The following demographic information exists for a population.

<table>
<thead>
<tr>
<th>Age $x$</th>
<th>$S_x$</th>
<th>$b_x$</th>
<th>$F_x$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pre-Breed</td>
</tr>
<tr>
<td>0</td>
<td>0.6</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>1</td>
<td>0.85</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.95</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

1. Fill in the Net Fecundity Rate column for each age class.
2. Provide a symbolic and numeric version of a pre-breeding Leslie matrix for the population. For the symbolic version, write out the formula using $S_x$ and $b_x$ terms with the appropriate number for age replacing $x$. When writing out those formulae, I strongly recommend writing out the terms in the order that each occurs in the real life of the species. In the pre-breeding matrix, the element in position $[1, 2]$ of the matrix would contain “$b_2 S_0$” because the newborns produced by 2-year olds would be born at rate $b_2$ right after the census and then those newborns would survive to the next age class at rate $S_0$.
3. Provide a symbolic and numeric version of a post-breeding Leslie matrix for the population. I again strongly recommend writing out the terms in the order that each occurs in the life of the organism. In the post-breeding matrix, the element in position $[1, 2]$ of the matrix would contain “$S_1 b_2$”, because the 1-year olds would survive to age 2 at rate $S_1$ and then those that survived would produce newborns at rate $b_2$ just before the next census.
4. Provide a life-cycle graph for this population for a pre-breeding census.
5. Modify the file `LeslieIntro.r` as needed to determine both the population’s transient dynamics and asymptotic properties for both the pre-breeding and post-breeding matrix. To keep things organized, I recommend that you create an R script for each version of the matrix, i.e., one script for the pre-breeding matrix and another one for the post-breeding matrix. For each scenario, start with a population vector that has 10 animals in each age class. You do not need to show me your code, but you should make sure you can write, use, and understand the code for each scenario. (Hint: if you have things correct, your asymptotic value of lambda will be 0.9920233 for each version of the matrix).
6. Provide me with the resulting population vectors for the first 8 years & compare/contrast the results obtained using a pre-breeding vs. a post-breeding matrix.
7. Provide me with lambda for each of the first 8 years & compare/contrast the results obtained using a pre-breeding vs. a post-breeding matrix.
8. Provide me with vectors of the proportion in each age class in each of the first 8 years & compare/contrast the results obtained using a pre-breeding vs. a post-breeding matrix.
9. How many years does it take to attain the asymptotic value of lambda for each matrix? (NOTE: you may need to beyond 50 years to find out.)
10. What is the stable age distribution for each matrix?
11. Produce a matrix plot of the number of animals in each age class each year for the pre-breeding matrix.
12. Produce a matrix plot of the proportion of animals in each age class each year for the pre-breeding matrix.
13. Produce an x-y plot of lambda in each year for the pre-breeding matrix.
Calculate the sensitivity of lambda to small changes in each of the matrix elements using an approximation method that should help your understanding of sensitivity.

1. Record the matrix’s asymptotic value of lambda (to many decimal places). Working with 1 matrix element at a time, do the following.

2. Add 0.001 to a matrix element and re-calculate the matrix’s asymptotic value of lambda (to many decimal places) while all other vital rates are at their original values.

3. Calculate lambda’s sensitivity to a change in that matrix element as: \[
\frac{\lambda_2 - \lambda_1}{0.001}.
\]

14. Report the sensitivity values obtained in this way for each matrix element in a simple table for the pre-breeding matrix.

15. Which elements of the pre-breeding matrix is lambda most sensitive to?

16. Which elements of the pre-breeding matrix is lambda least sensitive to?