Heads, you're dead

Life history tables can be confusing. A good strategy to understanding is to make up an example and try to apply the new concept or tool. So, today in class we will play simple little game, "Heads, you're dead, roll to reproduce."

The rule for *survival* are simple:

- Each coin represents an individual in our cohort[1]
- Each time step we will flip all "living" coins one time
- Any coin that has its head up is "dead"[2]

[1] Individuals born at the same time that we will track over time.

[2] A coin can only die once (i.e., once it's dead, it isn't flipped any more)

The rule for *fecundity* are not to bad either:

- For each surviving coin, you will roll one die to determine if you reproduce
- If you roll a number that is $\leq x$, where x is the time step, you reproduce. If not, you do not reproduce in that time step.
- If you reproduce, roll again to determine how large your clutch is

We'll start with everyone having a set number of coins to flip and then track how many are alive after each flip (aka time step) as well as how many offspring all of the live coins have. Please record the class data in the n_x (number alive) and F_x (number born) columns in the table. (We'll fill in the rest as we go.)

x	n_x	F_x	l_x	m_x	$l_x \times m_x$
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

x is the time step (e.g., week, month, or year 0, 1, 2, 3...)

n_x is the number surviving at the beginning of that time step

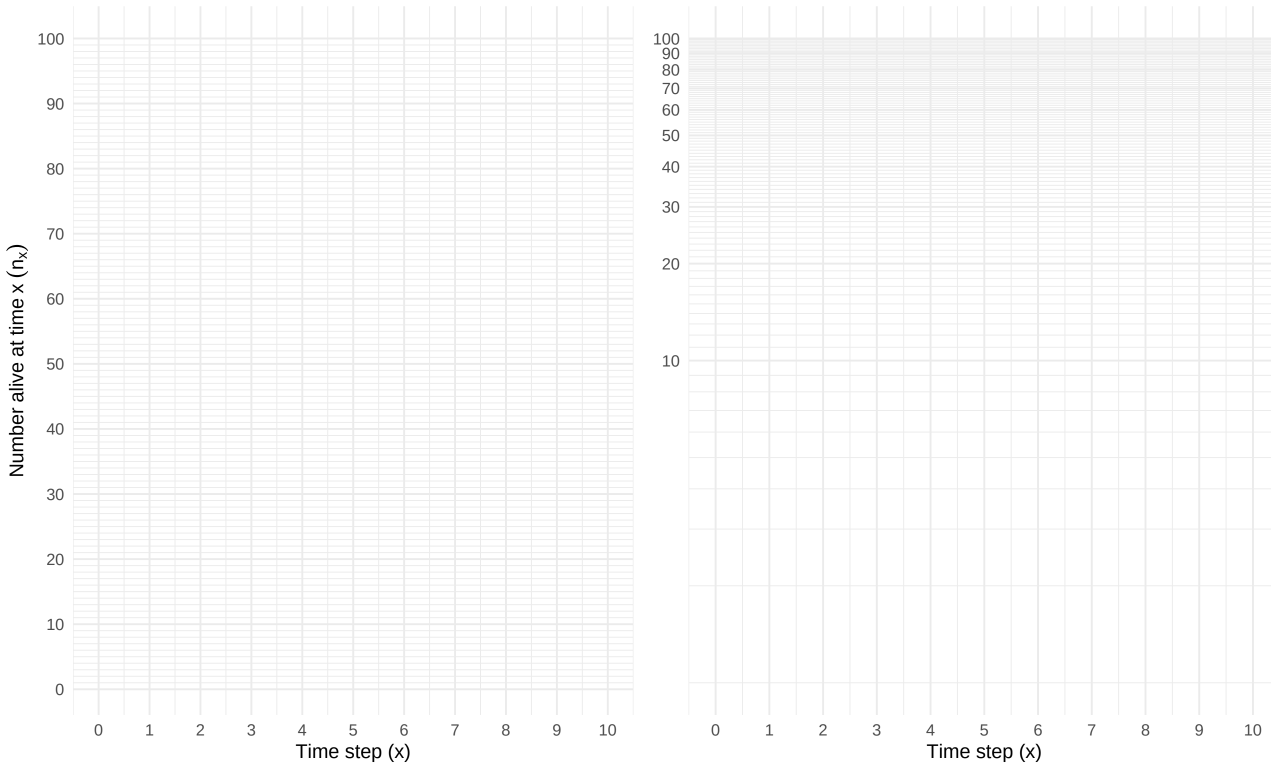
F_x is the number offspring born to the whole cohort in a time step

l_x is the *proportion* surviving at the beginning of that time step

m_x is the *fecundity*, the average number of offspring produced by a live individual in the period from x to $x + 1$.

Graphing our data

With the survivorship data in hand, plot n_x against x on these two sets of axes:



Do the graphs match your expectations? What fraction of individual coins did you expect to be alive at each time point? What do you notice about the slope on the graph with the logarithmic y-axis?

Now would also be a good time to think about what these curves would look like for, say, a set of humans where each time step is 10 years, or a mouse where each time step is a month.

Filling in the table

We still need to fill in our life table. You can start with l_x, which is just the proportion of the original cohort that survived to each point (i.e., $l_x = n_x/n_0$).

Next we need to calculate fecundity based on the reproductive output observed. This is just the average reproduction by someone alive in that time step. That is, $m_x = F_x/n_x$. Fill in these numbers in the table.

With standardized survivorship (l_x) and fecundity (m_x) we actually have everything we need to estimate the growth (or rate of decline) of this population.

This may not be obvious, but in the next step we need to weight the fecundity by the probability of surviving to that point. This is essentially the amount of reproductive output we can expect from a newborn in time step x. It is simpler than it sounds: just multiply l_x by m_x in the right-most column.

Finally, if we sum up all of the $l_x m_x$'s we get the expected reproductive output of a coin over its *entire* lifetime. We call this R_0. That is, $R_0 = \sum l_x m_x$. We can expect every individual[3] will, on average, produce R_0 offspring before it dies.

So, here's a question for you: will this population of coins tend to grow, shrink, or stay the same?

[3] Note that we are assuming every individual is reproductive

Using life tables to guide interventions

Often we want to intervene in a population to make it more or less likely to grow or grow fast. We might want to help an endangered species persist by making sure R_0 is large enough, or instead we might want to reduce the R_0 of an invasive species, pest, or parasite to minimize the harm it does.

Thus, your challenge: imagine you can change the biology of this coin population in one way to make it growth (if it was shrinking) or shrink (if it was growing). What is the best way to intervene to achieve your goal? Your choices are:

- alter one survival transition by 20% (e.g., if the probability of surviving from one time step to the next was 0.5, you could change one of these steps to 0.5 ± 0.1).
- alter the fecundity of one stage/age by 50%
- delay or accelerate reproductive maturity (i.e., when $m_x > 0$) by one step.