Population ecology assignment: Population growth

1. A population of elk in Alberta was studied in the year 2015, and estimated to have 120 individuals, with an approximate per-capita instantaneous birth rate of $= 0.12/\,\mathrm{yr}$ and per-capita instantaneous death rate of $0.2/\,\mathrm{yr}$.

a. Write a continuous-time model equation explaining how this population changes through time, assuming that the birth rate and death rate remain constant. What is the estimated instantaneous rate of change r?

We could write $dN/dt = (b - d)N$, or $dN/dt = rN$. Based on the description, $b = 0.12/\,\text{yr}$ and $d = 0.2/\,\text{yr}$, so $r = b = d = -0.08/\,\text{yr}$

b. How long should it take before the expected size of this population drops below 50? Write the solution for your equation; do an algebraic calculation with units; and work out the answer with a calculator or calculator program.

$N(t) = N_0 \exp(rt)$.

$t = \log_e(N(t)/N_0)/r$.

$t = \frac{\log_e(50\,\text{indiv}/120\,\text{indiv})}{-0.08/\,\text{yr}}$. The numerator and denominator are both negative, giving a positive answer.

$t = 10.9\,\text{yr}$

c. What could be some possible reasons for this population's decline?

Most likely would be habitat destruction by humans. Overgrazing is unlikely to cause gradual decline over so many years, and it's hard to think of likely competitors.

2. Two competing fly populations are introduced to McMaster campus. They each breed once a year, and adults die after breeding. In "blue fly" population, the population size is 16 in 2010 and the average number of successful offspring per female is 2.8; in the "green fly" population, the population size is 40 in 2015 and the average number of successful offspring per female is 2.4. The sex ratio is 1:1 in each species.

a. How would you model these populations, and what parameters would you use for each species?

We convert the numbers given to unitless values of λ by using the sex ratio. Formally using units, we multiply each of the offspring numbers (indiv/female) by 1female/2indiv to obtain unitless values. Since we have closed the loop, we can think of these unitless values either as representing females per female, or individuals per individual.

Once we have λ values we can use them equally well to predict total population size, or number of females (obtained by dividing total population size by 2). It is important, however, to remember which number you are tracking, and to convert it at the end, if necessary. In this case, since we are given and asked for population sizes, it's easier to *not* convert to number of females.

Since the adults die after breeding, the populations are modeled well and simply by a discrete time model with $\Delta t = 1\,\mathrm{yr}$. You should use 40; 16 for N_0, and 1.2; 1.4 for λ.

b. Write an equation, and calculate the number of bugs expected in each population after 10 years.

Since the time step is one year, we want to use the equation $N = N_0\lambda^T$, with $T = 10$, for each population.

For the green flies, this means $40 \times 1.2^{10} \approx 248$ flies.

For the blue flies, this means $16 \times 1.4^{10} \approx 463$ files.

c. For *one* of the species, make a table showing the number of successful offspring and successful females for each year. You may use pen and paper, a spreadsheet program, or some other method.

We chose to model the green flies. Please see our spreadsheet at `http://bit.ly/1DGDJtt`.

d. Make a graph with labeled axes showing the number of individuals for your species through time. Explain in words what choice you made in scaling the axes, and what your graph shows.

You should use a linear scale for time (since we start at time 0). You can use a log scale for number of bugs, showing that the population is growing at a constant rate (in proportional terms), or a linear scale for the number of bugs, showing that the population is growing exponentially faster (in absolute terms).

Click at the bottom of our spreadsheet to see the "chart". You can also copy the chart and change it to the blue fly parameters if you like!