Goals For This Week

In this lab we’ll study the logistic function. Then we’ll simulate a population growing in a noisy environment. This means we’ll have to get R to generate random numbers to use in our simulation.

1 Logistic Growth

Logistic growth arises when a population is growing in the presence of a limited resource. Specifically,

\[ P(t) = \frac{KP_0e^{rt}}{K + P_0(e^{rt} - 1)} \]  

(1)

Here \( P_0 \) is the initial population size, \( K \) is the maximum population size based on the resources, \( r \) is the growth rate of the population. Let \( t \) be the time in years.

Your first task is to encode this as a function in R.

```r
logistic<-function(t,r,K,P0){...
}
```

Let \( K = 100 \ P_0 = 1 \) and \( r = 1 \). Plot the size of the population for 100 years.

2 Modified Logistic Growth

The logistic formula assumes that the growth rate and the maximum population size are constant over time. This is not likely to be true. Unfortunately, there is no simple formula that gives the population size if the environment changes, so we’ll have to simulate it.

First, write a function \( f \) that describes how the population changes over one year. Outside of the function’s ‘skeleton’, it will only consist of three lines.

First we’ll pick a random number from a normal distribution with mean \( K \) and variance \( \text{var} \). This will be the carrying capacity for the year.

\[ C<-rnorm(1,K,\text{var}) \]

Then, we can compute the population size in the following year.

\[ R<-r*(1-p/C) \]
\[ \exp(R*t) \]

Before going on, make sure you have the function ‘f’ written. It should consist of the three lines I provided enough, with an extra function command at the beginning.

We’ll need to write another function called “popsim” (or whatever you want). It takes all the same arguments as the logistic function as well as the new argument called "var". The value of "var" represents the variability of the environment. Also, it takes a function \( N \), representing the number of years that the simulation will run for. We don’t need to give it \( t \).
popsim<-function(N,r,K,P0,var){
}

I want the popsim function to
1. Simulate \( N \) years of the population growth. This uses the function \( f \) (when calling, \( f \), let \( t=1 \)).
2. Plot the result, with appropriate labels and then
3. Plot a logistic curve over the top of the simulation results
This is extremely similar to many other functions that you have written.

3 Task for this week
1. Please include all your code (in the document, not the email)
2. Include the plot described in the first section
3. Calculate the limit of the logistic function as time goes to \( \infty \).
4. Find the point of inflection of this function.
5. Biologically, why does it have a point of inflection and what does it mean?
6. What (biological) factors do you think might influence the maximum population size? We’re drawing numbers from a fairly simple random distribution, can you think of a better alternative?
7. Use popsim, to simulate a population for 100 years, with initial population 1, max per capita growth rate \( r = 1 \) and \( K = 100 \). Use \( var = 0, 1, 5, 10, 20, 100 \).
8. Describe what happens when you increase the variance. Do you see any patterns in the population fluctuations?
9. Same as above except create 5 different plots with \( var = 40 \).
10. Describe what you think is happening to each of these five populations.