**BSEN 5250/6250**

**Simulating Predator-Prey Relationships**

**Laboratory #2**

**Objectives**

The objectives of this lab are

1) Enhance your understanding of VBA programming

2) Improve your understanding of predator-prey dynamics

3) Use a model to answer ecological engineering questions about the system

**Theory**

The equations that govern predator-prey relationships are shown below. This mathematical model represents a coupled pair of non-linear differential equations that are complex to solve analytically.

 Population of Prey

 Population of Predators

Where N – population of prey, No.

P – population of predators, No.

r - growth rate of prey at minimum population, 1/time

g - efficiency of predation

h - capture rate and conversion of prey into predators

m - predator death rate, 1/time

These equations can be solved using Euler Integration, leading to the following equations:

These equations can be solved for each time step for t = initial time to t=final time of the simulation.

**Spreadsheet Template**

The spreadsheet template for this lab can downloaded from Canvas in the \files\Labs\Lab 2-Predator Prey\ directory.

The first section of the spreadsheet is shown below. The Model Inputs section contains parameters (r, g, m, h), initial levels of the predator and prey populations (No and Po), and simulation control information (Duration and dT). If you go to the ***Formulas>Name Manager*** menu, you will see that an internal Excel variable called ***Inputs*** has already been defined for the input variables.



The next group of cells contain output information. The top table (shown below) contains a final summary the maximum and minimum levels of predators and prey during the course of simulation. The bottom table contains a detailed printout of the predator and prey levels at each timestep. See if you can find the internal Excel variables that are associated with these two tables (ie. go to the ***Formulas>Name Manager*** menu).



Next, you will notice two graphs on the right side of the screen. These graphs show the predator and prey population over time, as well as the population of prey vs predators. The lines on these graphs are set up to plot the data in the last output table, and should automatically update when the model is run.

**VBA Model Development**

Using the principles you learned last week, write a VBA program to compute the predator and prey levels over the user specified time duration using the user specified timestep from the input table. Your program should read coefficients from the Excel Input table, and write outputs to the output tables defined in the Excel template. Your program should include the following:

* At the top of your program, add some comments stating your name, the course, when the program was written, and a brief explanation of what the program does.
* Dimension all variables using the ***DIM*** command. For this lab, most of your variables should be dimensioned as either ***double*** or ***integer***.
* Use the remark or comment statement ( ‘ ) to add a variable list to your program. Define all major variables!!!
* Include comments throughout your program to explain to what each part of the model does.

**Engineering Analysis**

1. In the real world, the capture rate predation efficiency coefficient, g, is effectively the capture rate of prey by predators. In a physical system, the capture rate may be a function of the probability of an encounter between the predator and prey, which would be a function of habitat area. Let’s assume that your company was hired to estimate the impact of developing a lake (ie. reducing land area in the ecosystem which increases predation efficiency) on this 2-species ecosystem. Using the default parameters in the spreadsheet, conduct a sensitivity analysis on the predation efficiency, g. Vary it in the range of 0.001 to 0.011 in increments of 0.002. Plot the max/min predator and prey as a function of g. Describe the behavior of the populations due to changes in the predation efficiency. What behaviors are good/bad for the ecosystem? Explain why g has this effect. Use appropriate graphs to support your work.

2. Food supply can impact populations dynamics in ecosystems. Assume that the population of predators can be increased by providing supplemental feed, which effectively increases the lifespan, or reduces the rate of death (m) of individuals in the predator population. Likewise, let’s assume that a fire in the ecosystem reduces the food supply and increases the death rate (m) of predators, but has no effect on prey. Conduct a sensitivity analysis on the m coefficient by running the model from m=0.05 to m=0.5 in increments of 0.05. Plot the max/min predator and prey populations and discuss what you found. How do changes in food supply impact the behavior and health of the ecosystem? (Hint: Pay close attention to what happens when m=0.3!). Use appropriate graphs to support your work.

3. What happens when you introduce more predators into this system? Alternatively, what would happen if you introduced more prey into the system? Run the model for predator populations from 20-200 by increments of 20, keeping the initial prey fixed at 1500. Run the model for initial prey populations from 500-4000 in increments of 500 keeping the initial predator population fixed at 50. (Note what happens when the initial prey population is 1000!). Develop graphs showing how the max/min populations for predators and prey change as a function of initial predator and prey values. Discuss the results and how initial conditions affects the behavior and health of the ecosystem.

**What to Turn In**

1. Develop a lab report to answer the questions above. Include publication quality graphs and/or tables to support your work. I will grade based on model accuracy, grammar, details of your analysis and quality of your graphs. Use 12-point font and double spacing in your lab report.
2. Upload your spreadsheet to Canvas and turn in a hard copy of your lab report.