NAME ________________________________

DATE ________________________________

Carolina EcoKits™:

Simulating Methods to Estimate Population Size

Background

If you have ever been hunting or fishing, then you may know that hunting and fishing limits often indicate the number, size, or type of organism that can be removed from a population during a specific time of year. These limits often vary year-to-year depending on the condition of the population in question. Hunting and fishing limits are set according to the results of population counts conducted on the target organisms.

Another way that you may be familiar with population size is through discussions of endangered species such as the giant panda, the Queen Alexandra's Birdwing butterfly, or the dragon tree. Often, discussions of endangered species are accompanied by numbers indicating how many are left in the wild. These numbers are determined through population counts. How, you might ask, are these numbers determined? Certainly all the organisms do not line up in orderly rows and allow scientists to count them, so what is it that scientists do to determine the size of an animal or plant population?

When subject are sessile (unmoving) like botanists' and foresters' subjects, researchers plot squares, called quadrats, or straight lines, called transects, in areas that most accurately represent the populations. A critical part of these studies is making sure the quadrats and transects accurately represent a true sampling of the area. Zoologists, on the other hand, study populations of animals that can move or hide; this can make determining the size of a population more difficult. Aside from locomotion, animals also have other behaviors that can make population counts difficult—schooling, herding, and flocking, for example. The most straightforward method of determining animal populations is by direct count, but this is rarely practical except in small, contained habitats. As with plants, population estimates for relatively easy-to-spot animals, such as birds and fish, also can be based on counts from sampling transects or quadrats. These counts yield population indices or trends, and significant population changes therefore can be recognized and monitored over time.

Scientists have devised other sampling techniques that are grounded in statistics. One method is to capture and mark a small number of individual members of a larger population. Recording the number of marked individuals that subsequently are recaptured can give scientists an idea of the size of the population. Another method is to remove the captured individuals from the population, called removal sampling. After several capture-and-removal trials, the number of individuals captured will decrease, which can lead to an understanding of the original size of the population.

There are variations of these types of sampling, depending on what is being sampled. The data from sampling can also be presented and interpreted in different ways. For instance, a forester might want to know the percent coverage of each type of tree in a forest, an ichthyologist might want to track the actual number of bass in a lake, and an ecologist might monitor the density trends of an invasive plant species.

©2011 Carolina Biological Supply Company/Printed in USA.

Activity 1: Estimating Population Cover With Transects

Introduction

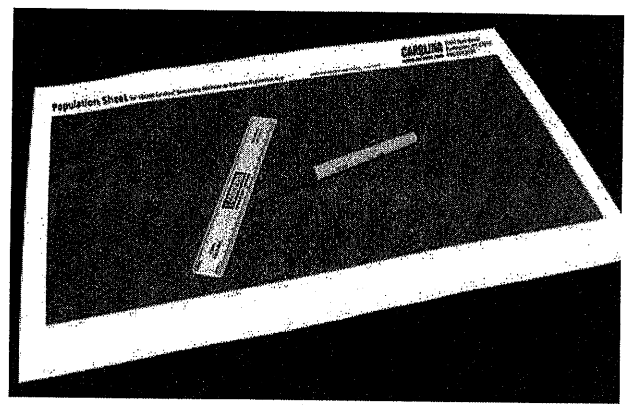
Using transects is one way to estimate population size, population density, and diversity within a habitat. This common sampling technique is based on the statistical principle that the average population found along a transect is equivalent to the total population in the habitat. This type of sampling allows for data collection over a larger range of the habitat being studied.

Perhaps the most common method of using transects is to run multiple transect lines randomly throughout the habitat to be studied. At set distances along each transect, an observer records the population at each point. After the data from several transects has been gathered, it is compiled and averaged, with the results extrapolated to apply to the entire area for which the data was gathered.

In this activity, you will use transect lines to determine the percent coverage of each of the three colors on the Population Sheet. This process also could be used to determine the density of one of the colors, or even the diversity of colors on the sheet.

Materials

Population Sheet
overhead marker
ruler
calculator


Transect setup

Procedure

1. Using the ruler and marker, make five 10-cm lines, or transects, on the Population Sheet. Each line should be randomly placed on the sheet, and can be drawn in any direction. All lines must be completely within the colored portion of the sheet.
2. Draw a small dot every 0.5 centimeter along each transect.
3. Find the 0.0-cm starting point of the first transect drawn, and note color of the square the transect line is touching. Record the color of the square in the "Transect Group Data" table on your data sheet (Transect 1, 0.0 cm).
4. Move along the transect toward the endpoint. At every 0.5-centimeter interval, determine what color square the transect line is touching. Record the color information for each of these points in the "Transect Group Data" table. In some cases it may be difficult to determine which square the transect line is touching, and you will have to make a judgment call. Be consistent with your criteria for determining which square the line is touching.
5. Repeat this process for the other four transects so that you have five complete data sets.
6. Count the total number of squares of each color as recorded in the "Transect Group Data" table. In the "Percent Cover Group Data" table on the data sheet, record the total number of red, blue, and green squares that were touching the transect lines, as well as the total number of squares counted.
7. For each color determine the percent cover by dividing the total number of points of that color by the total number of squares counted. Record the percent cover values in the "Percent Cover Group Data" table.
8. Share your percent cover data with the other groups in the class. Record this information in the "Percent Cover Class Data" table on the data sheet.

©2011 Carolina Biological Supply Company/Printed in USA.

9. Calculate the class average percent cover using the data for all 10 groups. Record the results in the "Percent Cover Class Data" table.

10. Answer the questions for Activity 1 on the Questions sheets.

Activity 2: Estimating Population Density Using Quadrats

Introduction

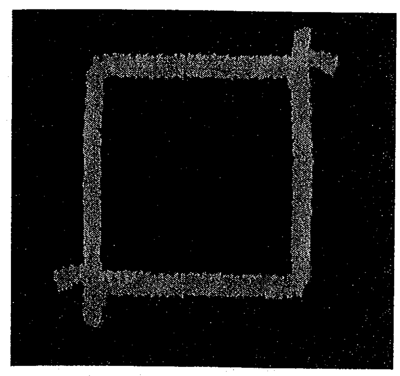
Using quadrats is one way to estimate population size, population density, and population diversity within a habitat. This common sampling technique is based on the statistical principle that the average of the populations within the quadrats is equivalent to the total population of the habitat. For example, if each 1 m^2 quadrat contains an average of 10 individuals of one species, then an area that is 1 km^2, or 1000 m^2, should contain approximately 10,000 individuals.

Quadrats in the field usually measure 0.5 m^2 or 1 m^2, although they may be any size. Researchers place the quadrats randomly throughout the test site, and then inventory what they find in each. A key to this sampling technique is the placement of the quadrats throughout the habitat. If an external condition influences the placement of the quadrats (e.g., placing them where there seems to be a higher concentration of a target species), the statistical probability will not be accurate.

In this activity, you will use quadrats to determine the density of red squares and green squares. For this activity, blue will represent open space. After the density per quadrat is determined, the population size for a given area can be estimated. Data obtained from the quadrats also could be used to determine the percent coverage of each color, and even the diversity of colors on the Population Sheet.

Materials

Population Sheet	clear tape
scissors	ruler
chenille stem	calculator



Quadrat

Procedure

1. Make a 6.25-cm^2 quadrat using the chenille stem. From the end of one of the stems, measure 3.0 cm, and then bend the stem at a right angle. Continue another 3.0 cm along the stem, and then cut the stem with scissors. Measure and bend the other piece of stem in the same way. Overlap the bent stems to create a square with ends that overlap one another by 0.5 cm. Bend the overlapping ends over one other to secure the stems in the shape of a square, as shown. The square should measure 2.5 cm × 2.5 cm.

2. The red and green squares on the Population Sheet each represent a different species, two species in all. Randomly place the quadrat on a section of the Population Sheet. Use clear tape to secure the quadrat to the sheet.

3. Count the number of red squares and the number of green squares inside the quadrat. It may be difficult to tell whether some squares close to the edge of the quadrat are inside or outside. Develop a criterion to either include or exclude these squares from the data.

4. Record the number of red squares and the number of green squares in the table for Activity 2 on the data sheet. Then, remove the quadrat from the Population Sheet.

©2011 Carolina Biological Supply Company/Printed in USA.

5. Repeat this process four times, each time at a different randomly determined location on the Population Sheet. For each count, be sure to use the same criterion for determining whether border squares are inside or outside the quadrat. Collect five data sets, and then find the total number of squares of each color for all five quadrats combined. Record this information in the data table for Activity 2.
6. Calculate the average density of red squares and green squares per 6.25 cm^2 by dividing the total number of individuals of each color (from all quadrats) by the total number of quadrats, which is 5. Record this information in the data table.
7. Calculate the density per square centimeter by dividing the average density of red squares and green squares by the area of one quadrat, which in this case is 6.25 cm^2. Record this information on the data sheet in the table for Activity 2.
8. Answer the questions for Activity 2 on the Questions sheets.

Activity 3: Estimating Population Size Through Mark and Recapture

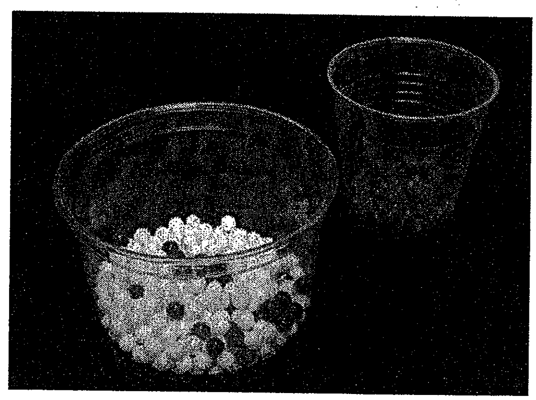
Introduction

Scientists can estimate populations using a method called mark and recapture. In this method, a sample of individuals is captured, tagged, and then released back into the environment. After sufficient time has passed to allow the animals to redistribute, scientists capture another random sample. Some of the captured sample will be marked individuals, and some will not. Knowing the percentage of marked individuals and the original number marked, one can calculate the approximate size of the population.

In this activity, you will work with your partners to simulate a method for estimating the population size of a species in an area using the mark and recapture method.

Materials

deli cup with white beads
deli cup with colored beads
2 small cups
calculator



Mark and recapture, in progress

Procedure

1. The beads in the deli cup represent a population of organisms found in a research area. White beads represent the untagged population. "Capture" a portion of the untagged population by removing a handful of white beads from the deli cup.
2. Count the white beads you captured, put them in a small cup, and then set the cup aside.
3. Count out a number of colored beads equivalent to the number of white beads you removed from the deli cup. Place the colored beads in the deli cup. The colored beads in the deli cup represent captured and marked individuals from the original population being returned to their environment. On your data sheet for Activity 3, record the number of colored beads (marked individuals) that are now in the population.
4. Randomly capture (i.e., remove) another handful of beads. This is Sample 1. In the table for Activity 3 on your data sheet, record the total number of beads in the sample you captured. Then, count and record the number of marked beads that you recaptured.
5. Calculate the percentage of the sample made up of individuals that were marked and recaptured. Record the results on the data sheet in the table for Activity 3.

©2011 Carolina Biological Supply Company/Printed in USA.

6. Return the beads to the deli cup.
7. Repeat steps 4, 5, and 6 until you have captured 20 samples.
8. Determine the average percentage of the sample marked and recaptured for all 20 samples.
9. Estimate the population size. First, multiply the original number of marked individuals by the average number of individuals captured. Then, divide that number by the average number of marked individuals recaptured. This is the population size. Record the population size on the data sheet for Activity 3.
10. After completing the calculation, count the total number of beads in the deli cup and see how accurate your estimate is.
11. Remove the colored beads and return them to their original cup. Place all the white beads (including those set aside as marked) back into the original cup. Do not share your population data with other groups.
12. Answer the questions for Activity 3 on the Questions sheets.

Activity 4: Estimating Population Size Through Removal Sampling

Introduction

Under certain conditions, scientists can estimate the size of a population by tracking how many organisms are captured and taken out of the population over time. This technique is referred to as the removal sampling method. The number of individuals caught and removed will decrease over time as the size of the population decreases. This method is commonly used in monitoring performed by fisheries. If there are few or no births or immigrations into a population, fewer individuals will be caught over time.

Hayne's method is a graphical estimation of population size based on removal sampling. In order for this method to work, several assumptions must be made. First, each individual in the population has an equal and independent chance of being captured. Second, except for the effect of trapping, the population is not increasing or decreasing. Third, each sampling event will capture the same fraction of the remaining population each time a sample is taken.

If all these assumptions are true, there is a correlation between how many organisms are captured and how many are left. When the number of organisms caught in each sampling trial is graphed against the total number of organisms previously removed, a linear relationship is observed. Extending the line to the *x*-axis will provide an estimate of the total population before the first capture occurred. Because the total number of individuals captured is known and there is an estimate of the starting population, the current size of a population can be estimated.

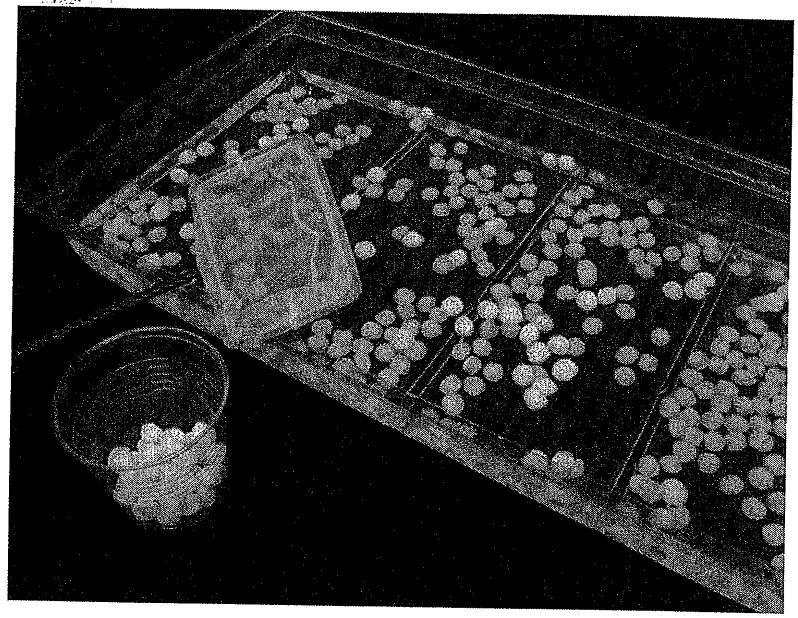
In this activity, you will work with your partners to simulate the removal sampling method for estimating the population size of a species in a given area. Then you will graph the data to determine the original population size.

Materials

plastic tray filled with pom-poms in water
5 small cups
dip net
graph paper
ruler
calculator

©2011 Carolina Biological Supply Company/Printed in USA.

Procedure



Removal sampling setup

1. Assign one member of the group as the collector, one as the data recorder, and another as the environment manager. The environment manager's responsibility is to swirl the water in the tray and keep the pom-poms moving through the water at a constant speed. It is important that the same motion and speed conditions be observed for each trial.
2. While the environment manager keeps the pom-poms moving, the collector should use the dip net and make one sweep across the tray to capture a random sample of the pom-pom population. The sweep should be in a straight line and at a constant speed. The idea is to get a random sample of the whole population. The manner in which this is done should be replicated exactly for each trial.
3. After the collector has made the sweep, empty all the captured pom-poms from the dip net into one of the small cups. The data recorder should count the number of pom-poms caught. Record the number caught in the "Sampling Trial" table on the data sheet for Trial 1. Then, determine the total number of pom-poms already removed from the population, and enter this number into the table.

   Note: For Trial 1, the total number already removed from the population is 0.
4. Repeat the capture, removal process four more times, for a total of five trials. Record your data for each trial in the "Sampling Trial" table on the data sheet.
5. On a piece of graph paper, plot the results using the "Total Number Removed" data for the x-axis and the "Number Caught" data for the y-axis. When determining the scale of your graph, make sure the x-axis extends to 400, even if your figures are not this high.
6. With a ruler, find the best-fit line connecting all the data points. Some points may be farther off the line than others. After you have figured out where the best-fit line should be placed, draw a line extending from the y-axis all the way to the x-axis. Where the line touches the x-axis is the x-intercept. This point is an estimation of the original population.
7. Use the first and last data points to determine the slope of the line. **Note:** The slope of your best-fit line may differ from the calculated slope, depending on how close the data points are to the actual line. The farther off either point is, the farther off the calculated slope will be from the line you drew. Record the calculations for slope on the data sheet in the "Calculations" table.
8. Find the x-intercept based on the calculated slope using the equation $y = mx + b$. Remember that at the x-intercept y is zero, and that the y-intercept (b) is found when x is zero. Record the calculations for the x-intercept (i.e., the original population size) on the data sheet in the "Calculations" table.
9. Answer the questions for Activity 4 on the Questions sheets.

©2011 Carolina Biological Supply Company/Printed in USA.

NAME ______________________________

DATE ______________________________

Carolina EcoKits™:

Simulating Methods to Estimate Population Size

Activity 1: Estimating Population Cover With Transects

	Transect Group Data				
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
0.0 cm					
0.5 cm					
1.0 cm					
1.5 cm					
2.0 cm					
2.5 cm					
3.0 cm					
3.5 cm					
4.0 cm					
4.5 cm					
5.0 cm					
5.5 cm					
6.0 cm					
6.5 cm					
7.0 cm					
7.5 cm					
8.0 cm					
8.5 cm					
9.0 cm					
9.5 cm					
10.0 cm					

©2011 Carolina Biological Supply Company/Printed in USA.

NAME ______________________________

DATE ______________________________

Carolina EcoKits™:
Simulating Methods to Estimate Population Size

Activity 1 (continued)

	Percent Cover Group Data	
	Total	Percent Cover
Blue		
Red		
Green		
Total Squares Counted		

Percent Cover Class Data											
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Average
Blue											
Red											
Green											

Activity 2: Estimating Population Density Using Quadrats

Quadrat #	# of Red/6.25 cm^2	# of Green/6.25 cm^2
1		
2		
3		
4		
5		
Total for 5 Quadrats		
Average Density/6.25 cm^2		
Density/1 cm^2		

©2011 Carolina Biological Supply Company/Printed in USA.

NAME ________________________________

DATE ________________________________

Carolina EcoKits™:

Simulating Methods to Estimate Population Size

Activity 3: Estimating Population Size Through Mark and Recapture

Number of marked individuals (colored beads): ______

Sample No.	No. of Marked Beads Recaptured in Sample	Total Number of Beads in Sample	% of Sample Marked and Recaptured
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Average			

Estimated population size: ________________

Actual population size: _______

©2011 Carolina Biological Supply Company/Printed in USA.

NAME ______________________________

DATE ______________________________

Carolina EcoKits™:

Simulating Methods to Estimate Population Size

Activity 4: Estimating Population Size Through Removal Sampling

	Sampling Trial				
	1	2	3	4	5
Number Caught					
Total Number Removed					

Calculations						
y_1	y_2	$y_2 - y_1 = \Delta y$	x_1	x_2	$x_2 - x_1 = \Delta x$	$\Delta y/\Delta x = m$ (slope)

©2011 Carolina Biological Supply Company/Printed in USA.

NAME ______________________________

DATE ______________________________

Carolina EcoKits™:

Simulating Methods to Estimate Population Size

Activity 1: Estimating Population Cover With Transects

1. In terms of percent coverage, using the group data, rank the colors on the Population Sheet from highest to lowest.

2. Compare your results with the class data. Describe and explain any inconsistencies between the sets of data.

3. How do you think your data would change if 10 transects were run during this activity?

4. In addition to percent cover, what other information could you determine about each population using the transect data you collected?

5. List three situations or types of organisms for which this type of population study is appropriate.

6. Give an example of a situation where this type of population study would not be ideal.

©2011 Carolina Biological Supply Company/Printed in USA.

Activity 2: Estimating Population Density Using Quadrats

1. Given the density calculated for 1 cm^2, what would the estimated population be for an area that is 20 cm by 40 cm in size?

2. Compare your results with those of another group. Describe and explain any inconsistencies between the sets of data.

3. How do you think your data would change if 10 quadrats were sampled for this activity?

4. In addition to population density, what other information could you determine about each population using the quadrat data you collected?

5. List three situations or types of organisms for which this type of population study is appropriate.

6. Give an example of a situation where this type of population study would not be ideal.

©2011 Carolina Biological Supply Company/Printed in USA.

Activity 3. Estimating Population Size Through Mark and Recapture

1. How far off was your estimate from the actual number of beads?

2. Share your results with another group. Were your results the same? If not, explain why.

3. How do you think your data would change if 40 samples were taken?

4. List three situations or types of organisms for which this type of population study is appropriate.

5. Give an example of a situation where this type of population study would not be ideal.

©2011 Carolina Biological Supply Company/Printed in USA.

Activity 4. Estimating Population Size Through Removal Sampling

1. What are some sources of error when sampling with this method?

2. Share your results with another group. Were your results the same? If not, explain why.

3. How do you think your data would change if 10 samples were taken?

4. List three different situations or types of organisms for which this type of population study is appropriate.

5. Give an example of a situation where this type of population study would not be ideal.

©2011 Carolina Biological Supply Company/Printed in USA.