**Phenology and Climate Change (Part 2)**

**BEFORE STARTING: WATCH THE POWERPOINT POSTED IN THE DISCUSSION BOARD**

**Overarching question**: Based on observations of phenology, which species are most likely to be impacted by climate change?

**Data Source**: All data for this module were collected by citizen scientists and are available from the National Phenology Network website.

**Learning objectives**: In this lesson, you will manipulate data to make and interpret scatterplot graphs and regressions about the phenology of bumblebees and other organisms. You will make decisions about which data to use and evaluate your confidence in your conclusions given the nature of the available data.

**You can work individually or with a classmate on this Activity!**

**Student/s Name/s: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Activity A: How has bumble bee emergence phenology changed over time?**

*Rationale*: One way to predict how a species will respond to climate change in the future is to examine at how it has responded to climate change in the past. The National Phenology Network provides data about the day of the year when the first siting of adult bumblebees occurred at a site in the years from 2010 to 2019. Six of these years are among the top 10 warmest years on record.

1. Sketch your predictions: What pattern would you expect to see for the relationship between phenology and year? Label your axes. **You can sketch this by hand**
2. Explain your reasoning for your prediction.
3. Sketch other possible relationships you might find between phenology and year. What might be explanations for those relationships? **You can sketch this by hand**

**The data**: Open the “Phenology\_v\_time” data file posted on the discussion board for this project. The first tab contains all the records, and the second tab contains just the data for Minnesota. Each file contains a column with the year of record for a site and a second column with the day of the year when bumblebees were first recorded for the site.

1. Before you plot the data, what are the advantages and disadvantages of using the whole dataset and of using the data just from Minnesota?
2. **Plot the data**: **You will have to create the two graphs in the computer this time!**

Make a separate plot for each dataset, **You can do this first by hand here, as a draft, but you will have to submit the final version of the graphs done in the computer**

 All Available Data Minnesota Sites

 m= m=

 R2= R2=

 N= N=

1. If the data show a linear trend, it can be helpful to identify the **slope** so that we can compare graphs. To do this, **add a trend line or conduct a linear regression analysis**. The equation of the regression line is written in the form ***y = mx + b***, where ***m* is the slope** and ***b* is the intercept.** Record the slope (m) for each graph above.

The **R-squared (R2)** is a statistic resulting from a linear regression analysis that describes the proportion of variation in the dependent variable explained by the independent variable. When R2 ~1, the data form a perfectly straight line. As the data become more scattered from the line, R2 decreases toward 0. Higher R-squared values indicate a stronger relationship between the two variables. **Record your R2 value above as well.** Finally, record the number of **data points used for each graph (N).**

1. Describe the pattern you observed in words.
2. Identify several possible explanations for the national and MN patterns you observed.
3. Use the figure below, which shows estimates of the mean annual temperature between 2010 and 2019, to identify a time frame when temperatures were consistently and continuously increasing.

Write the range of years here: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Based on temperature anomaly data through November from https://www.ncdc.noaa.gov/cag/global/time-series/globe/land\_ocean/ytd/11/1880-2019

1. Remake your plot with **MN data** from above to include only the range of years that you identified in the previous question. To do this, first sort your entire dataset by year. Then, select the data from the appropriate years to plot. **Record and reflect on your results below as your draft, and in a new graph done in the computer.**

 m=

 R2=

 N=

1. Now, hypothesize some environmental variables at a site that might help to predict the emergence phenology of bumble bees in a given year.