EEB 319 Lab 2 - Grizzly Bear Population Dynamics

The Excel file Bears.xls 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 black circles with white fill as your symbol on the plot and connect the symbols with a black line. Remember to label your axes, make your axis labels easily readable, and include a figure caption. Describe in words the trend in abundance.

2. (10 points) In the spreadsheet, create a new column beside the bear abundances and label it 'lambda' and in it calculate the timeseries of annual geometric population growth rates, $\lambda_t = N_{t+1}/N_t$ for each year (note there will be one less λ_t observation than the abundances). Create another new column beside the lambda column and in it calculate the annual exponential population growth rate $r_t = \ln(\lambda_t)$. What is the mean of the exponential population growth rates and what is its standard deviation (hints: use the excel functions 'LN', 'AVERAGE' and 'STDEV'.

3. (15 points) A simple exponential growth model (without stochasticity nor density dependence) for grizzly bear population dynamics is
   $N_{t+1} = N_t \exp(r)$
   where r is the average population growth rate. Using the mean population growth rate r, simulate the model for 50 years using an initial population size of 44 at time t=0 (Hint: start a new spreadsheet and create a column for time and a

column for abundance and use the exponential growth formula above to relate population size at the current time step relative to the abundance in the previous time step (one cell above it) then copy the formula down the column of cells to the row corresponding to t=50). What is the final population size at time t=50? Do it again and determine how long it will take the population to decline to less than 20 bears. Include a plot of the simulation.

A simple stochastic density-independent population model for grizzly bear population dynamics is

$N_{t+1} = N_t \exp(r + \varepsilon_t)$,

where r is the mean population growth rate and ε_t random variable from a normal distribution with a mean of zero and standard deviation of the growth rates you calculated in section (1). Recall from lecture that this model has a solution

$N_t = N_0 \exp(rt + \phi_t)$,

where N_0 is the initial population size, r is the mean exponential population growth rate, and ϕ_t is a random normal variable with mean=0 and variance = $t\sigma^2$ where the σ^2 is the variance of the r_t values.

(4) (15 points) In this question we will analyze how the mean and variance of the predicted population size change through time. Plot the predicted mean population size +/- 1 standard deviation from time t=1 to t=50 with a starting population size of 44 at time t=0. (Hint: create three columns for the predicted population size at each time step, one for the mean plus 1 standard deviation, and one for the

mean minus one standard deviation). What is happening to the range of uncertainty around the predicted population size as time increases?

5. (15 points) For the stochastic model of grizzly bear population dynamics $N_{t+1} = N_t \exp(r + \varepsilon_t)$, conduct a stochastic simulation of the model from time t=1 to t=50 years with initial population size of 44 at time t=0. (Hint: you can use a similar method to question (3) but you need to add the random variable at each time step. In Excel the function NORMINV(RAND(),mean,sd) will generate a random normal variable from a distribution with a mean and standard deviation that you specify). Include a plot of the simulation and describe what you see in words.

6. (20 points) Suppose we set 20 bears as a critical minimum population size above which we want to maintain the population. We are interested in estimating the probability that the population will drop below this threshold over a time period of 50 years. Using the model in question (5), estimate this probability by conducting 100 simulations and counting the number of simulations where the population size dips below 20. (Hint: you will need to create 100 new columns for the simulations and at the bottom of each column you can use the IF and MIN function to help you identify and count up the simulations that dropped below 20)

7. (15 points) For the set of 100 simulations above, calculate the average final population size and the 95% confidence intervals on this estimate (Hint: the 2.5th and 97.5th percentiles of the distribution of final population sizes – look up the function PERCENTILE in Excel).