GIS and animal behavior:
A case study with animal movement data

Course name and date

In this lab exercise we will explore bird migration data and how it can be used to understand animal movement patterns. Our main tool for this exercise is Movebank, an online geographic information system for animal movement data.

To get started,

- Go to www.movebank.org.
- Log in as *GIS lab*, password *TeamGISlab!*
- Select **Tracking Data Map** from the main menu.

Here you can browse animal tracking datasets visible to the public on Movebank. You can search by search terms, by selecting a sensor type (the method that was used to collect the data), or by restricting the list just to those that allow you to view some or all of the tracks. For this exercise we're going to look at some large datasets of raptor migrations between North and South America.

Part 1: Vulture migrations

- Select the box below the Search field next to "only studies where I can see data".
- In the Search field, type "Dodge et al. 2014". You will get one result, for the study "Turkey vultures in North and South America (data from Dodge et al. 2014)".
- Click the check box to the left of the name of the study. Be patient while the map loads the tracks (over 200,000 locations!).
- Click on the "+" to the left of the study name to view a list of the birds in the study.
- For details about viewing information on the map see movebank.org/node/44. In addition, you can view them using Google Earth if you prefer. The dataset was downloaded from Movebank as a Google Earth file and is available in the "Movebank files" folder on the computers ("Turkey vultures in North and South America (data from Dodge et al. 2014).kmz"). Google Earth allows you to view the timestamps of individual locations, which may be helpful for some of the questions below.

This study contains tracks of 19 turkey vultures (*Cathartes aura*) tracked using GPS tags between 2003 and 2013. The data were collected as part of a long-term study by researchers at Hawk Mountain Sanctuary, about 90 minutes northwest of Philadelphia. (To see a study description, go to the "i" box to the right of the study name and select **Open in studies page**.) You'll see there are individuals tracked from several regions. You can select a bird from the list on the left to highlight his or her track on the map. Alternatively, you can select a location on the map to highlight the related track/s, and the associated animal/s will also be highlighted on the list. A summary of information about the animals is available in the "Movebank files" folder ("Vultures Reference Data").

Questions for Part 1

1. How many birds are tracked from each region in the dataset? Do the individuals in this study represent the entire distribution range for the species (hint: Google it), and what might this mean for representativeness of the sample? Are Steamhouse 1 and Rosalie likely to start a family, and what might this mean for the evolution of migration patterns?

2. Select **sort by number of data points** from the sorting menu below **search result**. This will sort the birds so that those with the most locations are at the top of the list. Look at the five birds with the most locations. For each, how many years have they been tracked for? How many "round-trip" migrations do the data show? For the birds that have made multiple migrations, do they seem to take the same routes each year?

3. Do all of the birds within a region show the same migration behavior? Relatedly, how might your inferences about these patterns be biased if, for example, the researchers had tracked only one vulture from each population? How would you determine what an adequate and representative sample is? What other criteria might influence how representative the sample is?

4. Do you think these different populations are potentially interbreeding? Why? What information would you need in addition to the tracking data to confirm your hypothesis? (How would behavioral observations help you here?)

Part 2: Osprey migrations

Now we'll look at another large dataset of another species of raptor: osprey (*Pandion haliaetus*).

- In the Search field, type "Bierregaard". You will see two results; we will use the second study on the list: "Osprey Bierregaard North and South America (2007-2013)".
- Click the check box to the left of the name of the study. Be patient while the map loads the tracks.
- Click on the "+" to the left of the study name to view a list of the birds in the study.
- For details about viewing information on the map see movebank.org/node/44. In addition, a Google Earth file of the dataset is available in the "Movebank files" folder on the computers.

This study contains tracks of 49 osprey tracked using GPS tags on the east coast of North and South America between 2007 and spring 2013. It is part of a long-term study by Dr. Rob Bierregaard, who has primarily been studying juvenile movements during their first few migrations. You can read more about Rob's research at www.ospreytrax.com. A summary of information about the animals is available in the "Movebank files" folder ("Osprey Reference Data"). (This study is ongoing, and new data are automatically added daily to the study "Osprey Bierregaard North and South America". Select **sort by last update** from the sorting menu below **search result** to see which birds are still being tracked today.)

Questions for Part 2

1. Use the reference data about the animals to find out which are adults and which are juveniles. What differences, if any, do you see between adult and juvenile migration routes?

2. What happened to Chip?

3. Comparing the vulture and osprey datasets overall, what is the major difference in the migration routes between these two species? What possible reasons can you think of for this difference?

Part 3: Raptor locations and land cover type

Lastly, let's look at the land cover and habitat use of the animals in these two studies. Zooming in on the wintering and breeding grounds of the individuals, you can use the satellite map view to get a general idea of their habitat preferences. However, it is hard to really quantify or compare preferences just by looking on the map. The Env-DATA Track Annotation Tool is a powerful tool on Movebank that lets users link tracking data to many global environmental datasets, such as weather models and satellite imagery. One of the datasets included in this tool is GlobCover 2009, a global map showing the estimated distribution of 22 land cover classes defined by the United Nations Land Cover Classification System and distributed by the European Space Agency. Land cover classes are defined at a 300-meter resolution using satellite imagery collected throughout 2009. More information about this dataset is available at http://due.esrin.esa.int/page_globcover.php.

The Env-DATA Track Annotation Tool has been used to identify the land cover classification at each recorded bird location in the osprey and vulture datasets. In the file "GlobCover annotated.xlsx" in the "Movebank files" folder, you will find the full datasets, along with a summary table. In the summary table (the "landcover" worksheet), you will see the number of locations found within each land cover type.

For each dataset, calculate the percentage of locations that fall within each land cover class by adding to the summary table. To do this,

- Create a new column, "Percentage" to the right of the "Count" column for each dataset.
- For the first land cover type (in row 3), create an equation calculating the percentage of total osprey locations that are in "post-flooding or irrigated croplands".

Using equations in Excel allows you to make many calculations quickly without using a calculator, and allows these equations to be stored in the file so you can check your work later. For this particular calculation, the equation is "=C3/C$26*100", which translates to "the Count of osprey records in post-flooding or irrigated croplands (cell C3) divided by the total number of osprey records (cell C26) multiplied by 100".

- You can now cut and paste this equation into the rest of the "Percentage" column cells for the osprey and vultures.

Notice that Excel will automatically update the row number for the first value in the equation so that the calculation is relevant to that row (i.e., "C3" will automatically change to "C4" when you paste it on the 4th row). However, it will not change the reference to cell C26, the total number of locations, because the equation says "C$26" instead of "C26"—the "$" tells Excel you always want to use the value from row 26 in the equation.

- To reduce the number of visible decimal places and make the values easier to read, you can highlight a column, right click, select "Format Cells", go to the "Number" tab, and define how many decimal places you want to see in the "Number" category.

For answering the questions below, you can also try grouping the land use classes into similar land use types and totaling the percentages for these groups, if you think that is more biologically meaningful.

Questions for Part 3

1. Based on this table, which land cover classes are the most common for osprey? For the vultures?

2. For these datasets, what are the biggest differences between land cover use of osprey and vultures?

3. Do you think these data are a good representation of reality? What are possible causes of error between this dataset and the actual habitat types used by these species?

4. How might you quantify the actual land use *preferences* of the animals in these studies?