Name: KEY Email: ____________________________ MARS 6920_Spring 2010

Homework Set #5 (10 points)

1) Using the population matrix =

0	0	1	15
0.2	0	0	0
0	0.9	0	0
0	0	0.9	0.6

which describes the population dynamics of a species with four age classes (0, 1, 2 and 3), answer these questions (show your calculations for full credit). What is the probability that a newborn will survive to age class 3? (+0.25 point)

This matrix shows the probability of transitioning from one state (age class) to other states (age classes) in one time step. The transition of a newborn to age class 3 involves three transitions. Because all three need to take place for this newborn to reach age 3, these probabilities need to be multiplied.

Probability of surviving from age class 0 to 1 = 0.2
Probability of surviving from age class 1 to 2 = 0.9
Probability of surviving from age class 2 to 3 = 0.9

So, 0.2*0.9*0.9 = 0.162
probability of surviving from being a newborn (age class 0) to age class 3.

What is the probability that a newborn that survived to age class 1, will survive to age class 3? (+0.25 point)

Following the same logic, the transition from age class 1 to age class 3 involves two transitions.
Probability of surviving from age class 1 to 2 = 0.9
Probability of surviving from age class 2 to 3 = 0.9

So, 0.2*0.9*0.9 = 0.81
probability of surviving from age class 1 to age class 3.

Name: KEY Email: ____________________________ MARS 6920_Spring 2010

What is the probability that an individual in age class 3 will die? (+0.25 point)

To determine the mortality rate of age class 3, it is necessary to figure out the probability of transitioning from age class 3 to age class 3 (or surviving in age class 3). This matrix cell shows that 0.6 (60%) of the individuals will remain in age class 3. Because there are no other possible fates for age class 3 individuals (e.g., they cannot get younger), we can assume that the remaining individuals (40%) who are not accounted for must have died. Thus, 1.0 – 0.6 = 0.4 = mortality rate for age class 3.

2) You have been working on an albatross banding study and these are your data over two years:

Age Class	**First Census (time = day 1)**	**Fecundity (# eggs produced)**	**Second census (time = day 365)**	**Third census (time = day 366)**
first-year-animals	**100**	**0**	**60**	**200**
second-year-animals	**50**	**100**	**30**	**60**
third-year-animals	**25**	**100**	**0**	**30**

Fill in the table below, and please show your calculations (e.g., 100 / 100 = 1).
NOTE: These are annual rates (calculated every 365 days) (+0.25 each)

Age Class	**Fecundity Rate**	**Survivorship Rate**	**Mortality Rate**
first-year-animals	***0.0***	***0.6***	***0.4***
second-year-animals	***2.0***	***0.6***	***0.4***
third-year-animals	***4.0***	***0.0***	***1.0***

Name: KEY   Email: ______________________________   MARS 6920_Spring 2010

Fecundity rates:

- First year animals: 0 eggs / 100 animals = 0.0 eggs/animal
- Second year animals: 100 eggs / 50 animals = 2.0 eggs/animal
- Third year animals: 100 eggs / 25 animals = 4.0 eggs/animal

Survivorship Rates:

- First year animals: 60 animals at end of year 1 / 100 animals at start of year 1 = 0.6
- Second year animals: 30 animals at end of year 2 / 50 animals at start of year 2 = 0.6
- Third year animals: 0 animals at end of year 3 / 25 animals at start of year 3 = 0.0

Mortality Rates:

- First year animals: (100 animals at start – 60 animals at end) / initial amount of 100 = 0.4
- Second year animals: (50 animals at start – 30 animals at end) / initial amount of 50 = 0.4
- Third year animals: (25 animals at start – 0 animals at end) / initial amount of 25 = 1.0

Fill in the following Leslie Matrix:

0.0	***2.0***	***4.0***
0.6	***0.0***	***0.0***
0.0	***0.6***	***0.0***

Matrix Multiplication

The Leslie Matrix allows us to "project" the population size and structure into the future. For each time step (year), we have a vector of the population age structure: [P Q R]

P: # first-year-animals   Q: # second-year-animals   R:# third-year-animals

To project into the future, we multiply the vector (at time t) by the matrix, and get the vector at the next time step (at time t + 1). This is how matrix multiplication is done:

$$\begin{bmatrix} A & B & C \\ D & E & F \\ G & H & I \end{bmatrix} \begin{bmatrix} P \\ Q \\ R \end{bmatrix} = ?$$

$$\begin{bmatrix} A & B & C \\ D & E & F \\ G & H & I \end{bmatrix}\begin{bmatrix} P \\ Q \\ R \end{bmatrix} = \begin{bmatrix} AP + BQ + CR \\ DP + EQ + FR \\ GP + HQ + IR \end{bmatrix}$$

Following this example, use the population vector and the matrix you created to predict the number of individuals in the next two time steps (year1, year2). Show the vectors and the overall population size at both time steps (Hint: start with population of 100, 100, 100 birds).

(+0.25 each)

Age Class	**Year 0**	**Year 1**	**Year 2**
first-year-animals	***P_0=100***	***P_1=600***	***P_2=360***
second-year-animals	***Q_0=100***	***Q_1=60***	***Q_2=360***
third-year-animals	***R_0=100***	***R_1=60***	***R_2=36***
Population Size	***$P_0+Q_0+R_0$=300***	***$P_1+Q_1+R_1$=720***	***$P_2+Q_2+R_2$=756***

To get from Year 0 to Year 1:

P_0=100		***0.0***	***2.0***	***4.0***		***(0.0)(100)+(2.0)(100)+(4.0)(100)***		***600***
Q_0=100	***x***	***0.6***	***0.0***	***0.0***	=	***(0.6)(100)+(0.0)(100)+(0.0)(100)***	=	***60***
R_0=100		***0.0***	***0.6***	***0.0***		***(0.0)(100)+(0.6)(100)+(0.0)(100)***		***60***

To get from Year 1 to Year 2:

600		***0.0***	***2.0***	***4.0***		***(0.0)(600)+(2.0)(60)+(4.0)(60)***		***360***
60	***x***	***0.6***	***0.0***	***0.0***	=	***(0.6)(600)+(0.0)(60)+(0.0)(60)***	=	***360***
60		***0.0***	***0.6***	***0.0***		***(0.0)(600)+(0.6)(60)+(0.0)(60)***		***36***

Calculate Lambda (year 0 to 1) (+0.25):

Lambda is calculated as the ratio of the final (year 1) and the initial (year 0) population size:
720 / 300 = 2.4 = lambda = population growth rate

Calculate Lambda (year 1 to 2) (+0.25):
756 / 720 = 1.05 = lambda = population growth rate

3) Mountain lions have the following average population demography rates:

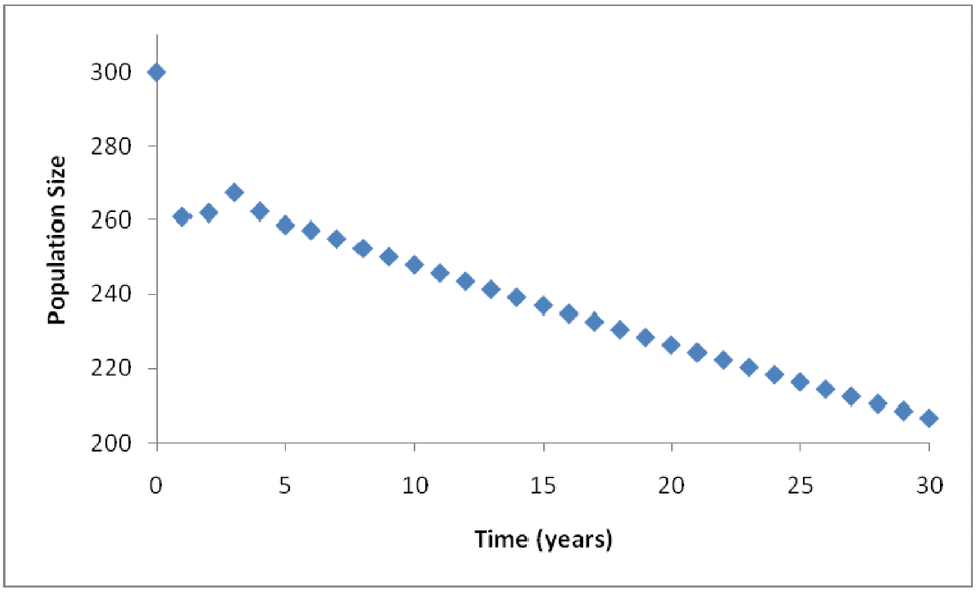
- Probability of a 0 to 1 year old female giving birth = 0
- Probability of a 2 year old - or older - female having a litter in a given year = 0.40
- The mean litter size is 1.4 pups
- Probability of surviving from 0 to 1 years of age = 0.65
- Probability of surviving from 1 to 2 years of age = 0.65
- Probability of yearly survival after 2 years of age = 0.75

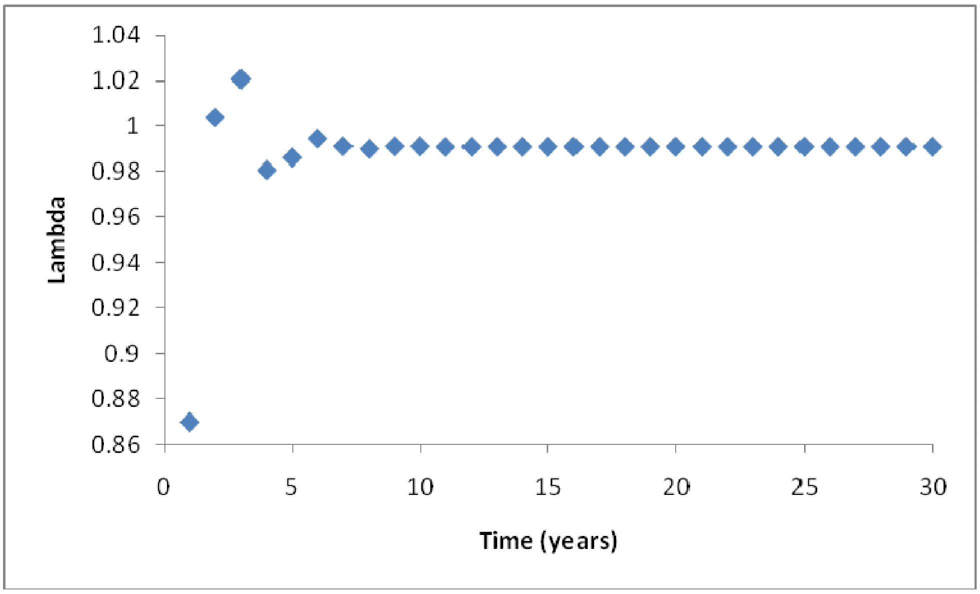
a) Use these rates to create a three-stage population matrix for female lions: newborns, one-year olds, and two-to-infinity year olds (+0.25). Draw matrix below:

		FROM:		
		Age class 1	***Age class 2***	***Age class 3***
TO:	***Age class 1***	***0.0***	***0.0***	***0.56***
	Age class 2	***0.65***	***0.0***	***0.0***
	Age class 3	***0.0***	***0.65***	***0.75***

b) Use this matrix to predict whether mountain lions are increasing or decreasing over time. Project the population into the future until the Lambda you calculate for each time step stabilizes (your estimate has a S.D. of +/- 0.02). Hint: To do this, enter the data into Excel and use the program to project numbers into the future. Start with a population vector {100, 100, 100} at time = 0, and run Excel for 30 time steps. Turn in a plot of population size over time (31 years) and report your statistics (Mean lambda, CV lambda, minimum lambda, maximum lambda) for the following groups spans of 10 generations: 1-10, 11-20, 21-30 (+0.75)

Figure 1. Annual population size projection and resulting Lambda values





The mountain lion population is decreasing (the slope of the best fit line is – 2.27). The projection of the annual population sizes and lambda values revealed that these values stabilized within the desired range (SD = 0.02) at year 5. These rates remain stable thereafter.

These are my results of the calculations for consecutive 10-year periods:

Years 1-10:
Mean Lambda: 0.982
CV Lambda: CV = 4.16 %
Minimum Lambda = 0.87
Maximum Lambda = 1.02

Years 11-20:
Mean Lambda = 0.9909
CV Lambda: CV = 0.0030%
Minimum Lambda = 0.9908
Maximum Lambda = 0.9909

Years 21-30:
Mean Lambda = 0.9909
CV Lambda: CV = 0.000001%
Minimum Lambda = 0.9909
Maximum Lambda = 0.9909

Table 1: Statistics for annual lambda values during three time periods:

	Mean Lambda	**CV**	**Minimum**	**Maximum**
Years 1-10	0.9820	0.0416174	0.8700	1.0208
Years 11-20	0.9909	0.0000302	0.9908	0.9909
Years 21-30	0.9909	1.62626E-08	0.9909	0.9909

c) On the basis of this matrix - once you have reached stable population growth and composition – use the mean proportion of the individuals in the different age classes to determine the probability that if you encounter an adult lion (not a pup), it will be a one-year-old, rather than a two-or-older-year-old (show your calculations)? (+0.25)

Using the data from years 5 to 30 (once the population structure has stabilized):
Determine the average of the three age classes, out of the total population size:

Mean of individuals in age class 2, at year 5 and later: 44.43
Mean of individuals in age class 3, at year 5 and later: 120.02

So, if an adult lion is encountered, it could be age class 2 or age class 3.

Divide the number of age class 2 by the total of non-pus (age classes 2 and 3):

44.43 / (44.43 + 120.02) = 0.27

This is the probability of encountering a one-year-old adult.