**EXERCISE 3: Range Shifts**

**Introduction**

Changes in climate may cause species to shift their geographic ranges in order to track a set of environmental conditions. Previous studies of single species and targeted species groups have found that, for many species, ranges are moving toward the poles and upwards in elevation as the climate warms. However, targeted studies risk focusing on groups likely to respond to climate change, and results in a given system or region may not apply globally.

**Data**

For this activity we will be working with data from Chen et al. 2011[[1]](#footnote-1), a study analyzing the results of 23 peer-reviewed studies of changes in species’ ranges over time. Each row of the table “Ex3\_rangedata.xls” corresponds to a previously published peer-reviewed study carried out on a defined taxonomic and geographic group. For example, row 1 summarizes the results of a study of range shifts of butterflies in Finland.

The column for “Mean observed shift” corresponds to the average distance away from the poles that species’ ranges moved during the study period. Negative values indicate movement towards the equator. “SE observed shift” is the standard error of shift distances between species in each study. Standard error is a measure of the amount of variability in a dataset (specifically, the standard error is: *SE*=*SD*/sqrt(*n*), where *SD* is the standard deviation and *n* is the sample size). The “Expected shift” column was calculated by finding the distance that species would have to have shifted in order to experience the same climate at the end of each study period as they did at the beginning. Another way of thinking of this is:

*expected shift (km) = velocity of climate change (km/year) \* duration (years)*

The “Duration” column gives the number of years each study covers. “Temperature Change” is the change in average annual temperature (°C) observed in the ranges of focal species over the period covered by surveys.

**Questions**

Use the Chen 2011 data to respond to the following prompts. Include your answers and any supporting charts in a word document or PDF.

1. What is the average observed speed (km/year) of latitudinal range shifts?
2. Did species experiencing more warming show greater observed range shifts? Produce a plot supporting your answer.
3. Produce a scatter plot of observed (y-axis) versus expected (x-axis) range shifts, and include standard error bars on each point.[[2]](#footnote-2) Add a one-to-one line (a line with the equation: y=x)[[3]](#footnote-3).
   1. How many studies documented greater than expected range shifts? Less than expected?
   2. According to this data, are species “keeping up” with the pace of climate change?
4. What is one shortcoming of this dataset that makes it difficult to generalize the findings to all global ecosystems?
5. In your opinion, do these results provide convincing evidence that species’ ranges are shifting in response to climate change? Why, or why not?

1. Chen et al., 2011. *Science.* http://science.sciencemag.org/content/333/6045/1024 [↑](#footnote-ref-1)
2. **Adding Error Bars:** Go to chart layout > error bars > error bars options > custom > … then select the “SE observed shift” column for both positive and negative values. Note that Excel’s automatic “standard error” error bars option does **not** work. [↑](#footnote-ref-2)
3. **Adding a One-To-One Line:** Go to “select data” and click “add series”. Now select the “expected shift” column for both x and y axes, and click ok. You should see a series of points making a diagonal across the chart. Right click on these new points (not the original data) and select “format data series”. Change the marker style to “no marker” and the line style to “solid black”. You should now see a diagonal line across the plot with a slope of 1 and a y-intercept of 0. Points above this line are studies that observed more than expected range shift, and points below are studies with less than expected range shift. This line is also called an “identity line”. [↑](#footnote-ref-3)