Assignment 2 - Grizzly Bear Population Viability Analysis

The data file Grizzly.csv contains a time series of the abundance of adult female grizzly bears in Yellowstone National Park, USA, between 1959 and 1978. For this assignment you will analyze the population dynamics of grizzly bears, in particular their risk of extinction.

1. (10 points) Plot the abundance of female grizzly bears through time. Use open circles as your symbol on the plot and connect the symbols with a line. Remember to label your axes and include a figure caption. Hint: look up the plot, points, and lines functions. Describe in words the trends in abundance 1959-1978.

2. (10 points) Calculate the timeseries of annual population growth rates, $r_t=\ln(N_t/N_{t-1})$ for Yellowstone grizzly bears. What is the mean population growth rate (+/- approximate 95% Confidence Intervals) for the period 1959 to 1978?

3. (15 points) A simple deterministic model for grizzly bear population dynamics is
   $N_{t+1} = N_t \exp(r)$,
   where r is the average population growth rate. Show (with equations, not simulations) how this model can be obtained from our calculation of the population growth rate. Using the mean population growth rate r, simulate the model for 50 years using an initial population size of 44. What is the final population size? Do it again and determine how long it will take the population to decline to 10 bears. Include a plot of the simulation.

4. (15 points) A simple stochastic population model (via parametric bootstrap) for grizzly bear population dynamics is
   $N_{t+1} = N_t \exp(r_t)$,
   where r_t is a single annual observation of the population growth rate drawn randomly (with replacement) from the set of annual population growth rates we calculated in (2). Conduct a stochastic simulation of the model over 50 years with initial population size of 44 bears using the r_t estimates for the time period 1959 to 1978. The Include a plot of the simulation.

5. (15 points) Suppose we set 10 bears as a critical minimum population size. We are interested in estimating the probability that the population will drop below this threshold over a time period of 50 years. Using the r_t estimates for the time period 1959 to 1978 and an initial population size of 44, estimate this probability by conducting 1000 stochastic simulations of the model in 4

and counting the number of simulations where the population size dips below 10. Hint: you will need to use the 'for' and 'if' commands.

6. (15 points) For the sets of 1000 simulations above, calculate the average final population size and the 95% confidence intervals on this estimate (Hint: the 2.5^{th} and 97.5^{th} percentiles of the distribution of final population sizes – look up the function quantile).

7. (20 points) Repeat 5 and 6 above but approximate the distribution of r_t with a Normal distribution with mean and standard deviation estimated from the r_t values. That is, the model is
   $N_{t+1} = N_t \exp(r+\varepsilon_t)$
   where r is the mean of the r_t values and ε_t is a random Normal variable with mean zero and standard deviation estimated from the r_t values. Hint: use the function rnorm. How do the results from the two different stochastic models (7) versus (5) compare?