Name: ______________________________ *BIO 320 — Fundamentals of Ecology*
30 points

Life Tables Homework

Due date: June 17th
You only need turn in pages 3-8. Staple together!

Introduction:

Age-specific mortality, survivorship, and reproductive data for populations of animals or plants can be summarized in a life table. A life table typically shows for each age interval the actual mortality, mortality rate, number of survivors, survival rate, and future life expectancy for a certain number, or **cohort**, of individuals that begin life together. Age-specific fecundity data are often included as well. Life tables thus furnish a quantitative tool for describing the effect of ecological factors on population dynamics and for projecting future population change. Life tables have been used most often with animal populations, where they have proved valuable in developing game management and pest control strategies, but they are increasingly being used in plant demography as well.

Survivorship curves can be constructed by plotting numbers of survivors against age. When the number scale is logarithmic, straight-line sections of the curve indicate periods of constant survival rate, whereas changes in slope indicate increase or decrease in survival rate.

Life Table Computations

A life table consists of columns of age-specific information on aspects of mortality, survivorship, and reproduction for a cohort of individuals. Life tables are frequently produced for cohorts of 1000 individuals, but can start with any number.

The columns of a typical life table are as follows, arranged from left to right:

age (x) = age interval; for long-lived organisms this is typically years.

n_x = number alive at beginning of time interval x.

d_x = number dying during interval x. Can be calculated as: $d_x = n_x - n_{(n+1)}$

q_x = proportion dying during interval x. Calculated as: $q_x = d_x/n_x$

l_x = proportion surviving at the start of interval x. Calculated as $l_x = n_x/n_0$

m_x = age-specific fecundity (number of offspring produced by one adult of age x; alternatively, the number of female offspring per female of age x).

$l_x m_x$ = realized fecundity: expected offspring produced by adults at age x.

$x l_x m_x$ = age multiplied by realized fecundity. This column is not meaningful by itself, but can be used to calculate generation time.

These data then allow the calculation of several other parameters for the population:

R_0 = Net reproductive rate, that is the expected lifetime production of offspring per parent. Calculated as $R_0 = \sum l_x m_x$

Values < 1 represent a potentially declining population, while values > 1 indicate an likely increasing population. This parameter assumes that age-specific birth and death rates are constant.

T = generation time. Calculated as $\sum(x l_x m_x) / R_0$

r = per capita rate of increase (estimated). Calculated as $r = \ln R_0 / T$

Negative values indicate a declining population, while values > 0 indicate an increasing population. This parameter assumes that age-specific birth and death rates are constant.

Life tables can be based on either survivorship data (cohort life table), mortality data (static life table) or age distribution. Cohort life tables are produced by tracking a cohort through time and noting the number alive at each time interval (n_x) as well as fecundity. Such data can be difficult to obtain for many organisms, especially if they are highly mobile.

Static life tables are based on data about age of death. If carcasses can be aged at death (such as from growth rings or tooth wear), this provides data for the d_x column of the life table. n_x can then be calculated from this column ($n_x = d_x + n_{x+1}$). Such data would not provide information about fecundity, of course.

The age structure of a population can be used to generate l_x from the relative proportion of individuals in each age group. This assumes that the population is fairly stable and requires that the ages of individuals can be determined. Other columns can be back calculated (often the age of the youngest sampled individuals is set to age 0).

Part A — Cohort Life Table

1. An actual life table for a population of the copperhead, *Agkistrodon contortrix* (a snake), is presented on the next page with key survivorship (n_x) and fecundity (m_x) data. None of the snakes lived past 13 years of age. Fill in the remainder of the indicated columns. If you have some facility with using formulas in *Excel*, you may find recreating the table in *Excel* to be the easiest method.

age (x)	n_x	d_x	q_x	l_x	m_x	$l_x m_x$	$x l_x m_x$
0	278				0		
1	186				0		
2	125				0.53		
3	84				0.50		
4	59				0.62		
5	42				0.62		
6	30				0.70		
7	21				0.89		
8	15				0.99		
9	11				0.95		
10	8				0.95		
11	5				0.95		
12	4				0.95		
13	2				0		

2. Draw the survivorship curve for copperheads. Age (x) should be on the X-axis and the number surviving (n_x), should be plotted on the Y-axis. **You must plot the Y-axis on a logarithmic scale**. (If using *Excel*, create the graph using the n_x data [select the series tab in the second window to then be able to select the column for the x-axis labels otherwise they will start at 1 instead of 0]. Once the graph is completed, you will need to change the y-axis into a logarithmic scale by double-clicking on the y-axis, selecting the 'scale' tab and then checking the logarithmic scale button.)

3. Based on the shape of the curve you plotted for question 2, what type of survivorship curve do copperheads have?

4. Calculate the net reproductive rate, R_0, for this population of copperheads (show equation and work).

5. Calculate the mean generation time, T, for copperheads (show equation and work).

6. Calculate the per capita rate of increase, r, for this population (show equation and work).

7. Based on the net reproductive rate and/or per capita rate of increase, is this population increasing, decreasing, or remaining stable?

8. In addition to the survivorship graph (Question 2), we can also visualize other aspects of the data. For example, graphing age-specific survivorship against age allows us to detect variation in survivorship, such as when individuals are particularly vulnerable or when they senesce. Survivorship data can be calculated by subtracting the age-specific mortality rate from 1 ($survivorship_x = 1 - q_x$).

9. Based on the graph in Question 7, how much does survivorship change with age in copperheads? Is this what you would have expected based on the survivorship curve in Question 2?

10. Graph the age-specific fecundity (m_x) against age.

11. How does fecundity change with age? How can you explain this pattern? Do these data show evidence of senescence (deterioration in performance due to age)?

12. At which age was the fecundity (m_x) of copperheads greatest? For which age was the expected reproductive contribution ($l_x m_x$) greatest (Question 1)? Why are these different?

Part B — Static Life Table

13. The following age of death data were collected from human grave markers in an Ann Arbor, MI cemetery for 60 graves of persons born before 1870 (why this cutoff date?). Fill in the rest of the table by calculating from the data given. Hint: you should start at the oldest age category, and assume noone survived past 100.

Age class (x)	n_x	d_x	q_x	l_x
0-5		3		
6-10		0		
11-15		1		
16-20		3		
21-25		2		
26-30		2		
31-35		0		
36-40		3		
41-45		1		
46-50		3		
51-55		1		
56-60		5		
61-65		4		
66-70		4		
71-75		4		
76-80		7		
81-85		5		
86-90		10		
91-95		0		
96-100		2		

14. Draw the survivorship curve for the Ann Arbor human population. *Don't forget to plot the Y-axis on a logarithmic scale.*

15. Based on the shape of the curve you plotted for Question 14, what type of survivorship curve did this human population have?