

Natural History along the Natchez Trace Parkway



Classroom Lesson:

Population Estimation: Capture, Mark, and Recapture Method (Code HSS)

➤ **Grade Level:**

9-12

➤ **Subject Areas:**

Biology, math, environmental science, ecology, community service

➤ **Setting:**

Classroom

➤ **Duration:**

50 minutes or more

➤ **Skills:**

➤ **Vocabulary:**

Population, Capture-Mark-Recapture

Summary:

Students will learn how to estimate an animal population and evaluate the results when an unnatural event affects that population.



Materials Needed:

For each pair or group of students:

2 cups uncooked dry pinto beans

1 cup uncooked dry white beans

A paper bag and two plastic cups or similar containers

One of each data sheet, the instruction sheet and the report sheet for each student or student group.

Instructional Information

Tennessee Course Level Expectations:

Biology: CLE 3210.2.1 Investigate how the dynamic equilibrium of an ecological community is associated with interactions among its organisms.

CLE 3210.2.2 Analyze and interpret population data, graphs, or diagrams.

CLE 3210.2.3 Predict how global climate change, human activity, geologic events, and the introduction of non-native species impact an

ecosystem.

Embedded Math: **CLE 3210.Math.2** Utilize appropriate mathematical equations and processes to understand biological concepts.

Biology 2: **CLE 3216.2.1** Describe how the stability of an ecosystem is maintained.

CLE 3216.2.2 Investigate the major factors that influence population size and age distribution.

CLE 3216.2.3 Describe the varying degrees to which individual organisms are able to accommodate changes in the environment.

Ecology:

CLE 3255.1.3 Relate specific animal behaviors and plant tropisms to survival.

CLE 3255.2.1 Cite examples of populations limited by natural factors, humans or both.

CLE 3255.4.4 Summarize the human impact on ecosystems.

CLE 3255.6.1 Investigate the role of public lands in sustaining biodiversity.

CLE 3255.6.2 Examine state, national, and international efforts to sustain native species and ecosystems.

CLE 3255.6.3 Evaluate the impact of personal actions on the environment.

CLE 3255.6.4 Identify and explain choices you can make to lessen your impact on the environment.

Wildlife Management and Recreation:

Standard 3.0

Analyze the importance of public education and information in wildlife management and recreation.

Standard 8.0

Analyze the important recreational, therapeutic, ecological, and environmental values of Tennessee parks to the public.

Environmental Science:

CLE 3260.4.4 Evaluate the impact of human activities on natural resources.

Objectives: The student will 1.) understand how the capture, mark and recapture method is used to estimate wildlife populations. 2) estimate an imaginary population of the spotted salamander by a pseudo mark and recapture method. 3) analyze and list factors that can affect the accuracy and precision of a population estimate. 4) observe the affects of a disastrous event on the salamander population. 6) predict results, observe and record data, report results.

Teacher Set: Discuss the necessity for researchers to know how many animals there are in a population. Discuss various events that might affect an animal population. (See discussion leader sheet) Explain the unfortunate phenomenon that in some locations along the Natchez Trace Parkway, spotted salamanders must cross the Parkway at night, in the rain to reach the pools where they will breed. Students should work in pairs or small groups. They will start with a “spotted salamander population” represented by white beans. They will then “mark” salamanders by replacing spotted beans with white beans. Using the mark-recapture formula, they will estimate the number of individuals in their population. Finally they will discuss weaknesses and benefits of using this method of population estimation.

Teacher Background: (see attached Fact Sheet) The spotted salamander is indigenous to the areas surrounding the Natchez Trace Parkway. When the salamanders breed, they usually return to the same vernal pond from which they hatched. Unfortunately for some populations, this presents a hazard as the Natchez Trace Parkway is in between their forest habitat and the vernal breeding ponds. In the spring during the first few warm rains, the salamanders migrate en masse to the vernal pools. This means that many of them are crossing the road at the same time. Unfortunately, many are killed during this reproductive migration. As time passes, the salamander population may be affected. Population estimates will be necessary.

To get the most accurate population estimations, a variety of methods must be employed when attempting to estimate a population. The capture, mark and recapture method (CMR) is used by wildlife biologists. The CMR method is a sampling method that is particularly useful with animals where the researcher cannot see or find all of the animals in a particular area.

Ear tags, tattoos, clipped ears, bird bands and other methods mark the animals more or less permanently. In the case of salamanders, one of their toes is removed.

In field biology on the recapture, animals may be harvested (taken out of the population) or they may be returned to the population.

The Petersen CMR formula is one method for estimating population size:

$$P = \frac{N1 \times N2}{M}$$

where:

N1 = number of individuals initially capture and marked

N2 = number of individuals in second or recapture sample

M = number of *marked* individuals in second or recapture sample

P = population estimate

Student Instruction: The students will be learning one method that wildlife biologists use to estimate the population of an animal species. Hand out the worksheets and explain to the students the elements of the CMR formula. Next have the students get a paper bag and put two cups of dry pinto beans in the bag. They will also need about 1 cup of white beans in a separate container (plastic cups work well). The second plastic cup will be for “trash” beans.

Student Task: Complete the worksheet assignment.

Teacher Closure: Discuss possible weaknesses and strengths of this population estimator. Brain storm about how spotted salamanders could be saved from destruction.

Student Assessment: Participation in the activity.

Suggestions for re-teaching: As the opportunity occurs, relate the problem with the spotted salamander to other environmental problems.

Have the students further research and write reports about the spotted salamander.

Have the students research how others are attempting to help the spotted salamander.

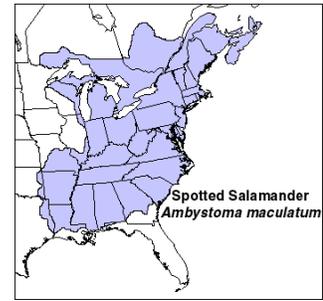
Extension:

Organize a debate comparing two different viewpoints as to what should be done about the salamanders getting run over.

Have the students draft a management plan for the spotted salamander.

Fact Sheet for Spotted Salamander *Ambystoma maculatum*

Kingdom: Animalia
Phylum: Chordata
Class: Amphibia
Order: Caudata
Family: Ambystomatidae - Mole Salamander



Description: Spotted Salamanders are black, dark grey or brown with 24 to 45 round yellow or sometimes orange spots. The belly is dark grey. The females may grow up to 10 inches (25cm) long. The males are usually 6 inches (15cm) or less. Glands on their backs and sides produce a mildly toxic nasty tasting liquid if the spotted salamander is grabbed by a predator.

Habitat: They usually live in shallow burrows they have found and only leave them during breeding season or when they cannot find enough food in their burrow. They are territorial and protect their burrows from other spotted salamanders. Each salamander only uses about 9 square yards (9 m² or 29 ft²) of forest floor.

Life History:

Eggs:

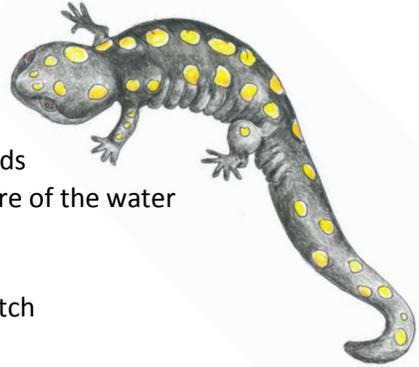
- laid in water in jell-covered groups of 100-300 eggs
- attached to vegetation or debris on bottom of vernal ponds
- take 28 to 49 days to hatch, depending on the temperature of the water

Larval stage:

- has gills and weak front legs when they hatch
- about 12 to 17 mm (1/2" to 2/3" inch) long when they hatch
- are dull olive green
- live in leaf litter on the bottom of vernal pool
- take 60-120 days to metamorphose into small adult (27 to 60 mm)

Adult:

- active only at night
- eats insects, worms, spiders, millipedes
- take two to three years to become an adult (or in the north, up to 7 years)
- may live up to 30 years



Breeding behavior: Vernal ponds are ponds that exist during rainy seasons but disappear during warmer dryer seasons. They lay eggs in vernal ponds because these ponds do not contain fish that would eat the salamanders' eggs. The pond where a salamander lays its eggs is usually the very same one from which it hatched. Salamanders return to the same pond year after year to breed. They will bypass closer ponds to find their home pond.

Their breeding routine starts with spring rains. They migrate en masse from their forest habitat areas to the ponds. They move to the ponds only on rainy nights. The males get to the ponds before the females and do a special "dance", bumping each other and coming up to the surface to gulp air.

Of the approximately 200 eggs laid, only about 40 survive to leave the pool. Of those 40, perhaps only one will survive to adulthood.

Information from: Pajerski, L., G. Hammond and N. Stout. "Ambystoma maculatum" (On-line), Animal Diversity Web. Accessed May 25, 2010 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Ambystoma_maculatum.html.

Capture! Mark! Recapture!

Instructions

In this exercise instead of taking the time to mark each “captured” spotted, pinto bean, we will remove the “captured” spotted beans, set them aside and replace them with white beans. These white beans will represent marked beans. In other words, these will be the marked salamanders. Broken or abnormally small beans are counted as another species so they are not counted in the sample size.

Procedure 1: Natural Population

1. Take a small handful of pinto beans from the bag, count them. Enter this number in the Sample 1-N1 block. This will be the salamanders you captured and marked. Replace all the spotted beans by putting the same exact number of white beans back into the paper bag.



At this point imagine that some time passes. Shake or stir the beans in the bag.

2. Capture another small hand full of pinto beans and write the number (N2) in the Sample 1-N2 block. Now in that same second handful, count and record the number of white beans, “marked individuals” (M). Record this number in the Sample 1-M block.
3. Calculate a population size estimate (P) using the mark and recapture formula provided above. Record the estimate in data table.
4. Repeat steps 1-3, two more times. HOWEVER, each time the number entered in the N1 block needs to be added to the N1 above it. For example: If the N1 in Sample 1 is 51 and the N1 in Sample 2 is 63 then the number to be entered in the N1=Sample 2 block would be 114 (51+63). Next replace the pinto beans with white beans and add all those white beans back into the container.
5. Calculate an average or mean population estimate. If you know how, calculate the deviation from the observed mean, and the average deviation. Record on Table 1.
6. Record your population estimate (mean or average) and average deviation.
7. Optional: for comparison, count all of the beans in the paper bag.

Part Two: Salamander Slaughter!

In part two, you will enter an element of disaster. During the spring reproduction migration across the Natchez Trace Parkway many spotted salamanders are run over by cars.

Start the exercise again with two cups of pinto beans with no white beans mixed in. Before you start, answer question 1 on the report sheet.

Procedure 2: Salamander Slaughter

1. Take a small handful of pinto beans from the bag, count them. Enter this number in the Sample 1-N1 block. This will be the salamanders you captured and marked. Replace all the spotted beans by putting the same exact number of white beans back into the paper bag.

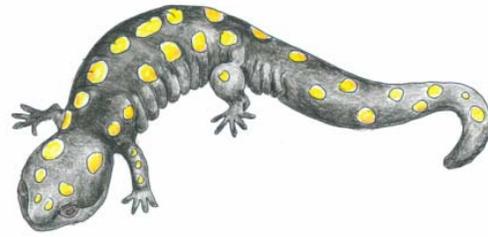


At this point imagine that some time passes. Shake or stir the bag well. ----

2. Take a handful of beans and set them aside. These represent salamanders that got run over by cars when trying to reach their pools to reproduce.
3. Capture another small hand full of beans write the number (N2) in the Sample 1/N2 block. Now count and record the number of marked individuals (M) in that second handful. Record this number in the Sample 1/M block.
4. Calculate a population size estimate (P) using the mark and recapture formula provided in the introduction. Record in data table.
5. Repeat steps 1-4, two more times and enter the data in the blocks for Samples 2 and 3.
6. Calculate an average or mean population estimate. {If you know how, calculate the deviation from the observed mean, and the average deviation.} Record on Table 1.
7. Record your population estimate (mean or average) and average deviation.

Capture! Mark! Recapture! Natural Population

Spotted Salamander *Ambystoma maculatum*



Population estimation formula:

$$P = \frac{N1 \times N2}{M}$$

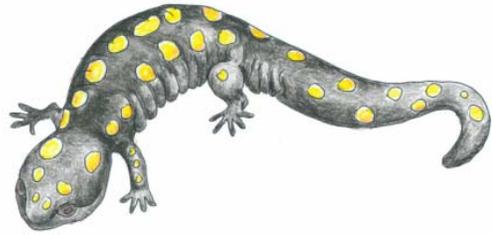
N1 = number of individuals initially capture and marked
 N2 = number of individuals in second or recapture sample
 M = number of *marked* individuals in second or recapture sample
 P = population estimate

Table 1.

Sample	N ₁	N ₂	M	P	deviation from observed mean
1					
2					
3					
				Mean/Avg.=	Avg. dev. =

Capture! Mark! Recapture! Salamander Slaughter!

Spotted Salamander *Ambystoma maculatum*



Population estimation formula:

$$P = \frac{N1 \times N2}{M}$$

N1 = number of individuals initially capture and marked
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Table 1.

Sample	N ₁	N ₂	M	P	deviation from observed mean
1					
2					
3					
				Mean/Avg.=	Avg. dev. =

Name _____

Salamander Population Estimation

Report Sheet – attach your data sheets to this report

- 1. Predict what will happen when the “slaughter” is introduced to the procedure.**
- 2. Was your prediction correct? Explain.**
- 3. What do you think would really happen to the salamander population over time?**
- 4. What could the community do to help the salamanders survive?**
- 5. Draw a graph to illustrate the mean population estimates of the natural and the man-affected populations.**
- 6. Why don't the salamanders change their behavior?**