ESTIMATING POPULATION SIZE USING
CAPTURE AND RECAPTURE:
A GYPSY MOTH STUDY INCLUDING SIMULATIONS
STUDENT LAB TEMPLATE

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This lab was produced using the design format developed by the
Environmental Literacy Council's educator advisory group with funding
from the Department of Education's Fund for the Improvement of
Postsecondary Education (FIPSE).
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Abstract

In this lab, you will learn the principles of the capture/recapture method used to estimate a population. Three different data-collection methods can be used: field study with gypsy moth larvae (caterpillars), a hands-on simulation, or computer-generated sample data. Regardless of the data source, all are analyzed with the same formulas.

Objectives

At the end of this lab you will be able to:

- Perform a simple capture/recapture population study
- Estimate the population from capture/mark/release/recapture data

Introduction

Leopold Trouvelot introduced gypsy moths to the United States in 1869 in an effort to develop a domestic silk industry in Massachusetts. The silk business never materialized, but the moths escaped and have wreaked havoc on local ecosystems ever since, slowly expanding their range, which now reaches from Canada to North Carolina and west to Wisconsin. The eggs hatch in midspring and pass through five (male) or six (female) instars before pupating in early summer. The moths hatch about two weeks later to mate and lay eggs for the next year.

As with most insects, it is the larval (caterpillar) stage that does the greatest damage. While preferring oaks, gypsy moth caterpillars are capable of feeding on almost any tree. In their last two instars, they are capable of defoliating trees overnight. During a large infestation, the dropping frass (excrement) sounds like a light rain.

Until their final feeding frenzy, gypsy moth caterpillars prefer to munch leaves at night and retreat to shelter during the day. This makes it possible to trap the caterpillars by providing a convenient daytime hiding place in a burlap band tied around a tree.
Population estimates are necessary for both monitoring the spread of the gypsy moth and implementing effective control measures in infested areas. In the winter, population estimates are based on counts of egg masses on trees. After the moths have matured, pheromone traps are used to arrive at a population estimate. The method used in this exercise is appropriate for population estimates of the destructive larval (caterpillar) stage.

The references give a lot more information on gypsy moth life cycle and management.

Procedure

Part A1: The Real Thing!

Day 1
Select tree you want to study. Record location, species, dbh (diameter at breast height), and height. See data sheet on next page.

Wrap tree with burlap. Tie the twine at the middle of the burlap and let the burlap make a flap over the twine. The burlap should hang loosely on the tree.
Day 2
Look for gypsy moth larvae on the bark under the burlap band and in the layers of burlap. Gypsy moth caterpillars are easily distinguished by their pairs of blue, then red, dots running down their back.
Disregard anything that isn’t a gypsy moth caterpillar. (But come and show/tell us about anything interesting you found!)
Count and mark (with “white-out”) gypsy moth caterpillars. You can do this without removing the burlap or the caterpillars from the tree.

Day 3
Look for gypsy moth larvae on the bark under the burlap band and in the layers of burlap. Disregard anything that isn’t a gypsy moth caterpillar. (But come and show/tell us about anything interesting you found!)
Count both marked and unmarked gypsy moth caterpillars.
Remove burlap from tree.
Destroy gypsy moth caterpillars!
Neatly fold burlap and wrap with string for storage for next year.
The class will aggregate (pool) data to get a campuswide sample.

Part A2: Simulation

Each team needs to pick up a shoe box and two resealable bags of paperclips. Make sure your two bags have different colors of paperclips.
Empty one bag of paperclips into the shoe box and evenly distribute them by shaking the box.
Remove all those clips that land on a “tree” (sticker).
Replace these with paperclips from your second bag.
Shake box to mix and evenly distribute the paperclips.
Remove all paperclips that land on a “tree.”
Count the marked and unmarked paperclips you removed.
Sort the paperclips and replace them in the resealable bags.
Part A3: Excel Simulation

Generate a new “forest” with the “Create a New Map” button.

The “Distribute Larvae” button performs two functions:

1) First, it randomly distributes the caterpillars over the map grid. Those that land on a “tree” are considered marked.

2) Second, it randomly redistributes the caterpillars over the map grid. Those that land on a “tree” are recaptured. The recaptures are tallied by marked and unmarked.

The spreadsheet also does the calculations for you, but you should repeat them by hand (below) to make sure you understand the method.

You can repeat these steps as often as you wish — it only takes a second or two to generate a new map and larvae distribution.

Part B: Calculations

Regardless of how you obtained your data, you have the necessary numbers to estimate the population and construct a 95 percent confidence interval for that data. (See analysis below.)

Lab Tips

Part A1, Day 2

Mark your caterpillars as you count them. This eliminates the question, “Have I already counted that caterpillar?”
Data Sheet (or record in your laboratory notebook)

Gypsy Moth Capture/Recapture Population Estimate

Date: ________________________________

Location (lat/long, description): ________________________________________________

___________________________________________________________

Tree number: ________ dbh: ________ Height: ________

Tree species: ________________________________________________________________

Number of gypsy moth larvae: _________________________________________________

Larval size class (small, medium, large): _______________________________________

Comments: __________________________________________________________________

___________________________________________________________________________

Recapture date: __________________

Number of gypsy moth larvae: New: ________ Marked: ________

Larval size class (small, medium, large): ________

Comments: __________________________________________________________________

___________________________________________________________________________
Calculations:

Pooled class data

Total captured on recapture day:______________

Total number marked:______________

Total number marked and recaptured:______________

Estimate of total population:______________

Calculation of standard error:______________

Population range (95% confidence):______________

Analysis (Calculations)

Population Estimates
Capture/Mark/Recapture

\[
\begin{align*}
N & = \text{total population} \\
n & = \text{total captured on “recapture day”} \\
M & = \text{number marked} \\
R & = \text{number marked recaptured}
\end{align*}
\]
Estimate of total population:

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

Standard error:

\[ S.E. = N \sqrt{\frac{(N-M)(N-n)}{Mn(N-1)}} \]

Population range (95% confidence):

\[ N \pm S.E. \quad \text{or} \quad (N - S.E.) \text{ to } (N + S.E.) \]

Example (2001 data):

\[ n = 30 \quad M = 35 \quad R = 16 \]

\[ N = 30 \left( \frac{35}{16} \right) = 66 \]

\[ S.E. = 66 \sqrt{\frac{(66-35)(66-30)}{35 \times 30 \times 65}} = 8 \]

Population range (95% confidence): 66 ± 8, which is 58 to 74.

In the simulations, compare this to the original known population.
Further Reading: Internet Resources (all accessed March 2004):

The Gypsy Moth in Virginia
www.gypsymoth.ento.vt.edu/vagm/

USDA Gypsy Moth Handbook
www.fs.fed.us/na/morgantown/fhp/gm/gmhb.htm

Pest Alert — Gypsy Moth
www.na.fs.fed.us/spfo/pubs/pest_al/gm/gm.htm

Gypsy Moth Informational Guide
www.gypsy-moth.com