LAB #2. Spreadsheet Modeling of Exponential and Logistic Growth
v2. Fall 08

INTRODUCTION:

Modeling population growth involves repetitive iteration of relatively simple equations; procedures that are well suited to spreadsheet analysis. We will model exponential growth using the equation:

\[ \frac{dN}{dt} = rN \]  
[Eq. 1]

and logistic growth using:

\[ \frac{dN}{dt} = rN(1-(N/K)) \]

PROCEDURE

1. Read the Into to EXCEL for Bio 146 document.
2. Open a blank EXCEL workbook.
3. Set up a column headed ‘DATA’ (e.g. use column A)
4. Enter last weeks fly egg counts into this column (e.g. into cells A2 through A8)
5. Choose a convenient cell, and enter “MEAN”
6. In an adjacent cell, enter the formula “=AVERAGE(A2:A8)” When you press the <ENTER> key, the arithmetic mean of your data set will appear in this cell.
7. In the same way, set up a cell to calculate the standard deviation (e.g. “=STDEV(A2:A8)”).

Now, set up a new spreadsheet to calculate exponential growth of a population, starting with input values for the net reproductive rate \( R_0 \), generation time \( T_{\text{gen}} \), and the initial population size \( N_0 \).

Remember, \( r \), the intrinsic rate of increase, is the natural log of \( R_0 \), divided by the generation time. (note: if \( R_0 \) is less than 1, the natural log will be negative – use the absolute value, i.e make it positive or else you will get negative growth!) The Excel formula appears thus:

\[ \frac{-\ln(R_0)}{T_{\text{gen}}} \]

where LN is the mathematical function to generate natural logs, $D5$ is the cell address in which \( R_0 \) appears, and E5 is the cell address in which the generation time appears.

Click on the ‘Charts” icon and set up a scatter plot.

Your spreadsheet should look something like this:
Notice that the whole spreadsheet, including the graph, is “active”; if you change any of the input parameters (\(R_0\), \(T_{\text{gen}}\), or \(N_0\)), and hit <ENTER>, the whole spreadsheet and the graph will be updated.

Experiment by increasing and decreasing \(R_0\) and \(T_{\text{gen}}\). How does the population growth curve respond?

Estimate \(R_0\) and \(T_{\text{gen}}\) for Brown Rats, based on the life history information given in lab #1. Run this data on your spreadsheet. What would be the population size after 36 months?

Print out a copy of your ‘exponential’ spreadsheet and chart for your lab report.

What is the expected population size after 10 years (a) using the discrete timestep method above, in monthly increments, and (b) using the discrete timestep method above,
in annual increments, and (a) using the integral equation \( t = \frac{\ln(N_t)}{r} \) ? Given the differences, what do you suppose would be the best timestep to use for these rats?

LOGISTIC GROWTH.

Using your exponential growth model, develop it further to model logistic growth. Obviously, this will require an additional input parameter, the carrying capacity \((k)\). Check the model to make sure the chart shows the expected “s-shaped” logistic growth curve. Now run the model for various combinations of \(b, d, N_0\) and \(k\). How does the shape of the curve vary?

Now rerun the Brown Rat data, using an initial population of 4 and a carrying capacity of 1000 animals. **How long would it take for the population to stabilize at carrying capacity?** Print out your spreadsheet and chart.

THINGS TO CONSIDER

Go to the course website, labs, lab2, and download Klein’s paper on the reindeer of St. Matthew Island. Determine (or estimate) the basic natural history data (e.g., number of young, gestation period, life span, and carrying capacity) for these animals. **Use your spreadsheet** to plot the growth of the species to equilibrium. In what ways is the model unrealistic? What does it not include?