



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

---

Susan Wells Rollinson  
Jackson River Governor's School  
Dabney S. Lancaster Community College  
Clifton Forge, Virginia

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).

Copyright © 2004 College Entrance Examination Board. All rights reserved. College Board, Advanced Placement Program, AP, AP Central, AP Vertical Teams, APCD, Pacesetter, Pre-AP, SAT, Student Search Service, and the acorn logo are registered trademarks of the College Entrance Examination Board. PSAT/NMSQT is a registered trademark jointly owned by the College Entrance Examination Board and the National Merit Scholarship Corporation. Educational Testing Service and ETS are registered trademarks of Educational Testing Service. Other products and services may be trademarks of their respective owners.

For the College Board's online home for AP professionals, visit AP Central at [apcentral.collegeboard.com](http://apcentral.collegeboard.com).



## Permission to Reprint Statement

The Advanced Placement Program intends this publication for non-commercial use by AP teachers for course and exam preparation; permission for any other use must be sought from the AP Program. Teachers may reproduce this publication, in whole or in part, **in limited print quantities for non-commercial, face-to-face teaching purposes**. This permission does not apply to any third-party copyrights contained within this publication.

When educators reproduce this publication for non-commercial, face-to-face teaching purposes, the following source line must be included:

*Estimating Population Size Using Capture and Recapture: A Gypsy Moth Study Including Simulations, Student Lab Template.* Copyright © 2004 by the College Entrance Examination Board. Reprinted with permission. All rights reserved.  
apcentral.collegeboard.com.

**This material may not be mass distributed, electronically or otherwise. This publication and any copies made from it may not be resold.**

The AP Program defines “limited quantities for non-commercial, face-to-face teaching purposes” as follows:

Distribution of up to 50 print copies from a teacher to a class of students, with each student receiving no more than one copy.

No party may share this copyrighted material electronically — by fax, Web site, CD-ROM, disk, e-mail, electronic discussion group, or any other electronic means not stated here. In some cases— such as online courses or online workshops — the AP Program may grant permission for electronic dissemination of its copyrighted materials. All intended uses not defined within “*non-commercial, face-to-face teaching purposes*” (including distribution exceeding 50 copies) must be reviewed and approved; in these cases, a license agreement must be received and signed by the requestor and copyright owners prior to the use of copyrighted material. Depending on the nature of the request, a licensing fee may be applied. Please use the required form accessible online. The form may be found at: <http://www.collegeboard.com/inquiry/cbpermit.html>. For more information, please see AP’s Licensing Policy For AP® Questions and Materials.

## 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

(Source: Robert Leo Smith, *Ecology and Field Biology*, 5th ed., Benjamin-Cummings, 1996)

N = total population  
n = total captured on "recapture day"  
M = number marked  
R = number marked recaptured



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):

$n = 30$                    $M = 35$                    $R = 16$

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

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

Population range (95% confidence):  $66 \pm 8$ , 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.gpsymoth.ento.vt.edu/vagm/](http://www.gpsymoth.ento.vt.edu/vagm/)

USDA Gypsy Moth Handbook  
[www.fs.fed.us/na/morgantown/fhp/gm/gmhb.htm](http://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](http://www.na.fs.fed.us/spfo/pubs/pest_al/gm/gm.htm)

Gypsy Moth Informational Guide  
[www.gypsy-moth.com](http://www.gypsy-moth.com)