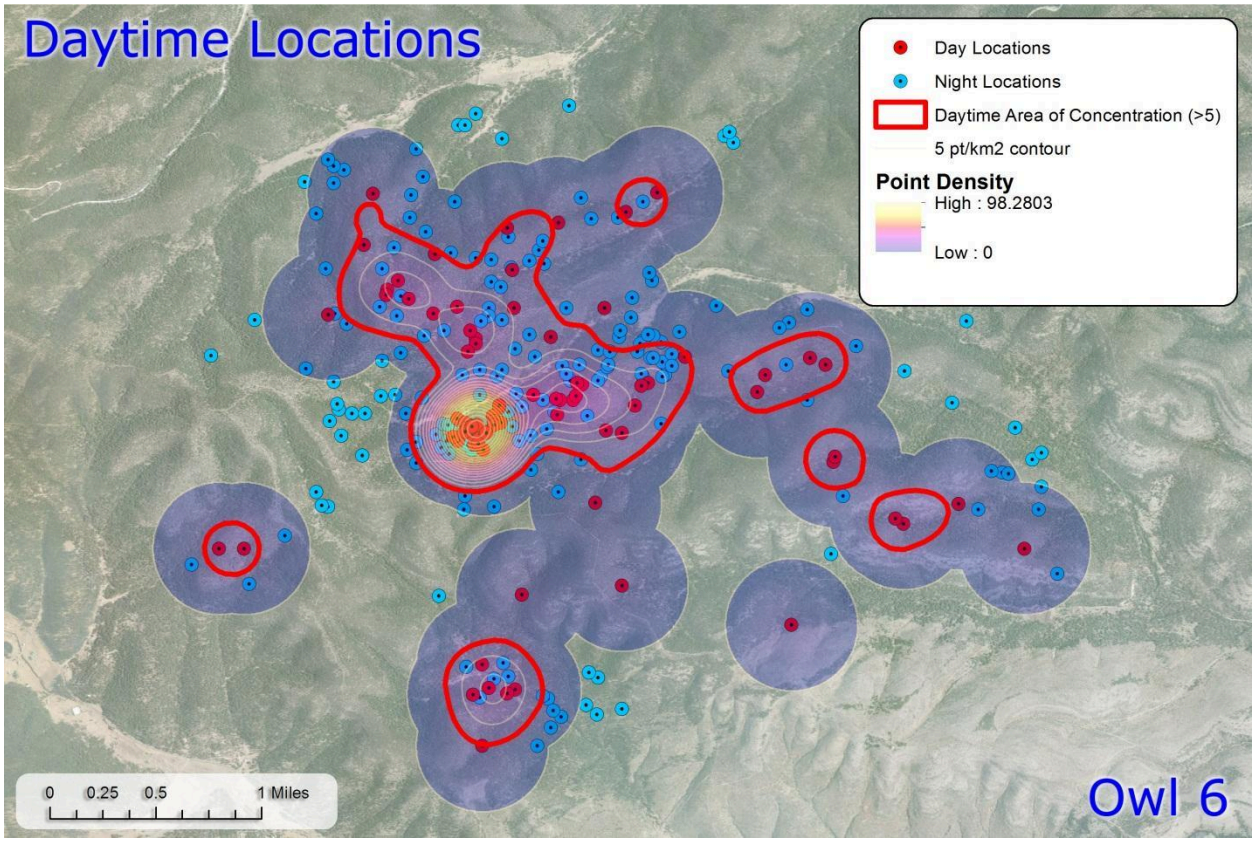

1000m Kernel Home Range
Owl 6 Locations; 1992 - 1994
Home Range (>5)
5 pt/km2 contour
Point Density
High : 58.8784
Low : 0
0 0.25 0.5 1 Miles
Owl 6

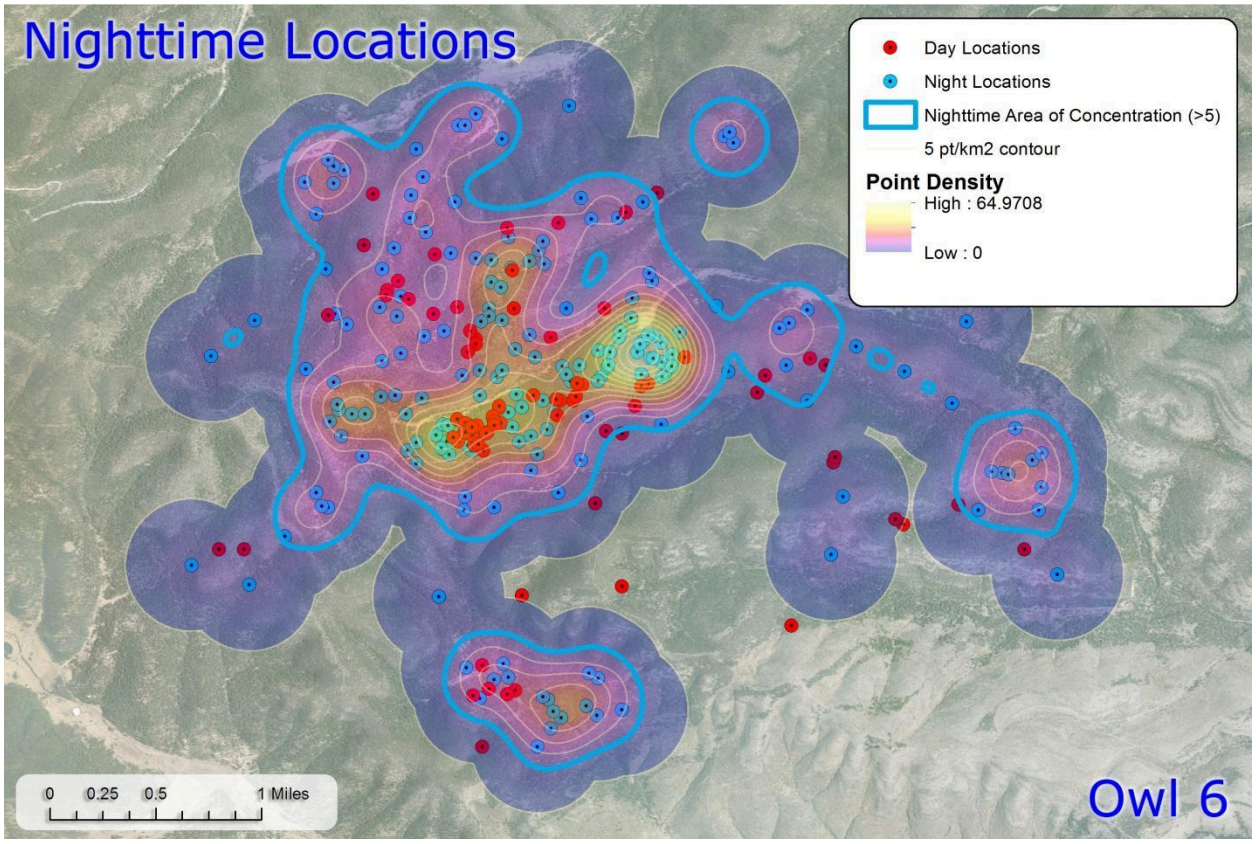

Comparison: 3 Kernel Sizes
Owl 6 Locations; 1992 - 1994
250m Kernel Home Range (>10)
500m Kernel Home Range (>5)
1000m Kernel Home Range (>5)
0 0.25 0.5 1 Miles
Owl 6

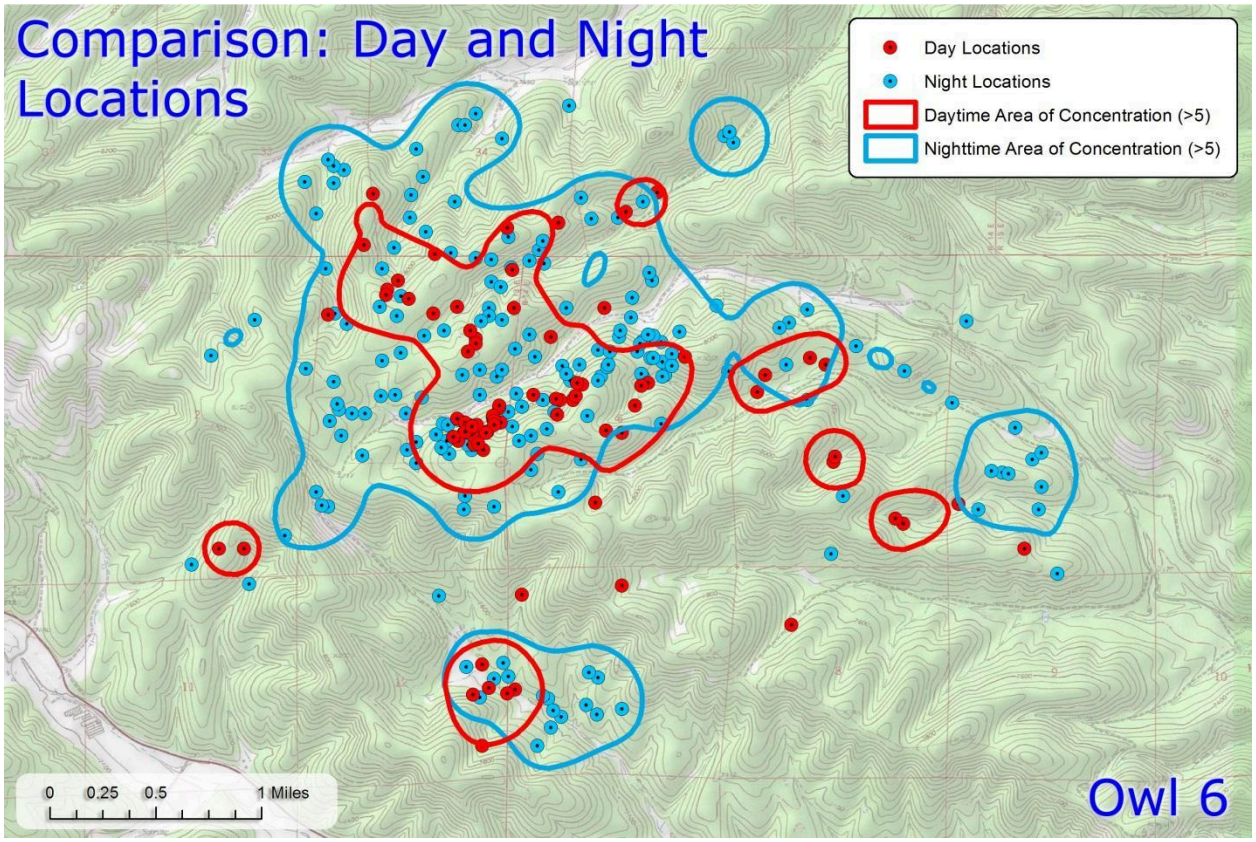

Breeding Season Density
Breeding Season Locations
Non-Breeding Season Locations
Breeding Season Home Range (>5)
5 pt/km2 contour
Point Density
High : 129.086
Low : 0
0 0.25 0.5 1 Miles
Owl 6


Non-Breeding Season Density
Breeding Season Locations
Non-Breeding Season Locations
Non-Breeding Season Home Range (>5)
5 pt/km2 contour
Point Density
High : 32.5968
Low : 0
0 0.25 0.5 1 Miles
Owl 6

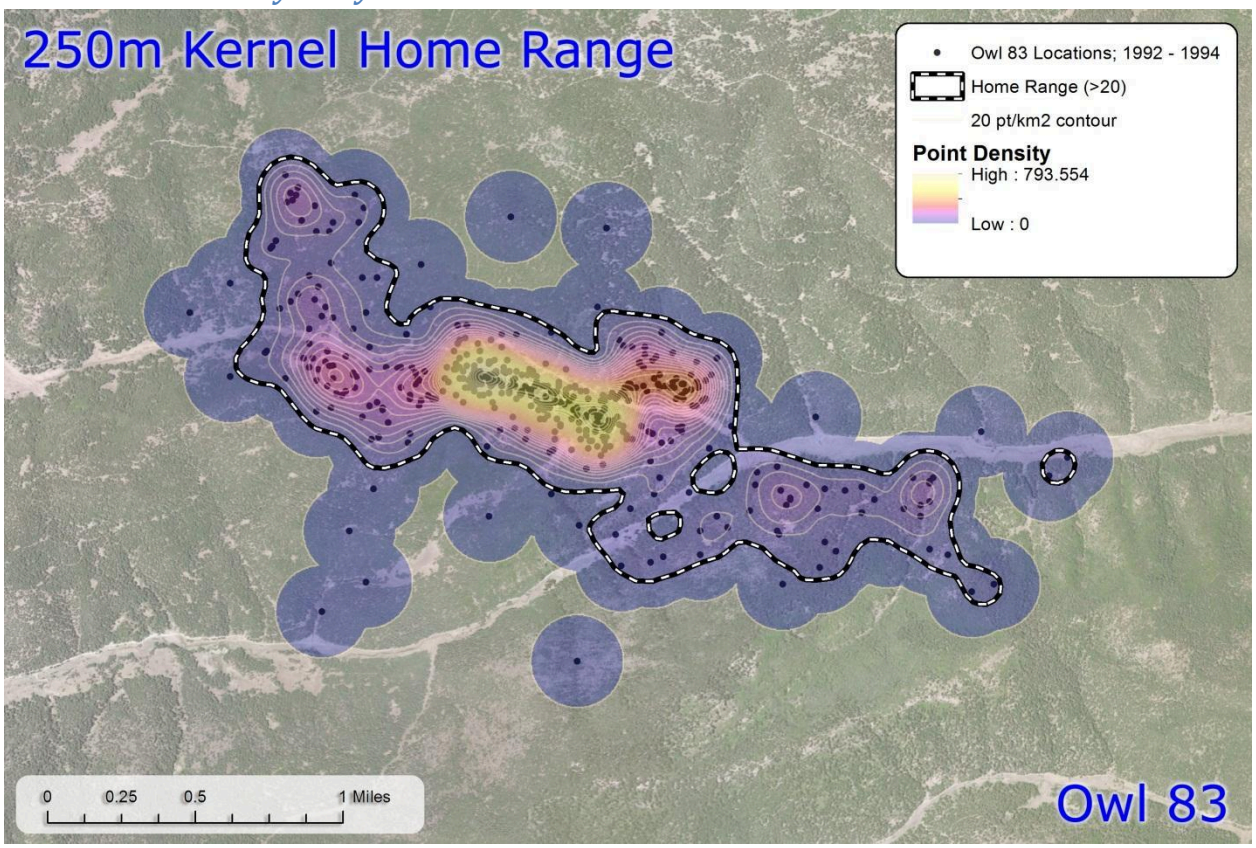

Comparison: Breeding and Non-Breeding Season
Breeding Season Locations
Non-Breeding Season Locations
Breeding Season Home Range (>5)
Non-Breeding Season Home Range (>5)
0 0.25 0.5 1 Miles
Owl 6

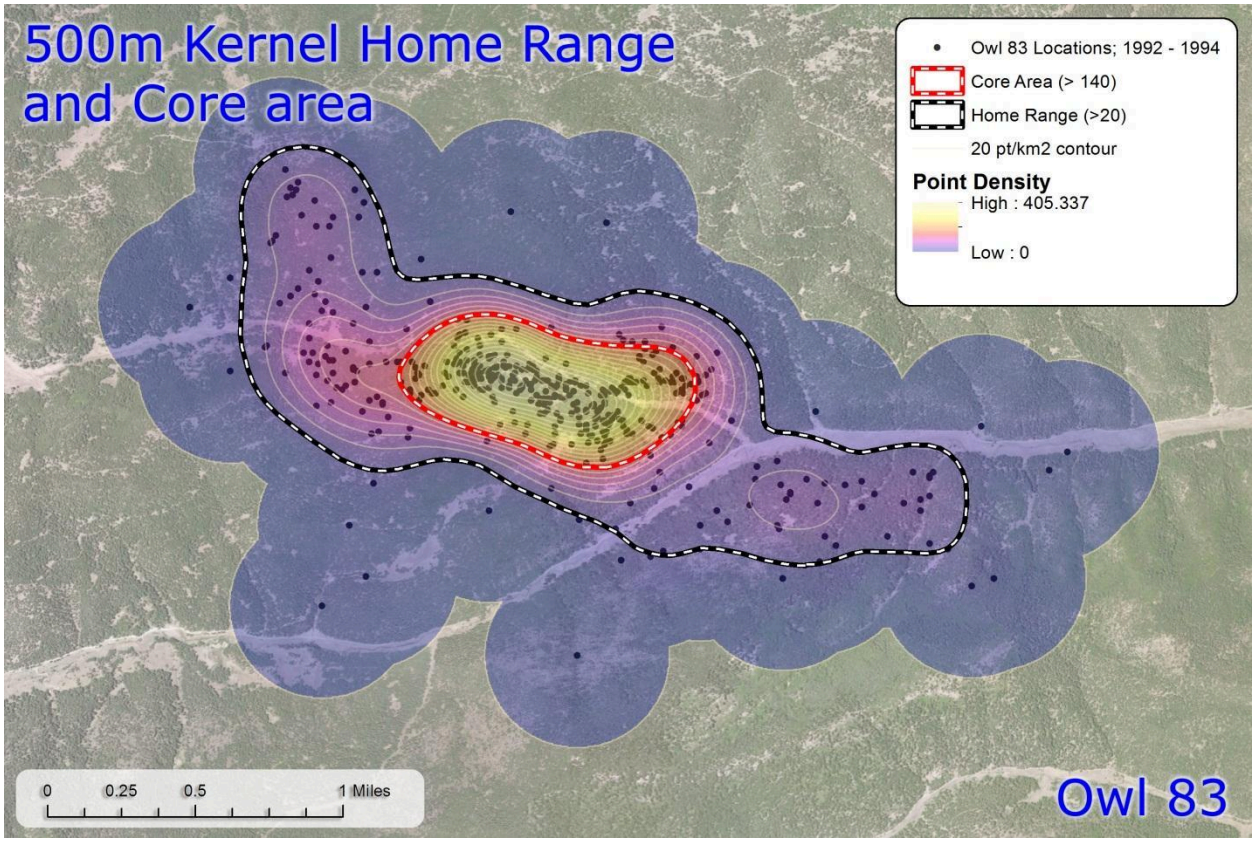

Daytime Locations
Day Locations
Night Locations
Daytime Area of Concentration (>5)
5 pt/km2 contour
Point Density
High : 98.2803
Low : 0
0 0.25 0.5 1 Miles
Owl 6

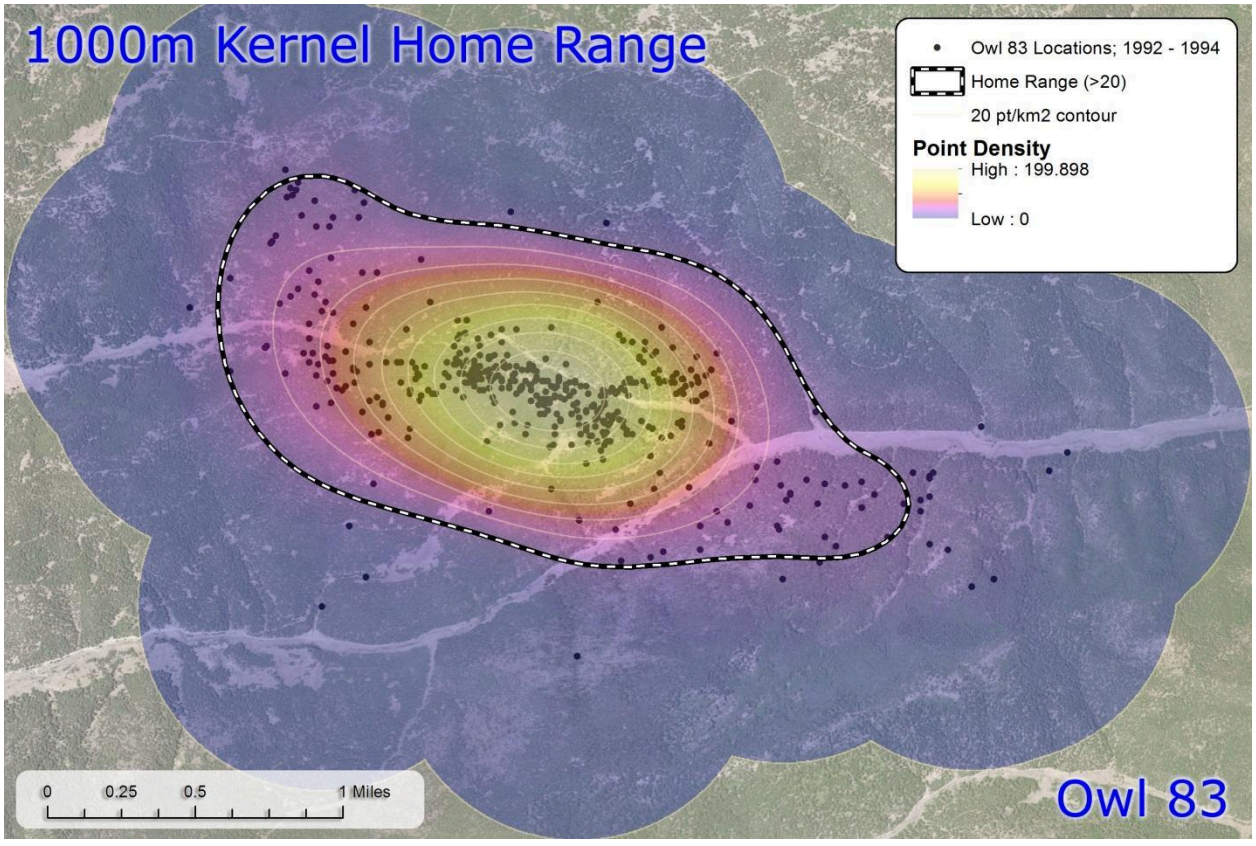

Nighttime Locations
Day Locations
Night Locations
Nighttime Area of Concentration (>5)
5 pt/km2 contour
Point Density
High : 64.9708
Low : 0
0 0.25 0.5 1 Miles
Owl 6

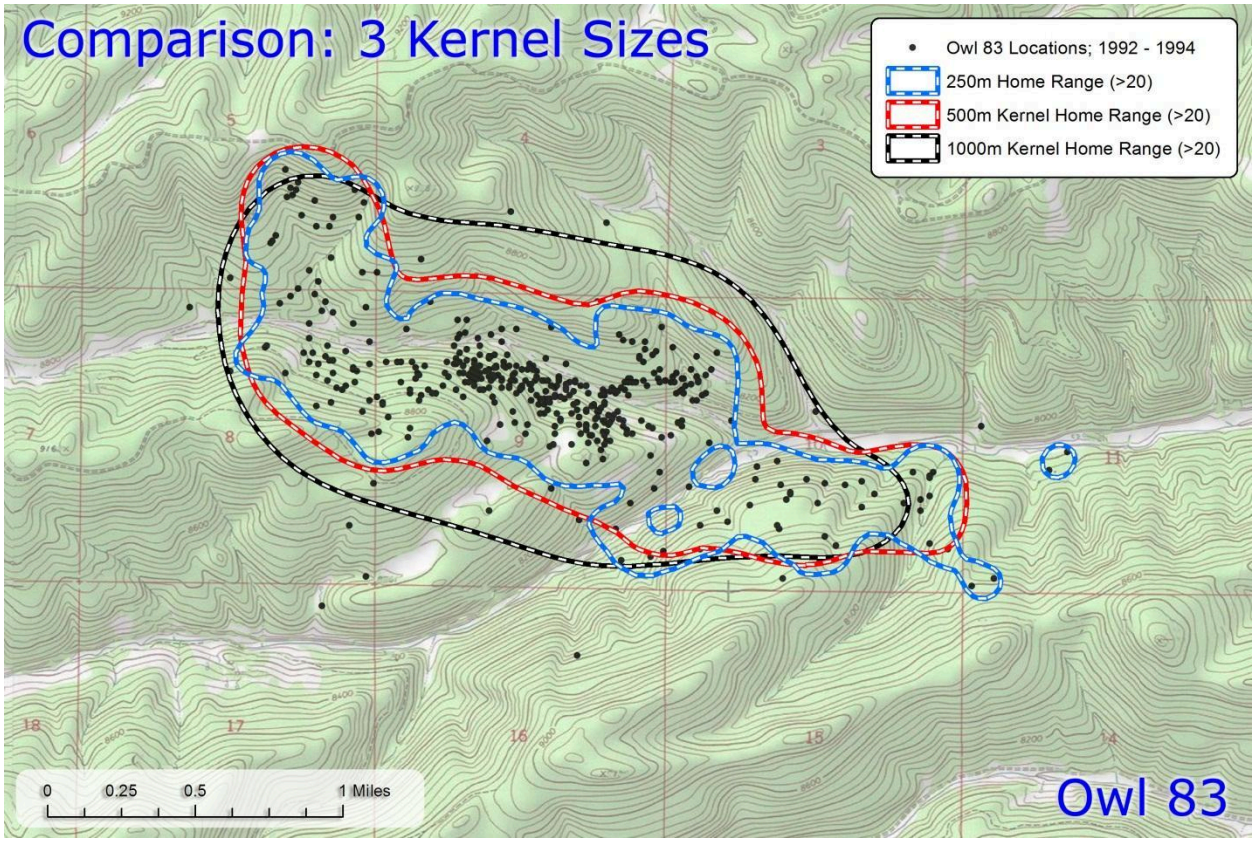

Comparison: Day and Night Locations
Day Locations
Night Locations
Daytime Area of Concentration (>5)
Nighttime Area of Concentration (>5)
0 0.25 0.5 1 Miles
Owl 6

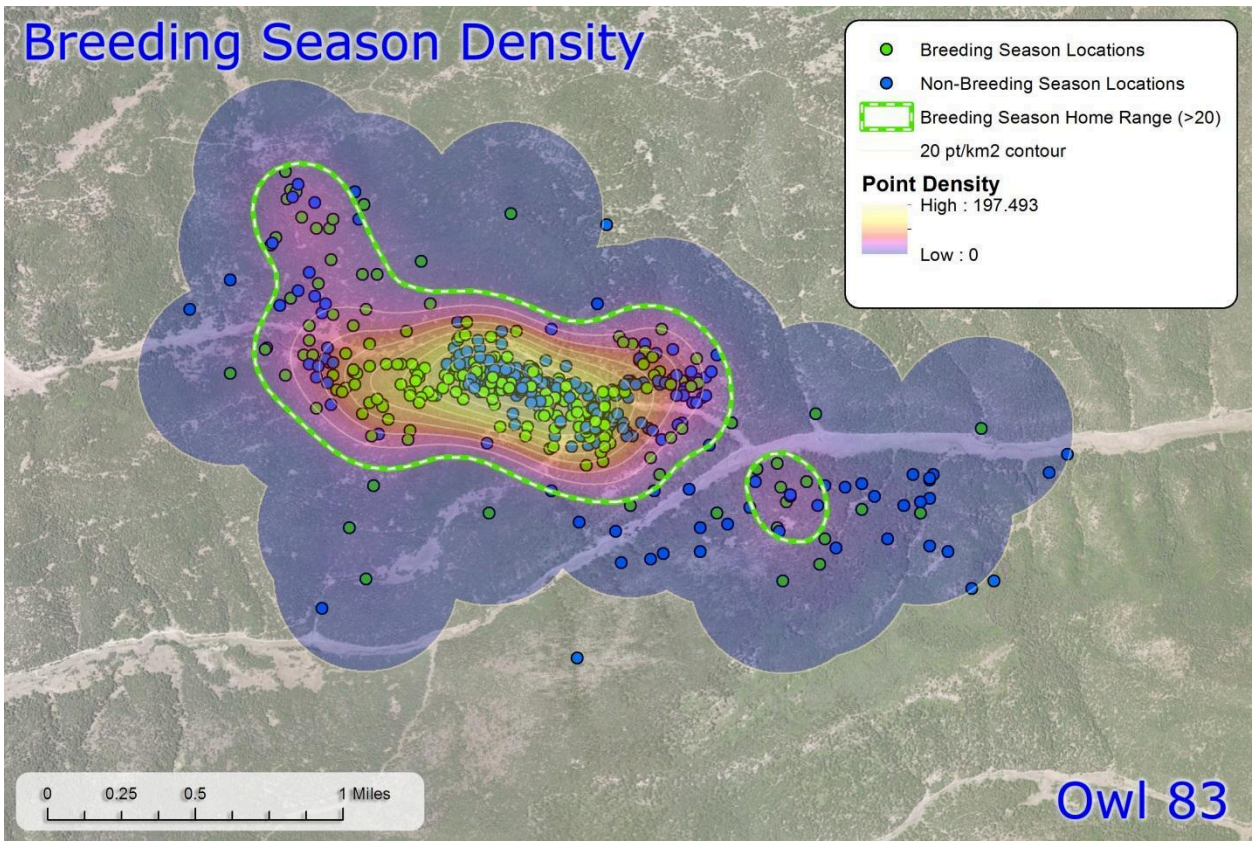
Owl 83 Kernel Density Analysis

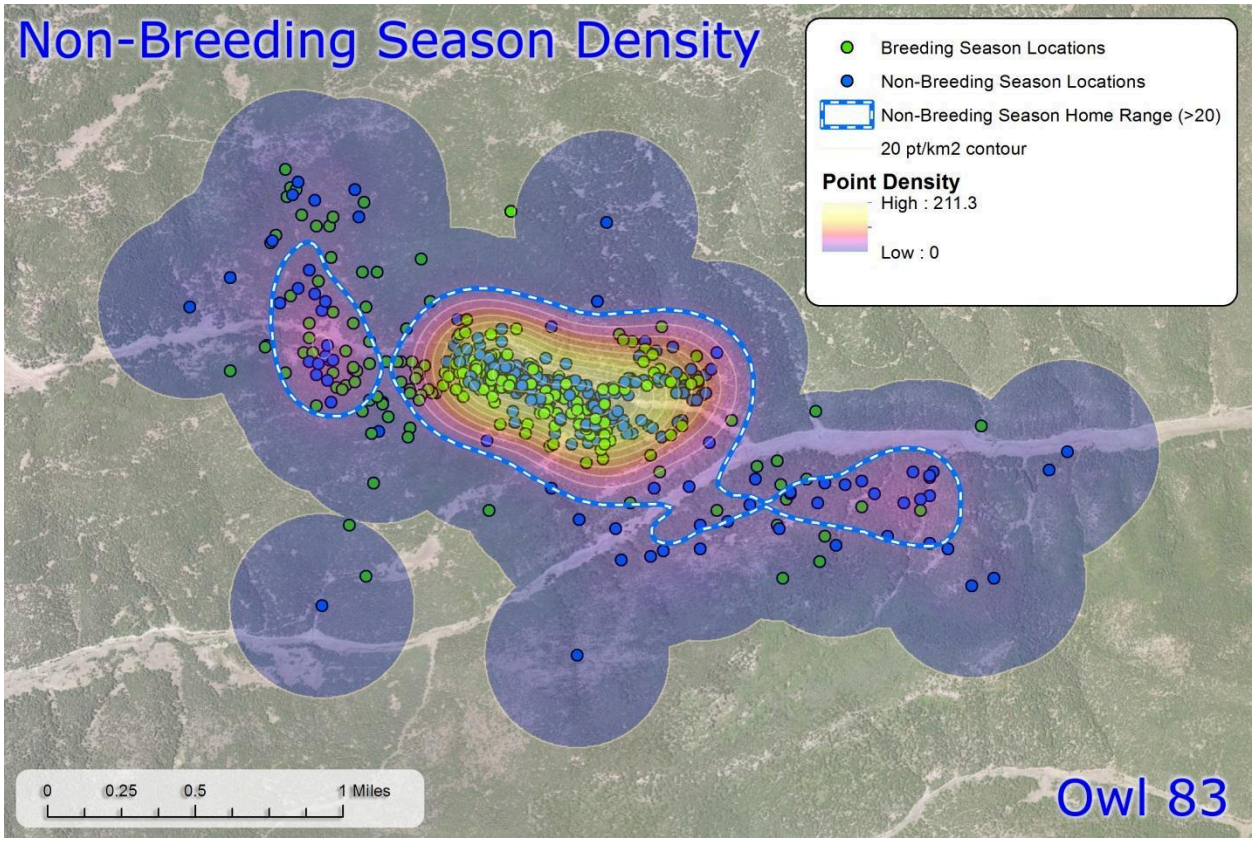


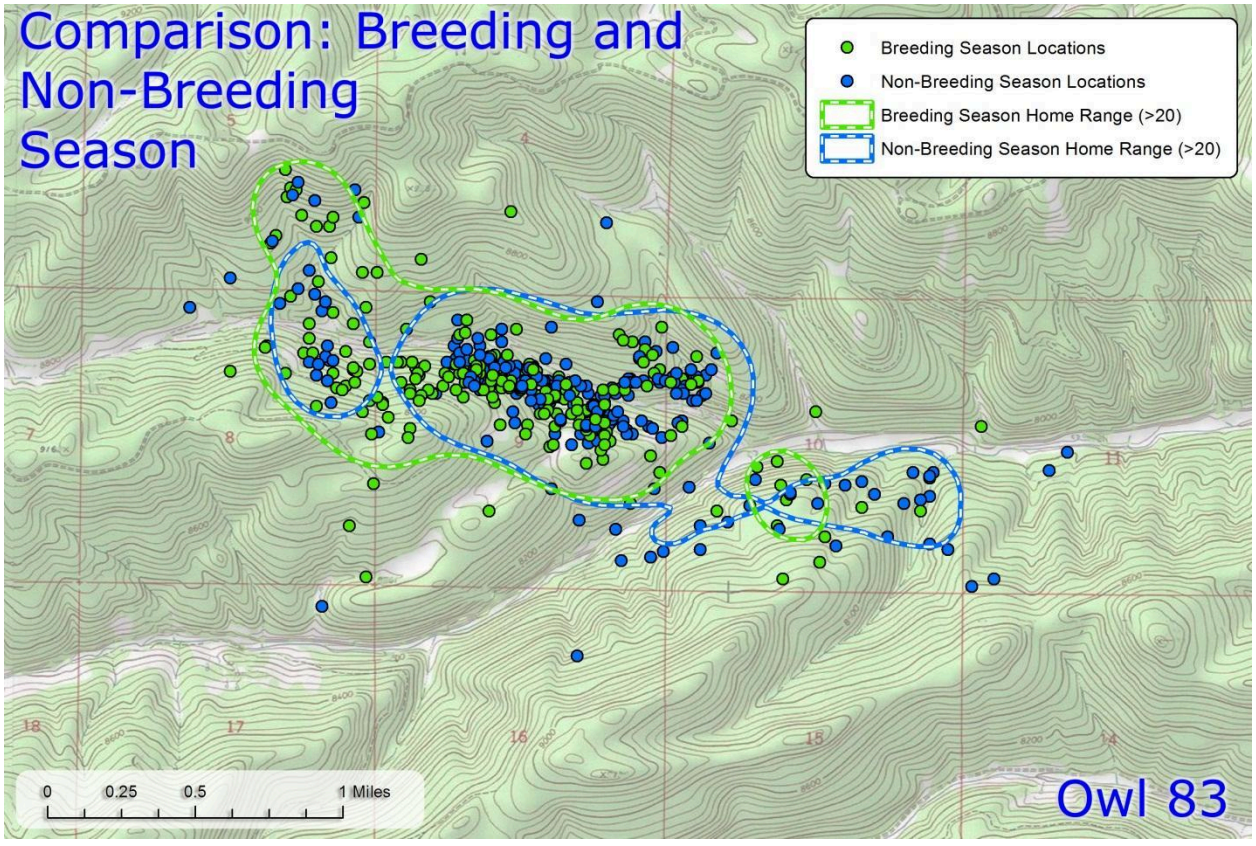

500m Kernel Home Range
and Core area
Owl 83 Locations; 1992 - 1994
Core Area (> 140)
Home Range (>20)
20 pt/km2 contour
Point Density
High : 405.337
Low : 0
0 0.25 0.5 1 Miles
Owl 83

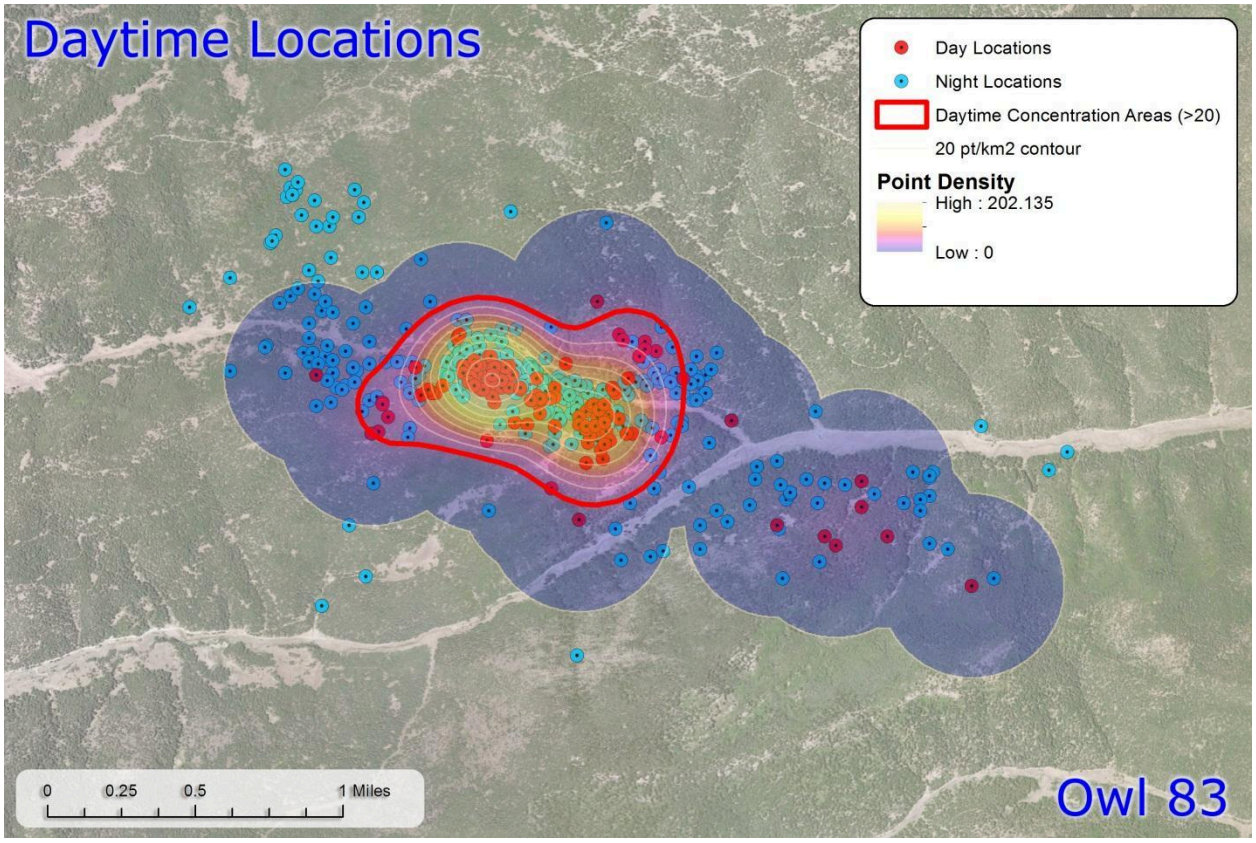

1000m Kernel Home Range
Owl 83 Locations; 1992 - 1994
Home Range (>20)
20 pt/km2 contour
Point Density
High : 199.898
Low : 0
0 0.25 0.5 1 Miles
Owl 83

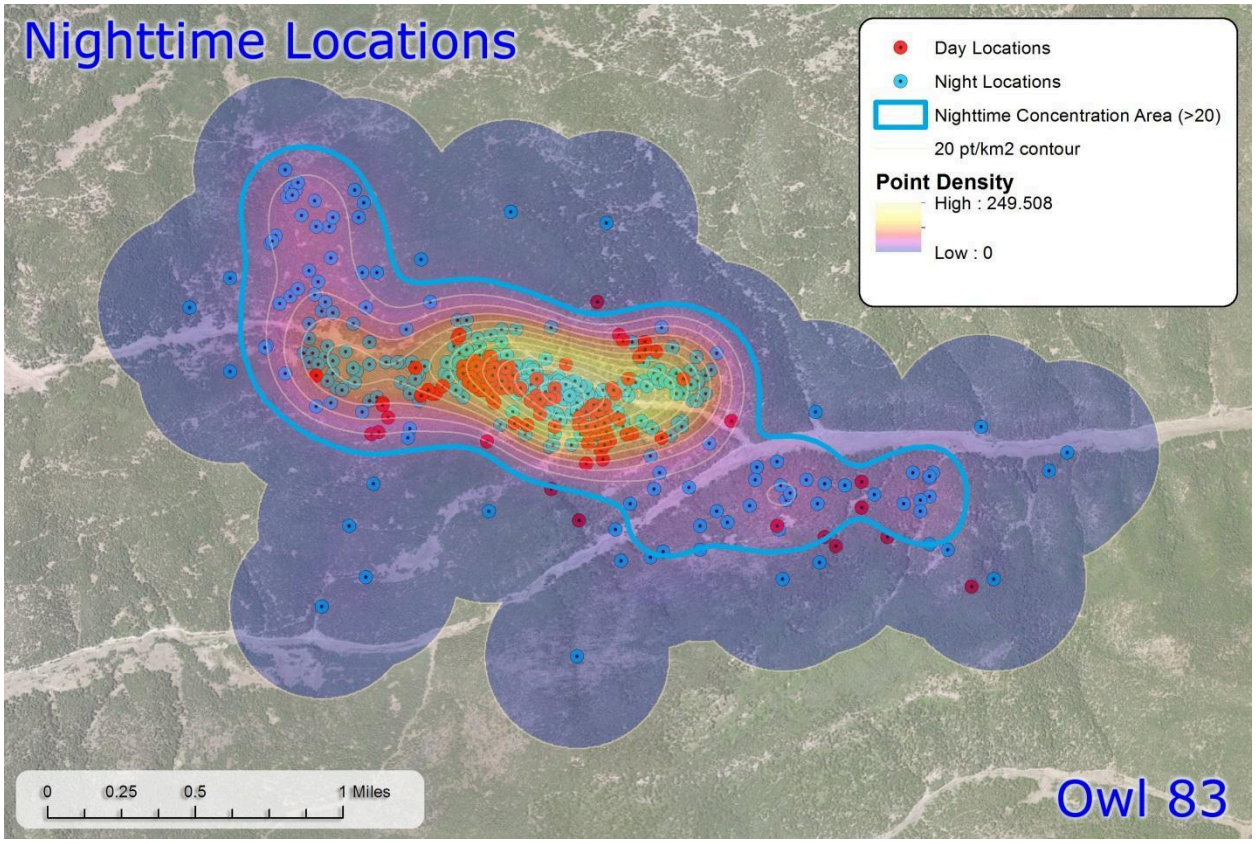

Comparison: 3 Kernel Sizes
Owl 83 Locations; 1992 - 1994
250m Home Range (>20)
500m Kernel Home Range (>20)
1000m Kernel Home Range (>20)
0
0.25
0.5
1 Miles
Owl 83

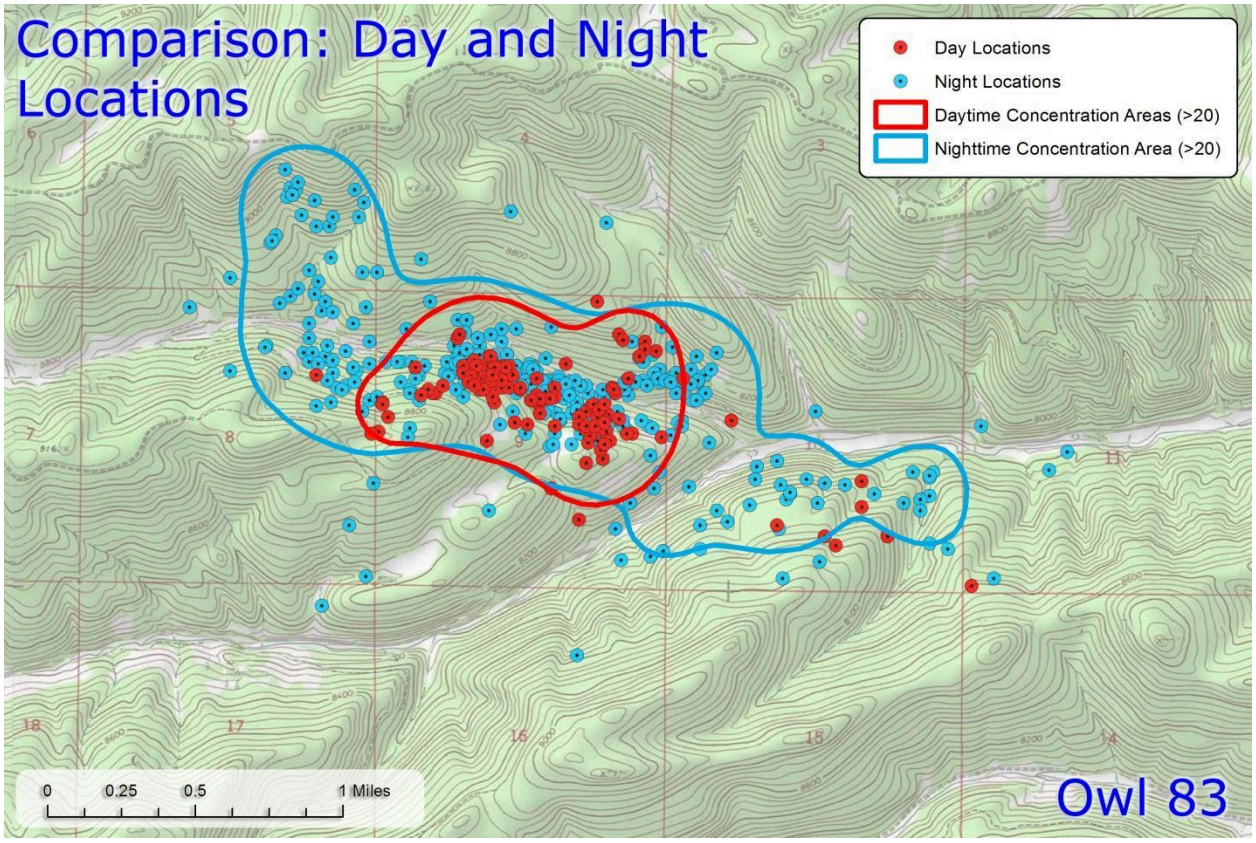

Breeding Season Density
Breeding Season Locations
Non-Breeding Season Locations
Breeding Season Home Range (>20)
20 pt/km2 contour
Point Density
High : 197.493
Low : 0
0
0.25
0.5
1 Miles
Owl 83


Non-Breeding Season Density
Breeding Season Locations
Non-Breeding Season Locations
Non-Breeding Season Home Range (>20)
20 pt/km2 contour
Point Density
High : 211.3
Low : 0
0
0.25
0.5
1 Miles
Owl 83


Comparison: Breeding and Non-Breeding Season
Breeding Season Locations
Non-Breeding Season Locations
Breeding Season Home Range (>20)
Non-Breeding Season Home Range (>20)
0
0.25
0.5
1 Miles
Owl 83


Daytime Locations
Day Locations
Night Locations
Daytime Concentration Areas (>20)
20 pt/km2 contour
Point Density
High : 202.135
Low : 0
0
0.25
0.5
1 Miles
Owl 83


Nighttime Locations
Day Locations
Night Locations
Nighttime Concentration Area (>20)
20 pt/km2 contour
Point Density
High : 249.508
Low : 0
0
0.25
0.5
1 Miles
Owl 83


Comparison: Day and Night Locations
Day Locations
Night Locations
Daytime Concentration Areas (>20)
Nighttime Concentration Area (>20)
0
0.25
0.5
1 Miles
Owl 83

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