Estimating Population Size: Mark-Recapture

Introduction
One of the goals of population ecologists is to explain patterns of species distribution and abundance. In today’s lab we will learn some methods for estimating population size and for determining the distribution of organisms.

Measuring Abundance: Mark-Recapture
Mobile animals are usually simpler to define as individuals, but harder to count, because they tend to move around, mix together, and hide from ecologists. For largemouth bass in a farm pond, you could easily draw a line around a map of the population, but how would you define the edges of a population of house sparrows in your community? Although house sparrows tend to be more concentrated in towns and urban areas, they do not stop and turn back at the city limit sign.

After defining the individual and establishing the limits of the population you wish to count, your next task is to choose a counting method. For estimates of absolute numbers, mark-recapture methods can be very effective. The first step is to capture and mark a sample of individuals. Marking methods depend on the species: birds can be banded with a small aluminum ankle bracelet, snails can be marked with waterproof paint on their shells, butterflies can have labels taped to their wings, large mammals can be fitted with collars, fish fins can be notched, and amphibians can have nontoxic dyes injected under the skin. Marked animals are immediately released as close as possible to the collection site. After giving the animals time to recover and to mix randomly with the whole population, the ecologist goes out on a second collecting trip and gathers a second sample of the organisms. The size of the population can then be estimated from the number of marked individuals recaptured on the second day.

The assumption behind mark-recapture methods is that the proportion of marked individuals recaptured in the second sample represents the proportion of marked individuals in the population as a whole. In algebraic terms,

\[
\frac{R}{S} = \frac{M}{N}
\]

where:
- \( R \) = animals recaptured on a second day
- \( S \) = size of the sample on the second day
- \( M \) = animals marked and released
- \( N \) = population size

Let’s consider an example. Suppose you want to know how many box turtles are in a wooded park. On the first day you hunt through the woods and capture 24 turtles. You place a small spot of paint on each turtle’s shell and release all turtles back where you found them. A week later you return and catch 60 turtles. Of these, 15 are marked and 45 are unmarked. You can now calculate the size of the whole population. \( M = 24, S = 60, \) and \( R = 15. \)

\[
\frac{15}{60} = \frac{24}{N}
\]

This can be rearranged to: \( N = \frac{(24)(60)}{15} = 96 \) turtles

This is called the Lincoln-Peterson Index of population size.
Lab: Mark-Recapture of Pinto Beans

Research Question:
How do population estimates using the Lincoln-Peterson Index compare to the true population size?

Method and Materials:
We will simulate an animal species by using pinto beans. This will allow us to evaluate the accuracy of the system. After reading the introduction and carrying out the practice problem, do the following:
1. Gather 400 beans (exactly), a large container to hold them, a small sampling device (spoon?), and a marker.
2. Put the beans in the container and then use the sampling device by filling it to the top. Count and record the number collected (M) and mark each collected bean with the marker. After marking, return the beans to the population and thoroughly mix the beans. Mix it again. And again.
3. After mixing it thoroughly, gather another sample. Count the total collected (S) and the number previously marked (R).
4. Using the Lincoln-Peterson Index, calculate the number of pinto beans in the total population (N).
5. Clean up: separate your beans according to the marks on them, as indicated by the teacher. Place them in the appropriate collection container.

Results:
Make a table below to display your raw data. Give the table a descriptive title and use a ruler to make straight lines. (show your calculations in the space provided on the next page)

Table 1: ____________________________
Show your calculations below:

(write the formula below)  (replace the formula variable with values)  (solve; don’t forget units)

Discussion:

1. Compare the total number you ESTIMATED for population size using random sampling to the number you COUNTED. Calculate percent error:
   a. Subtract COUNTED from ESTIMATED; take the absolute value
   b. Divide that answer by the COUNTED value; multiply by 100

2. Explain the difference between estimated and actual population size, accounting for experimental and procedural error. (reminder: poor technique is not “error”)

3. Propose a technique that could lead to more accurate population estimates