What Limits the Reproductive Success of Migratory Birds?
Warbler Data Analysis (50 pts.)

This assignment is based on background information on the following website:
http://btbw.hubbardbrookfoundation.org/.

To do this assignment, you will need to use the Data Analysis Add-in for Excel.
(http://office.microsoft.com/en-us/excel-help/load-the-analysis-toolpak-HP001127724.aspx)

Download Warbler Data.xls. The dataset contains the following data:

- *Predator Abundance* refers to the number of chipmunks and red squirrels detected per hour, on average, during predator observations. Predator abundance data were not collected in 1986, 1987, or 1991.
- *Food Abundance* refers to the biomass of caterpillars (in milligrams per 100 leaves) on the study plot during the breeding season. Food abundance data were not collected in 1999.
- *Reproductive Success* refers to the average number of young that left nests ("fledged") per territory in each year. This is a good measure of fecundity in passerine birds.

1. Researchers quantified how food abundance affected warbler reproductive success:
    a) What is the independent variable in this analysis? (2 pts.)

    b) What is the dependent variable? (2 pts.)

2. Create a graph of food abundance versus reproductive success. Be sure to label your axes! Add a trendline to your graph. (4 pts.)
    a) What is the relationship between food abundance and reproductive success? (2 pts.)

3. Test if the relationship you just graphed is statistically significant. To do so, do a regression analysis, using the data analysis add-in. Check the box to save the residuals from this analysis.
    a) Are the results of your regression statistically significant? What output did you use to make this determination? (3 pts.)

    b) Part of your output is an R^2 value. Report the result for this value, and how this result should be interpreted. (3 pts.)

    c) You saved the residuals from your analysis. What is a residual? Include in your answer how to interpret the sign (positive or negative) of each residual. (4 pts.)

4. Ecologists have found that nest predator abundance can also affect warbler reproductive success. In this question you'll test if differences in nest predator abundance between years might account for the deviations we saw from the relationship between food abundance and reproductive success. First, you'll need to paste the residuals you saved (which probably got output into a separate worksheet) in a column beside the original dataset. Be absolutely sure you line up the rows right! Next, because Excel cannot deal with missing values, you'll need to delete any rows with missing values in either the nest predator or residual columns. (It's smart to copy the whole dataset into a new worksheet, and then delete.)

a) Here we will test if variation between years in nest predator abundance can explain higher or lower warbler fecundity than expected for the food abundance in a given year. In this analysis, what is your independent variable, and what data will you use for your dependent variable? (2 pts.)

b) Make a graph of nest predator abundance versus the residuals you saved from the analysis of the effects of food on reproductive success. Use your answer from part a to decide which axis each variable should go on. Again, label your axes and add a trendline to the graph. (6 pts.)

5. Next, we'll do another regression analysis to test if the relationship we graphed in question 4 is statistically significant. This time, you don't need to save the residuals.

a) Are your results statistically significant? What output did you use to make this determination? (3 pts.)

b) Report the R^2 value, and how this result should be interpreted. (3 pts.)

6. Summarize the biological interpretation of your results, and the effects of food and nest predator abundance on warbler fecundity. (6 pts.)

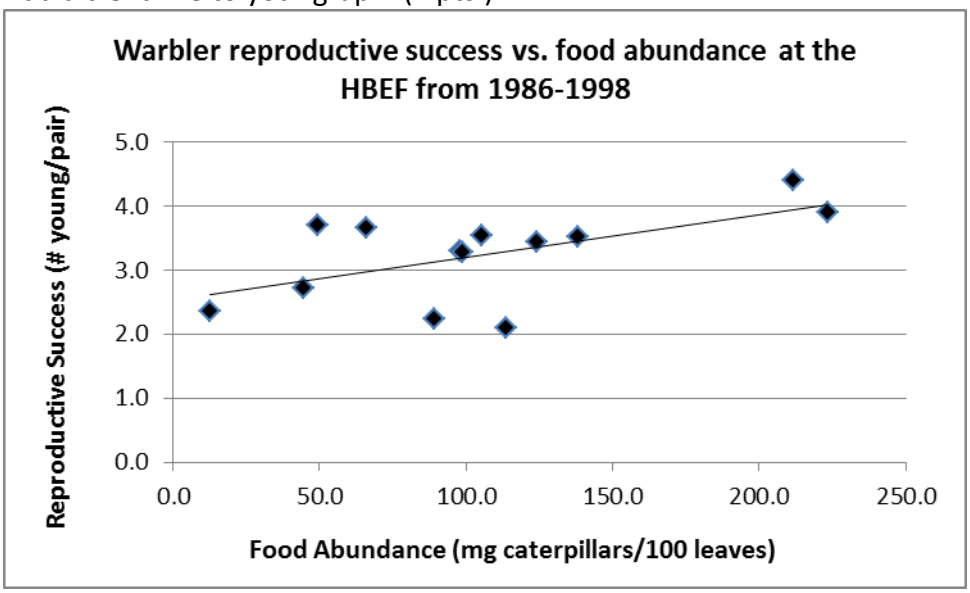
7. Based on the background information on the effects of density on warbler fecundity, look at the point for 1995 in both graphs, and predict whether the density in that year was above average, below average, or approximately average. Be clear about why you made the prediction you did. (5 pts.)

8. Can we say that variation in food and predators *causes* variation in warbler fecundity? If so, why? If not, what would need to be done to establish causation? (5 pts.)

What Limits the Reproductive Success of Migratory Birds?
ANSWER KEY
Warbler Data Analysis (50 pts.)

1. Researchers quantified how food abundance affected warbler reproductive success:
   a) What is the independent variable in this analysis? (2 pts.)
   Food abundance
   b) What is the dependent variable? (2 pts.)
   Reproductive success

2. Create a graph of food abundance versus reproductive success. Be sure to label your axes! Add a trendline to your graph. (4 pts.)



   a) What is the relationship between food abundance and reproductive success? (2 pts.)
   Reproductive success was higher in years with more food.

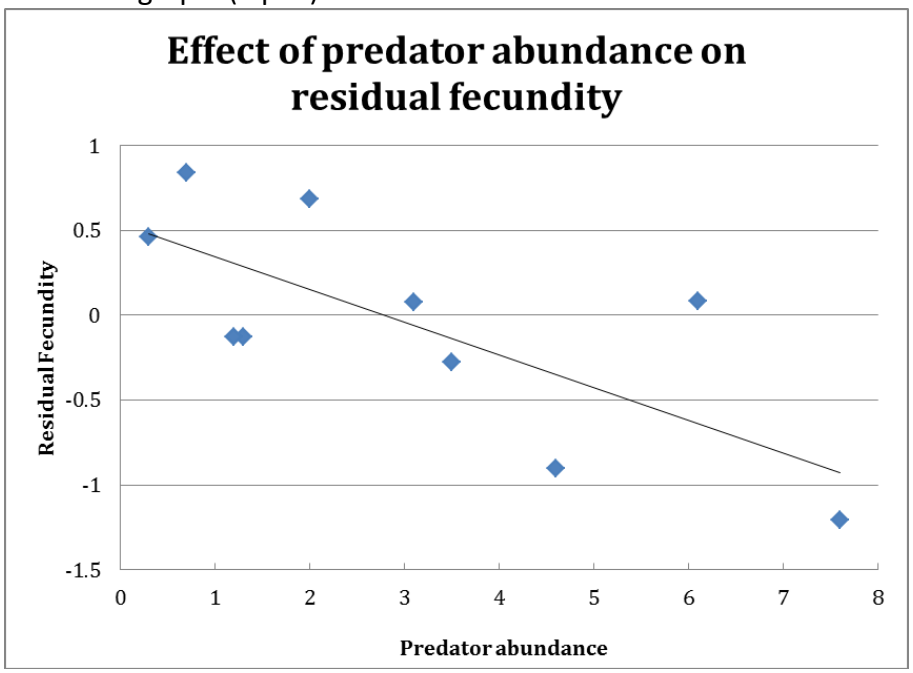
3. Test if the relationship you just graphed is statistically significant. To do so, do a regression analysis, using the data analysis add-in. Check the box to save the residuals from this analysis.
   a) Are the results of your regression statistically significant? What output did you use to make this determination? (3 pts.)
   Yes, because the p-value is less than 0.05; in this analysis *P* = 0.0391
   b) Part of your output is an R^2 value. Report the result for this value, and how this result should be interpreted. (3 pts.)
   The R^2 value is 0.33; this means that 33% of the variation in reproductive success is explained by variation in food abundance.

c) You saved the residuals from your analysis. What is a residual? Include in your answer how to interpret the sign (positive or negative) of each residual. (4 pts.)
Each residual measures how far a given point is from the expected relationship; it gives the distance from the regression line. Positive values indicate the Y-value is larger than expected, so the point is above the line.

4. Ecologists have found that nest predator abundance can also affect warbler reproductive success. In this question you'll test if differences in nest predator abundance between years might account for the deviations we saw from the relationship between food abundance and reproductive success. First, you'll need to paste the residuals you saved (which probably got output into a separate worksheet) in a column beside the original dataset. Be absolutely sure you line up the rows right! Next, because excel cannot deal with missing values, you'll need to delete any rows with missing values in either the nest predator or residual columns. (It's smart to copy the whole dataset into a new worksheet, and then delete.)

a) Here we will test if variation between years in nest predator abundance can explain higher or lower warbler fecundity than expected for the food abundance in a given year. In this analysis, what is your independent variable, and what data will you use for your dependent variable? (2 pts.)
Independent variable: Predator abundance
Dependent variable: residual fecundity

b) Make a graph of nest predator abundance versus the residuals you saved from the analysis of the effects of food on reproductive success. Use your answer from part a to decide which axis each variable should go on. Again, label your axes and add a trendline to the graph. (6 pts.)



5. Next, we'll do another regression analysis to test if the relationship we graphed in question 4 is statistically significant. This time, you don't need to save the residuals.

a) Are your results statistically significant? What output did you use to make this determination? (3 pts.)
Yes, *P* = 0.0175

b) Report the R^2 value, and how this result should be interpreted. (3 pts.)
R2 = 0.526, indicating that nest predator abundance explained 53% of the variation in residual fecundity

6. Summarize the biological interpretation of your results, and the effects of food and nest predator abundance on warbler fecundity. (6 pts.)
Both food abundance and nest predator abundance affected average warbler reproductive success in each year. In our analyses, we showed that variation in food accounted for approximately 1/3 of the variation in fecundity between years. Fecundity was higher in years with more food. When we analyzed the residuals from that regression, we found that deviations from expected fecundity were explained by variation in nest predator abundance between years. Specifically, nest predator abundance explained half of the variation in reproductive success that was not explained by food abundance. As the abundance of nest predators increased, reproductive success declined. This can be seen on the second figure where high nest predator abundance is associated with negative values of residual fecundity. This means that in years with many predators, fecundity was lower than would be expected just based on the amount of food.

7. Based on the background information on the effects of density on warbler fecundity, look at the point for 1995 in both graphs, and predict whether the density in that year was above average, below average, or approximately average. Be clear about why you made the prediction you did. (5 pts.)
In 1995, residual fecundity was approximately -1, so that year's fecundity was lower than expected given the food abundance. The abundance of nest predators in that year was relatively high, but the point still falls below the expected relationship between nest predator abundance and residual fecundity. High densities are expected to reduce fecundity. I would therefore predict that density in that year was higher than average, since fecundity was lower than expected given both food and nest predator abundance.

8. Can we say that variation in food and predators *causes* variation in warbler fecundity? If so, why? If not, what would need to be done to establish causation? (5 pts.)
No, we cannot say that variation in these ecological factors caused variation in warbler fecundity. Experimental manipulations are required to establish causation, whereas these data only show a correlation, although a very convincing one.