**Computer Lab #1 - Effects of Seed Predation on the population dynamics of Tidestrom’s Lupine**

The goal of this computer lab is to parameterize a structured population model from field data that is in excel, to calculate the population growth rate with and without the threat of seed predation, to project population size into the future, and to quantify the elasticity of the population growth rate to perturbations in each matrix element.

We are not going to support you with the function in each step but write them here in the beginning (Note there are only few functions we need today. Today you will spend more time using your data and understanding where parameter values come from in a structured population model).

**Useful functions for today and in general:** **read.xlsx(), subset(), paste(), sum(), mean(), plot(), data.frame(), matrix(), table(), eigen(), max(), Re(), log()**

**Good to know:** in a data frame, matrix or any other table like object the indexing is as follows: **df[“row”, ”column”].** So calling **df[1,]** will show you your entire first row, calling **df[,1]** will show you your entire first column. If your rows or columns are named you can also write **df[“name of row”,]** or **df[,”name of column”]**

**Note:** You (may) need to know this time how to work with characters in R depending on how you chose to solve these tasks. A character is a word, a letter or anything that is not a number. (So far this word document is one big character).

In R, characters are defined like this: **“I am a character”**. Test it by writing it with the **“…”** in your console. Try it also without it; you will get an error message. Numbers are defined as numeric and do not need special care.

1. Read your data into R
2. Create a life cycle graph for the Lupine based on the information below (don’t need to use R, I would recommend using power point).

Life: Lupines have four stage classes: seedbank, seedling, juveniles, adults. Seeds in the seedbank can germinate and become seedlings or can die from one year to the next. Seedlings that survive from one year to the next will be either juveniles or adults in the next year. Juveniles that survive from one year to the next will be either juveniles or adults in the next year. Adults that survive from one year to the next will be either juveniles (they can shrink) or adults in the next year. Adults produce seeds that can either enter the seedbank or seedling stage classes in the next year.

Hint: You can also translate the data frame given / matrix in three directly into the life cycle graph.

1. Create a matrix A as this:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Seedbank | Seedling | Juvenile | Adult |
| Seedbank | 0 | 0 | 0 | X |
| Seedling | X | 0 | 0 | X |
| Juvenile | 0 | X | X | X |
| Adult | 0 | X | X | X |

**Note**: X stands for missing values you need to fill in later.

**Information:** - I am going to give you three examples what the cells in the matrix mean

1. Seedbank (column) – Seedbank, the probability of a seed staying in the seedbank if it is in the seedbank. It is 0 that means there is no possibility that a seed stays in the seedbank
2. Seedbank (column) – Juvenile (row), the probability of a seed in the seedbank becoming a juvenile, which is 0.
3. Seedling (column) – Juvenile (row), the probability of a seed becoming a Juvenile, which is for you to figure out based on the excel data from the field study.
4. Fill in the gaps in your life cycle graph and your data frame / matrix.

4.1 There is a 100% chance of a seed in the seedbank becoming a seedling

4.2 For:

* Probability of a seedling becoming juvenile
* Probability of a seedling becoming an adult
* Probability of a juvenile staying an juvenile
* Probability of an adult staying and adult
* Probability of an adult becoming a juvenile

You can use your excel data from the field study to calculate those probabilities.

4.3 Calculate the number of seedlings produced by each adult. Beware of true zeros. The number of seedlings produced by each adult is the product of: s\*(1-p)\*f\*v\*g

**s = number of fruiting stalks produced per plant (you can use your data)**

**p = probability that a fruiting stalk is eaten (you can use your data)**

**f = Seed per fruiting stalk (f=14.13).**

**v = viability of seeds (v=0.04,** meaning that only 4% of the seeds are able to germinate at some point in the future)

**g = proportion of viable seeds that germinate immediately (g=0.25)**

4.4 Calculate the number of seeds in the seedbank produced by each adult: s\*(1-p)\*f\*v\*(1-g). Beware of true zeros.

1. Once you have filled in the matrix you can calculate the population growth rate. Do so. The growth rate is the maximum eigenvalue of the matrix. I will give you a hint that in the final step when you want to store the growth rate you need **Re()**.
2. Calculate the elasticity matrix. Which matrix element is the population growth rate most sensitive to changes in (highest elasticity)? For this I will provide the skeleton in the beginning and all of the code at the end as it is rather complicated and uses many not commonly used functions.

**lmax <-** which(what is the position of the maximum eigenvalue calculated?)

**W <-** Earlier you stored the results of **eigen()** let’s say **ev** (which is a **list**). Use **ev$vectors** to store the eigen vectors in **W**

**w <-**If we look at **W** now, we see that the values are considered complex numbers. Complex numbers do not work for the further steps so we need to store them as numeric values. We will use: **abs(Re(W[,lmax])**, **lmax** because we only need the eigen vector of our growth rate.

**V <- try(Conj(solve(W)), silent=TRUE)** just copy this, it basically applies a second (the inverse matrix) to W and calculates it for you.

**v <- abs(Re(V[lmax, ]))**

**s <- v %o% w**

**e <- s \* Ad/R**

1. What is the additive elasticity value of all matrix elements that could be altered by seed predation?
2. There is a beautiful Tidestrom’s Lupine population located at Point Reyes National Seashore in California. It currently contains 100 seeds in the seedbank, 25 seedlings, 150 juveniles and 500 adult plants.

Plot the size of each stage class for the next 50 years (make two plots: one visualizing the size of each stage class through time and another looking at the LOG size of each stage class through time). Make sure you turn in your plots with this computer lab. Matrixes are multiplied with vectors like so in R: matrix %\*% vector

1. What would the population growth rate be without mice predation? Change the necessary value and calculate the population growth rate again.