

## Lab 7: Life-table Methods

**Objectives:** The purpose of this exercise is to introduce you to the basic calculations that can be conducted with life-tables. Some of these metrics are also of interest in population models based on projection matrices. In this exercise, we will analyse a modified version of the data in Table 5.1 of Pianka's book on Evolutionary Ecology ( $m_x$  has been doubled). The age ( $x$ ), survivorship ( $l_x$ ) and fecundity ( $m_x$ ) are as follows:

Age ( $x$ )	$l_x$	$m_x$
0	1.0	0.0
1	0.8	0.4
2	0.6	0.6
3	0.4	2.0
4	0.4	1.2
5	0.2	0.2
6	0.0	0.0

### Calculations and Questions

1. To get started, set up a spreadsheet by typing labels into each cell as follows: A1=Age, B1= $l_x$ , C1= $m_x$ , D1= $px$ , E1= $l_x m_x$ , F1= $x l_x m_x$ , G1= $l_x m_x e^{-rx}$  and H1= $v_x$ . Enter the ages in the A column (cells A2 to A8), the  $l_x$  values in column B, and the  $m_x$  values in column C.

2. Complete the calculations to fill out columns D, E and F.

- a) What age-class has the highest fecundity and survival rates?
- b) What types of age-specific variation in demography are illustrated by this example?

3. Enter the labels GRR,  $R_0$ ,  $T$  and  $r_{est}$  into cells A10 to A13. Using the following formulae, calculate the gross reproductive rate (GRR), net reproductive rate ( $R_0$ ), generation time ( $T$ ), and an estimate of the instantaneous growth rate  $r_{est}$  and put these in cells B13 to B15.

$$GRR = \sum_{x=0}^w m_x \qquad R_0 = \sum_{x=0}^w l_x m_x \qquad T = \frac{\sum_{x=0}^w x l_x m_x}{R_0} \qquad r = \frac{\ln R_0}{T}$$

- a) Is the population stable, declining or growing?
- b) How many years would it take an average female to produce one female offspring? Do you think this species is likely to be short or long-lived?

4. You are now set to calculate the population growth rate with the Euler-Lotka equation. Enter the labels  $r$  and Sum into cells A15 and A16. Put your initial estimate of  $r$  from B13 into cell B15. Using the following formula for the Euler-Lotka equation complete the calculations for column G.

$$1 = \sum_{x=0}^w l_x m_x e^{-rx}$$

Define  $r$  as cell \$B\$15 and use the EXP function to raise  $-rx$  to an exponent. If you have done

these steps correctly, the sum of column G should be 1.03 which is not equal to one.

5. You can solve for  $r$  by iteratively adjusting the value in cell A15 until the sum in A16 is equal to one. Make a note of the value for  $r$  that you obtain, then change  $r$  back to your starting value. Next, try a feature of Excel to solve this problem. Go to Tools | Solver and pull up the menu. Set Target Cell \$B\$16 to value of 1 by Changing Cell \$B\$15 and click on 'Solve'. Click Okay to keep the Solver solution

a) Do the two methods give the same value of  $r$ ?

b) How does the value of  $r$  from the Euler-Lotka equation compare to  $r_{est}$ ? What are the assumptions of the two values of  $r$ ?

5. The last step is to calculate the age-specific reproductive value ( $v_x$ ). The formula for  $v_x$  is:

$$v_x = \sum_{y=x}^w \frac{l_y}{l_x} m_x$$

To remind yourself of the mechanics of these calculations examine the footnote of Table 4.1 from Pianka (given as a handout).

Here is a trick to save you some typing. Enter the following formula into cell H8 =1/B8\*(\$B\$8\*\$C\$8). Copy this cell into the row above and modify it by adding in the lmt product for that row (=1/B7\*(\$B\$8\*\$C\$8)+\$E\$7). Then copy that cell into the row above and repeat by adding \$E\$6. Reproductive values are usually scaled relative to the first age class by dividing all  $v_x$  values by value for the youngest age class ( $v_0$ ). In I1, type the label vscale and then fill column I with age-specific  $v_x$  values divided by  $v$  for age = 0.

a) What conservation or management strategies would you apply given your demographic analyses for this population?