Population ecology assignment: Population structure

1. A population of elk has $\mathcal{R} = 1.8$ and $\lambda = 1.2$ at its stable age distribution. 40% of individuals counted at age 1 survive to age 2.

a. What is the ratio between the number of individuals born in year x to year $x+1$ if the age distribution is stable?

Because $\lambda = 1.2$, each cohort starts with 1.2 times as many individuals as the previous one.

b. What is the ratio between the population of age class 1 and age class 2 in the stable age distribution?

If we compare the size of the two cohorts when they're both at age 1, the relative size is 1.2:1. If we compare when the older cohort has reached age 2, only 40% of the older cohort will have survived, so the relative size is 1.2:0.4, or 3:1.

Another way to do this is with the formula from the notes for the relative size of cohort x: $\ell_x \lambda^{-x}$. This gives $1/1.2$ for the relative size of the one-year-old cohort, and $0.4 \times (1/1.2^2)$ for the relative size of the two-year-old cohort, which works out the same if you're careful with your pencil or calculator.

2. A scientist studies a population of mice. She finds that they reproduce once a year, that a reproducing one-year old female produces (on average) 1 female offspring who survives to reproduce, and that a reproducing two-year old female produces (on average) 3 female offspring who survive to reproduce. She also finds that 40% of females survive from the first to the second year and no individuals survive beyond this.

a. Make a life table for this population. Should you count before reproduction or after?

We only have enough information to census *before* reproduction (we have no idea how many mice are actually born). The information about offspring surviving to reproduce correspond to $f_1 = 1$ and $f_2 = 3$. See life table below.

b. What is the reproductive number $\mathcal{R}$ for this population?

We obtain $\mathcal{R}$ by summing the $\ell_x f_x$ terms in our life table.

x	f_x	p_x	ℓ_x	$\ell_x f_x$
1	1	0.4	1.000	1.000
2	3	0	0.400	1.200
R				2.200

c. What do you *guess* would be the stable finite growth rate λ for this population?

Each female mouse counted produces 2.2 offspring on average. If these were all in the first year, we would expect the population to increase by that amount each year, so $\lambda = 2.2$. If they were all in the second year, we would expect the population to triple every two years, so $\lambda = \sqrt{2.2} \approx 1.49$. The real answer should be somewhere between. Since more reproduction is expected the second year, $\lambda = 1.6$ might be a good guess.

d. Use the equation $\sum_x \ell_x f_x \lambda^{-x} = 1$ from class to calculate λ for this population. We haven't reviewed this and won't test it, but it's a useful exercise. You can solve, or start from a guess and work it out numerically (2 decimal places is fine).

Substituting our values of ℓf here gives $\lambda^{-1} + 1.2\lambda^{-2} = 1$. Multiplying both sides by λ^2 and subtracting would give a quadratic equation that you could factor or solve, or you should be able to it by trial and error. The answer is 1.70. It is worth noting that this equation also has a negative solution, but this makes no sense biologically. In general, this equation will have one positive solution, and this is the λ we are looking for.