Lab 2 assignment — Geometric and logistic growth models
Due before Monday

Answer each of the following questions by completing the provided Excel template and by replicating your work in R. Upload your Excel file and R script to ELC before Monday. Name the files with your last name followed by your first name.

Exercise 1

A study was conducted in which a population of 100 Mexican grey wolves (*Canis lupus baileyi*) was monitored intensively for 1 year. In that time, 10 pups were born, and 20 of the original 100 individuals died. There was no immigration or emigration.

1. What are the values of B, D, b, d, r, and lambda (λ)?
2. Assuming geometric growth, what will population size be in each of the subsequent 10 years? Create a graph of the results, including important chart elements such as axis titles. Remember, the geometric growth model is: $N_{t+1} = N_t + N_t r$.

Exercise 2a

Many people assume that the human population acts differently than most wildlife populations and is increasing at an exponential rate, or close to it. The UN estimated that the human population was approximately 6 billion people in 1999, and 7 billion in 2012.

1. Given this data and the (multi-step) geometric growth equation: $N_t = N_0(1 + r)^t$, calculate r for the human population over this 13-yr period. You will need to recall how to solve algebraic equations with exponents. Google it if you forgot.
2. Use the (single-step) geometric growth equation ($N_{t+1} = N_t + N_t r$) and the value of r that you calculated above to predict the human population size from 2013–2021.
3. Graph your results.
4. How closely does your model's prediction compare to the actual human population size in 2021? You can find the current population size here: `https://www.worldometers.info/world-population/`. More data about the world population can be found here: `https://ourworldindata.org/world-population-growth`. Write your answer in the Excel sheet.

Exercise 2b

UN data on human population size from 1999 to 2012 are provided on sheet "Exercise 2b".

1. Calculate the population growth rate ("lambda": $\lambda_t = N_t/N_{t-1}$) for each year starting in 1999.
2. Using a starting values of 6 billion people in 1999, pick values of r that make a geometric growth curve closely approximate the actual data. Use trial and error to find a good value of r.
3. The logistic growth model is: $N_{t+1} = N_t + N_t r_{\max}(1 - N_t/K)$ where $r_{\max}$ is the maximum growth rate and K is the carrying capacity. Using a starting values of 6 billion people in 1999, pick values of r_{max} and K that make a logistic growth curve closely approximate the actual data. Again, use trial and error to find good parameter values.
4. Use the values you calculated above to make four graphs of:
   - Actual abundance (N) over time
   - Lambda (λ_t) over time
   - Predicted geometric growth over time
   - Predicted logistic growth over time.
5. Is recent human population growth more similar to geometric or logistic growth? Be explicit about how the observed trends of abundance and λ_t indicate how the human population is growing. Write your answer (3–4 sentences) in the Excel sheet.

R tips

Here's an example of a logistic growth model.

```r
rmax <- 0.1                  ## max growth rate
K <- 200                     ## carrying capacity
years <- 2001:2050           ## years
nYears <- length(years)
N1 <- rep(NA, nYears)
N1[1] <- 100                 ## abundance in first year
## for loop
for(t in 2:nYears) {
    N1[t] <- N1[t-1] + N1[t-1]*rmax*(1 - N1[t-1]/K)
}
plot(years, N1, type="l", xlab="Year", ylab="Abundance",
     main="Logistic growth")
```