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Lab 3 Worksheet

Human Population Example

**To forecast human population growth, we need λ**

**Nt = N0 λt**

*Open Human Population Growth Excel file*

Click on Spreadsheet: Human Pop Growth I

 Sheet contains Year and Population Size columns (filled out) plus blank lnN column

**Step 1**: Make figure of population growths

Make figure of Population Size (y-axis) vs. Year (x-axis)

Highlight both columns (Year and N)

Go to: Insert tab, Scatterplot

Excel defaults to using left-hand column as x-axis and right-hand column as y-axis

Clean up nonsense on figure

Click on chart – Go to Chart Layout tab at the top – Add y-axis title: Population and x-axis title: Year

🡪 This looks like multiplicative growth

Need to linearize to be certain; we’ll use natural logs

**Step 2**: Linearize data

Creating column of lnN

Fill out data under column heading: lnN

Create formula: =ln(B6)

Copy down column

Create new plot

Highlight Year column; press Ctrl; Highlight lnN column

Go to: Insert tab, Scatterplot

Clean up nonsense on figure

Add y-axis title: ln Population Size

Trend is non-linear!

This indicates growth rate of population is not constant

🡪 population grow slowly before 1950 (flatter slope, smaller λ)

🡪 population grew much faster after 1950 (steeper slow, larger λ – there is inflection point)

This is a problem for our model, Nt = N0 λt, since we assume that λ is constant

One solution:

Since we are **forecasting** population size, we can choose to work with only the last section of data (post-1950), i.e., 1970 - 1995

**Tangent**: How to calculate λ from linear regression

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**Step 3**: Work with last six data points

🡪 Calculate λ for last six data points

Reduce the data being plotted to last six points

 Click on points on figure

 Change the selection boxes for data in figure to just 1970-1995

Data look much more linear now

Step 4: Add a trendline

To get slope, we can add a trendline to data

Click on datapoints

Go to: Layout tab; select Trendline button; select linear trendline

 Looks good!

Now need equation and goodness of fit value, R2

Click on trendline

Click on trendline, Go to Layout tab, select Trendline button; click on “More Trendline Options’

Put check marks in “Display equation on chart” and “Display R-squared value on chart”

Slope = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

R2 =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 5: Calculate λ

Write slope value in a nearby cell: \_\_\_\_\_\_\_\_\_\_

To calculate λ:

Click in a neighboring cell

Type equation: =exp(cell)

🡪 λ = \_\_\_\_\_\_\_\_\_\_\_\_\_

Can use λ and population growth equations to forecast population growth

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**Step 6**: Forecasting population growth

Goal: Create a spreadsheet formula that calculates next year’s population size (Nt+1) based on:

 this year’s population size (Nt)

 birth rate (b’)

 death rate (d’)

Click on Spreadsheet: Human Pop Growth II

Spreadsheet has columns: Year (recoded), b’, d’, and N (relative & absolute addressing)

Population size for 1995 (5,750,000,000) is already included for Year=0

Create equation to calculate next year’s population size from last year’s population size:

=[cell above] \* (1 + [neighbor birth cell] – [neighbor death cell])

Show how could copy and paste formula the entire length of column

Show more general formula:

=[cell above] \* (1 + [b’cell] – [d’ cell])

Show how can use $ to keep specific cells

 This is useful of want to tinker with b’ or d’

Show how can copy and paste formula the entire length of column

Step 7: Include Immigration and Emigration

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Blue Whale Population Example

**Learning objectives**: In this lab, we will learn how a simple model of population growth can be used to make predictions about the fate of a harvested population. In the process, we will apply ideas learned in lecture about rates of gain and loss, reinforce the distinction between proportional and absolute rates of gain and loss, and introduce the concept of a maximum sustainable harvest. We also get our first exposure to positive feedback.

Part 1. Answer Exercise 1.1 in the textbook using pencil, paper, and a calculator.

Exercise 1.1: BLUE WHALE RECOVERY

This exercise is based on the Blue Whale example of section l.4.3. The population dynamics of the Blue Whale population and predictions of harvest levels have been made using exponential models. The growth rate *(R or* λ*)* of the population during the period represented in Figure l.9 was 0.82. i.e .. the population declined by 18% per year. The fecundity of Blue Whale has been estimated to be between 0.06 to 0.l4 and natural mortality to be around 0.04. In the absence of harvest, the growth rate of the population would be between l.02 and l.1O. We want to estimate the time it will take for the Blue Whale population to recover its 1930's level. Assuming a population size in 1963 of 10,000 and a target population size of 50,000, calculate how many years it will take the population to recover:

(a) if its growth rate is 1.10.

(b) if its growth rate is 1.02.

Hint: use the method for calculating doubling time, but with a different factor than 2. Remember that the population growth rate, R, in the textbook is equivalent to our growth rate, λ.

Part 2a. Estimate how long it will take the blue whale population to increase from 10,000 to 50,000 whales given a finite per capita birth rate (b') of 0.10, a finite per capita death rate from natural causes (d') of 0.05, and a **series** of annual harvests between 0 and 600 (e.g., 0, 100, 200...) whales per year. To solve this problem, create a population model using Excel in which population density for each year in the future is calculated based on population density in the preceding year, b', d', and annual harvest. Do this for all harvest levels. Find the time it takes to reach 50,000 whales from the time trajectory in each model.

What are your assumptions?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Starting Population | Birth Rate | Death Rate | Harvest  | Time to reach 50,000 |
| 10,000 | 0.10 | 0.05 | 0 |  |
| 10,000 | 0.10 | 0.05 | 100 |  |
| 10,000 | 0.10 | 0.05 | 200 |  |
| 10,000 | 0.10 | 0.05 | 300 |  |
| 10,000 | 0.10 | 0.05 | 400 |  |
| 10,000 | 0.10 | 0.05 | 500 |  |
| 10,000 | 0.10 | 0.05 | 600 |  |

1. What is the maximum sustainable harvest for the population?
2. Plot the relationship between harvest and number of years to reach 50,000 whales. Plot the trend in population size over time for the next harvest level **above** the maximum sustainable. Comment on the shape of both plots (i.e. describe what they tell us and what is happening in them).

Part 2b. Assume that, instead of a constant number of whales being harvested each year, a constant **proportion** of whales is removed each year. In this case, you can calculate how long it will take for the population to reach 50,000 whales without using Excel\*. Use a series of increasing harvest rates starting at 0.5% per year (and ending at the maximum sustainable harvest), and provide a table of the results.

\*A good practice exercise would be to also do this part with an Excel table and make sure you get same answers.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Starting Population | Birth Rate | Death Rate | Harvest Rate | Time to reach 50,000 |
| 10,000 | 0.10 | 0.05 | 0 |  |
| 10,000 | 0.10 | 0.05 | 0.005 |  |
| 10,000 | 0.10 | 0.05 | 0.010 |  |
| 10,000 | 0.10 | 0.05 | 0.015 |  |
| 10,000 | 0.10 | 0.05 | 0.020 |  |
| 10,000 | 0.10 | 0.05 | 0.025 |  |
| 10,000 | 0.10 | 0.05 | 0.030 |  |
| 10,000 | 0.10 | 0.05 | 0.035 |  |
| 10,000 | 0.10 | 0.05 | 0.040 |  |
| 10,000 | 0.10 | 0.05 | 0.045 |  |
| 10,000 | 0.10 | 0.05 | 0.050 |  |
| 10,000 | 0.10 | 0.05 | 0.055 |  |

Show your work and calculations below:

Based on your calculations, what is the maximum harvest rate for this population?