Assignment 2: Population Dynamics

Introduction

"Suppose that one catches a sample of animals from a population, marks them and releases them. Suppose further that, after allowing the marked animals time to become thoroughly mixed into the rest of the population, one takes another sample. It is reasonable to assume that the proportion of marked animals in the second sample is the same as that in the population at large. This idea can be expressed symbolically as follows. If n_1 is the number of animals first marked and released, if n_2 is the size of the second sample and m_2 the number of marked animals in that sample, and if N is the total population size, then we expect: $m_2/n_2 = n_1/N$. It is obvious that, since n_1, n_2, and m_2 are known, N can be estimated." (Greenwood 1996, pg. 17)

The paragraph above describes the basic idea behind the ecological census technique known as **mark-recapture**. Three different mark-recapture methods are shown below for comparison:

Method	**Petersen**	**Schnabel**	**Jolly-Seber**
Number of capture /recapture sessions	Two	Several	Several
Population open or closed	Closed	Closed	Open
Capture probabilities	Uniform	Uniform	Uniform
Type of mark required	Single	Single	Batch-specific or individual

Table 1. Different mark-recapture methods. (Greenwood 1996, pg. 20).

Dr. Smith uses the **Schnabel** method to estimate the population sizes of different species of rodents at her study sites. Rodents are trapped, marked with a spot of dark hair dye on their stomachs, and released. Because this method only applies to closed populations, we must assume that the following are true:

-There are no births or deaths within the survey time.

-There is no immigration or emigration within the survey time.

In a natural population, it is impossible to know if all these assumptions have been met. However, the Schnabel method can still provide a good estimate of the true population size. The Schnabel formula is described below:

$$\mathbf{N = \Sigma\, CtMt^2 \div \Sigma\, RtMt}$$

N = Estimate of population size
Ct = Number of organisms caught
Rt = Number of organisms recaptured
Mt = Number of marked organisms in the population

Greenwood, J. D. 1996. Basic Techniques: Mark-recapture methods. In *Ecological Census Techniques: A Handbook*. Ed. Sutherland, W. J. Cambridge University Press: Cambridge, MA.

Learning Goal

Students will be able to answer the question, "How do populations change over time?"

Instructions

Part I: Rodent mark-recapture

1) Access the online Burying Beetle Module at http://kmrobson.jimdo.com/burying-beetle-module/. Navigate to the Data sets section. Click on the button labeled "Schnabel Method: Rodents." Download the Google Sheets file as an Excel document.

2) We are going to use the **Schnabel method** to estimate population sizes and determine the **rodent biomass (g/ha)** at Bellview, Maxfield Meadow, and Kettle Ponds. The calculations for the years 2010-2014 have been completed for you. Look through these examples, and review the information in the introduction.

3) Complete the Excel sheet for the year 2015.

-If the sum of the "No. recaptures (Rt)" is less than 5 for any one species at any one site, **do not use the Schnabel method**. The population estimate will be biased. Instead use the sum of the numbers in the "No. newly marked" column.

-In column Q you must calculate the rodent biomass for every species (Pm, Zp, Mm) at every site.

-In column R you must calculate the total rodent biomass for each site. The values in column R then need to be *multiplied by a factor of 2.04* to scale the 70 m x 70 m sampling grid up to a 100 m x 100 m sampling grid. **This provides a final rodent biomass in units of grams per hectare.**

4) Complete the Summary sheet. *3 pts*

5) Open the *Tableau* application on your computer. If it is not already installed, you can download the free software at https://public.tableau.com/s/. You will have to enter an email address to initiate the download.

a) Watch the following *Tableau* tutorials, available at https://public.tableau.com/en-us/s/resources, before moving on to the next steps: "Creating Your First Chart," and "Using the Show Me Tool Bar."

b) Connect to the Schnabel Method: Rodents Excel file. Move the Summary sheet to where it says "Drag sheets here." Click on Sheet 1 in the bottom left corner of your *Tableau* console. Use *Tableau* to create a line graph of the change in biomass (g/ha) over time (years), at the three sampling sites.

c) Select File and "Save to Tableau Public as…" *Tableau* will prompt you to sign in. If you don't have a profile, you can create one for free. Make a title for your workbook and click Save. You will be redirected to your online *Tableau* profile where the graph is saved. Click the download button in the bottom right corner and select image.

d) Download and print the image. *4 pts*

6) There is a substantial increase in rodent biomass between the years 2013 and 2015. Propose an ecological explanation for this increase. *2 pts*

7) Based on the results, we can predict that beetle populations will be the highest at all three sites in the year _____. Explain your answer. *2 pts*

Hint: Think carefully about the life cycle of the burying beetle. The last minute of the video "What does the beetle say?" contains useful information.

Part II: Beetle population index

"An index is a measurement that is related to the actual number of animals or plants. Ideally, the relationship should be such that the ratio of the index to numbers is constant: $I / N = K$. In this case, even if the index ratio (K) is unknown, one can compare populations in different places or at different times by comparing the indices." (Greenwood 1996, pg. 63)

Instead of the Schnabel mark-recapture method, Dr. Smith uses a population **index** to estimate the population sizes of different species of burying beetles at her study sites.

1) Return to the online module. Navigate to the Data sets section. Click on the button labeled "Population Index: Beetles." Download the Google Sheets file as an Excel document.

2) We will use the **minimum # known alive** as a population index. The simple calculations for the years 2010-2014 have been completed for you. Look through these examples and complete the Excel sheet for the year 2015.

3) Complete the Summary sheet. *2 pts*

4) Open the *Tableau* application again.

a) Connect to the Population Index: Beetles Excel file. Move the Summary sheet to where it says "Drag sheets here." Click on Sheet 1 in the bottom left corner of your *Tableau* console. Use *Tableau* to create a line graph of the change in minimum # known alive over time (years), at the three sampling sites.

b) Select File and "Save to Tableau Public as…" *Tableau* will prompt you to sign in. If you don't have a profile, you can create one for free. Make a title for your workbook and click Save. You will be redirected to your online *Tableau* profile where the graph is saved. Click the download button in the bottom right corner and select image.

c) Download and print the image. *4 pts*

5) We will assume that the ratio of the index to numbers is constant ($I / N = K$). In other words, the ratio of the minimum # known alive to the true population size is constant. Even though the index is a significant underestimate of the true population size, it's *relative* value is useful for comparing across sites and over time.

Refer to your graph in order to answer the questions below:

a) The beetle populations at Kettle Ponds and Maxfield Meadow fluctuate more than those at Bellview. Propose an ecological explanation for this pattern. *3 pts*

b) In her field notes, Dr. Smith describes the summer of 2015 as "incredibly wet and rainy." Explain how this weather might affect trap success, and thus bias population estimates. *2 pts*

Part III: Past vs. Present

Long-term research is extremely important to ecologists; for example, long-term studies can measure biotic responses that encompass multiple generations, or time-lagged responses. Although Dr. Smith only published the results of her early work with beetle and rodent censuses, she has continued to monitor the populations and add to long-term datasets. We looked at the most recent years of these datasets (2010-2015) in Part I and Part II. Now we're going to compare our findings to a publication from the past.

1) Return to the online module. Click on the download button for the publication titled "Resource Availability and Population Dynamics of *Nicrophorus investigator*, an obligate carrion breeder." Read the **Abstract** for an overview of the study.
2) Locate **Figure 2** in the Results section.
   Use Figure 2 and the graph below to compare population sizes from 1996-1999 with 2010-2015. Describe differences and similarities between past and present abundances. *3 pts*

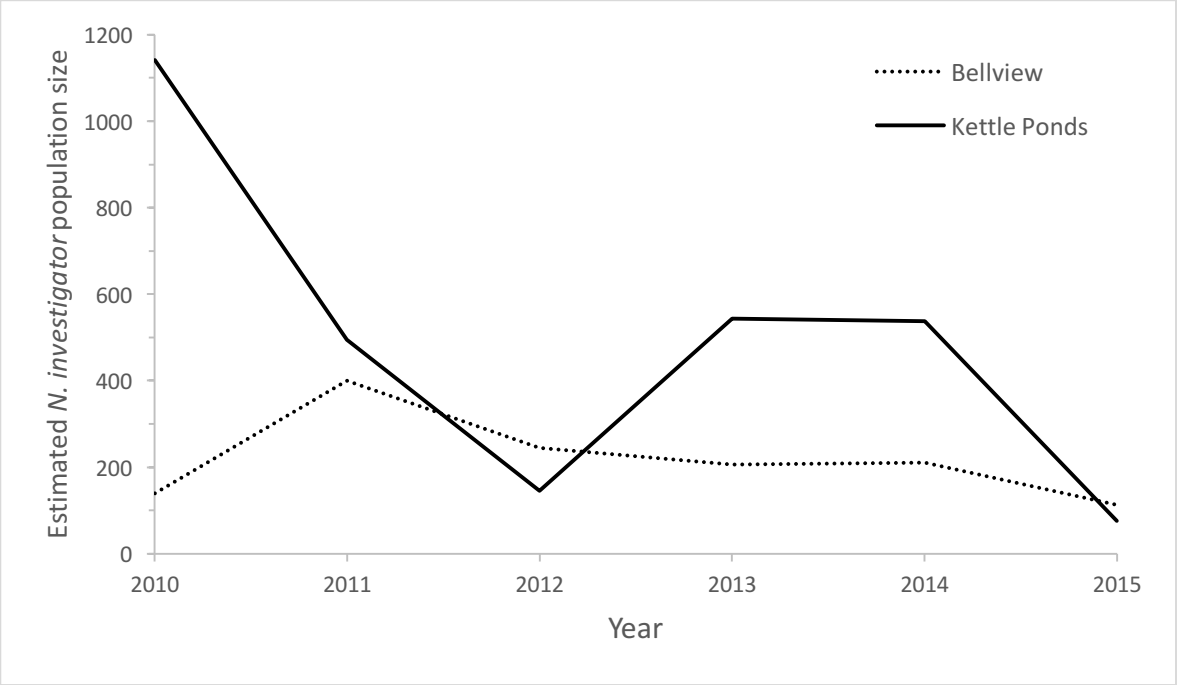

Figure 1. A comparison over 5 years of population sizes of *N. investigator* at two sites.

3) Locate **Figure 5** in the Results section and carefully read the caption. Return to the online module and locate the section with example *Tableau* visualizations. Click on the graph titled "The relationship between rodent biomass and beetle population size."
   a) Which graph in Figure 5 (a or b) is most similar to the *Tableau* graph? Justify your choice. *2 pts*
   b) *There is a significant positive relationship between rodent biomass (year X) and beetle population size (year X + 1) in past census data; however, current census data shows no association.*
   As a scientist, explain how you would interpret these results and how you would move forward. *3 pts*