Ecology, BI 325 Name________________________________

Homework 2 - Life tables and population growth

A. Read the following article: Tilman et al. 2002. Agricultural sustainability and intensive production practices. Nature 418:671-677. Briefly answer the following:
1. What factors determine human grain demand?
2. What factors determine (and may limit) agricultural production?
3. What ecosystem services are influenced by intensive grain agriculture and which of these could feedback to decrease future agricultural yields?
4. Is agricultural production likely to be a constraint on future human population growth? Globally? Locally? Why or why not?

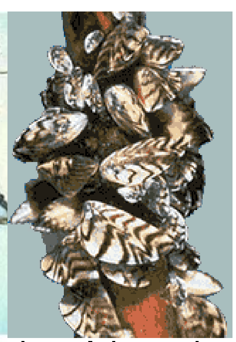
B. Life Tables and Population growth. You can work together and discuss these exercises, but if you do, be sure that you know how to do the required manipulations; there is a good probability that this material will appear on the next midterm or final.

1. Zebra mussels have invaded the Great Lakes region of the U.S. and cause a variety of problems, including clogging intake valves of power plants and overgrowing native species (see photos). Zebra mussels live 4-5 years, become reproductive after 2 years, and a given female can produce anywhere from 30,000 to 1 million eggs/year, ~1/2 of which are new females. Only about 2% of these survive to reproduce, however (http://www.nationalatlas.gov/articles/biology/a_zm.html). The following hypothetical life history table for the zebra mussel is based on these statistics. Given this life history table, overlapping generations, and continuous reproduction:

   a. (5 points) Calculate the net rate of increase (R_o), the generation time (T_c or T_g), and the intrinsic rate of increase (r). Fill in the rest of the table below and show all additional work, including equations used.

x	l_x	m_x		
0	1	0		
1	0.1	0		
2	0.02	15000		
3	0.015	30000		
4	0.01	75000		
5	0.005	250000		
6	0	0		


Crayfish covered with zebra mussels.


Closeup of zebra mussels on stick.

http://www.nationalatlas.gov/articles/biology/a_zm.html

b. (2 points) Based on the r you calculated in part a, if 10 adult zebra mussels are accidentally introduced to a new lake, what would be the population size after 5 years? Show your equations and your work.

c. (5 points) Suppose that biologists find a parasite of zebra mussel that effectively cuts its reproduction in half each year, but has no effect on mortality (i.e., assume that the values of l_x are unchanged but that m_x for each year is ½ of the values in part a). They introduce the parasite as a biocontrol agent. How would it affect r (calculate the actual value)? Show your work.

d. (2 points) How would the parasite affect the population size after 5 years, under the same conditions as in part b? Would this parasite be enough to stop the spread of zebra mussels? How do you know? Show your equations and your work.

2. Human population growth. Below is a table showing estimates of world population for the past 2000 years.

a. (2 points) Plot these data, preferably by computer. If you use Excel or other spreadsheet program (which I recommend), be sure to use an X-Y scatterplot NOT a line graph. **Turn in your graph with the homework**. What type of population growth is exhibited? Assuming continuous breeding, what is the equation that includes the terms N_0 and N_t that represents this type of growth? Write the equation here.

Year	Population (in billions)
0	0.30
1000	0.31
1250	0.40
1500	0.50
1750	0.79
1800	0.98
1850	1.26
1900	1.65
1910	1.75
1920	1.86
1930	2.07
1940	2.30
1950	2.52
1960	3.02
1970	3.70
1980	4.45
1990	5.30
1994	5.63
1999	6.00
2009	6.78

b. (2 points) Using the above equation, calculate r (the per capita rate of increase) for the human population from 1999 to 2009. [Hint: to calculate r, first rearrange the appropriate equation for the type of population growth exhibited in this example, i.e., set r on one side of the equation, and all other variables on the other side. Also, remember that for any value (x), $\ln(e^x) = x$, and $\ln(x*y) = \ln(x) + \ln(y)$]. Using this value of r, estimate the projected human population in the year 2025. Show your work.

c. (2 points) Using your estimate of r from the 1999-2009 period above, calculate the "doubling time" of the human population. The doubling time is the time it takes for the population size to double at the current rate of growth. [Hint: for a given r, the doubling time is the same no matter what the starting population size. Just think about a starting population size of X and a finishing population size of 2X, and solve for t.]

d. (1 point) From these data, can you predict the human carrying capacity of Earth? If so, what is it? If not, why not?